A Review of Domestic and International Research on the Health Digital Divide

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Abstract

Purpose/Significance: This study analyzes the domestic and international research status of the health digital divide, systematically reviews its research framework, and provides references for scholars worldwide to conduct related research. Methods/Process: Through keyword searching, 95 English and 21 Chinese articles related to the health digital divide were screened. Content analysis was employed to systematically analyze the research themes, content, and methods of domestic and international studies on the health digital divide, and to summarize and propose future research directions. Results/Conclusion: Through literature review, this study summarizes the research framework of the health digital divide, reveals its current research status, and identifies three manifestation dimensions, six major influencing factors, two types of impact outcomes, and four intervention measures for the health digital divide, thereby providing a research framework and theoretical foundation for promoting health digital equity and eliminating the health digital divide.

Full Text

A Review of Research on the Health Digital Divide at Home and Abroad

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Abstract

[**Purpose/Significance**] This study analyzes the current state of research on the health digital divide both domestically and internationally, organizes the research framework for the health digital divide, and provides a reference for scholars worldwide to conduct related research. [**Method/Process**] Through subject term searches, we screened 95 English and 21 Chinese articles related to

the health digital divide. Using content analysis, we systematically examined the research themes, content, and methods in this field, and summarized future research directions. [**Results/Conclusion**] Through literature review, we propose a research framework for the health digital divide that reveals its current research status, identifies three performance dimensions, six major influencing factors, two categories of impact outcomes, and four types of intervention measures, providing a research framework and theoretical foundation for promoting digital health equity and eliminating the health digital divide.

Keywords: health digital divide; digital health equity; digital health inequalities; digital health technology

With the accelerated global digital transformation, new technologies characterized by informatization, networking, and intelligence are driving traditional healthcare systems into the digital health era. In recent years, the potential of digital health to improve public health service outcomes and promote population health has been widely recognized. However, as digital health technologies have permeated and been applied in practice, the phenomenon of the health digital divide—stemming from differential access to and use of technology among various groups—has attracted widespread attention from society and scholars both at home and abroad.

The health digital divide refers to the unequal application and popularization of digital technology in healthcare, manifesting as disparities among different groups in accessing health information, healthcare services, and health outcomes through information and communications technology (ICT). It represents a specific form of the digital divide. According to the International Telecommunication Union' s (ITU) report "Measuring Digital Development: Facts and Figures 2022," 2.7 billion people worldwide still lack internet access, highlighting persistent imbalances in digital development. A European survey covering 17 countries found that 51% of adults over 50 cannot use internet-based medical services. In the United States, the COVID-19 pandemic exacerbated the impact of the digital divide on access to medical services for older adults, ethnic minorities, and rural populations. The health digital divide not only affects healthcare service access and utilization but may also intensify social inequality and health disparities. When certain populations cannot access digital health technologies and services due to various factors, their health risks increase, further exacerbating health inequalities. Additionally, limited access to health information and services reduces opportunities for disease prevention and early treatment, increasing healthcare resource demand and costs while potentially causing losses in social and economic benefits.

To narrow the health digital divide, countries worldwide have made multifaceted efforts through policy, technology, education, economics, and society to promote equitable access to and popularization of digital health technologies. The United Nations has recognized digital health as part of human rights and urged member states to formulate policies to universalize internet access and eliminate the health digital divide. The 2022 World Internet Conference emphasized the

necessity and urgency of "bridging the digital divide and achieving digital inclusiveness." In China, health information services have been prioritized in national informatization planning, with "fairness and justice" becoming a key strategic issue in Healthy China construction. Reducing the health digital divide and promoting equitable access to health services has become an important topic in implementing the Healthy China strategy. Therefore, this paper systematically analyzes representative literature on the health digital divide from recent years, striving to comprehensively present the current research status and framework both domestically and internationally, and to provide references and insights for scholars to conduct related research from innovative perspectives.

2.1 Literature Collection and Screening

We searched for literature on the health digital divide published between 2012 and 2022. For English literature, we used the search query TS=("health digital divide") OR TS=("digital health equity") OR TS=("digital health inequalities") OR TS=("digital health" AND "digital divide") OR TS=("health" AND "digital divide") in Web of Science and PubMed databases, retrieving 787 relevant English articles. After reading and screening, 86 articles were selected as primary research data. During analysis, nine additional relevant English articles were obtained through reference expansion searches, resulting in a final sample of 95 English articles for this study. For Chinese literature, we used the search query "SU= 健康数字鸿沟 OR SU= 数字鸿沟健康 *OR SU=* 数字健康不平等 *OR SU=* 数字鸿沟数字健康" in CNKI and Wanfang databases, retrieving 44 relevant Chinese articles. After reading and screening, 17 articles were selected as primary research data, with four additional articles obtained through reference expansion searches, yielding a final sample of 21 Chinese articles. Literature screening criteria included: (1) full texts from formal journals, conference papers, and dissertations; (2) relevance to the health digital divide and consistent with its definition; and (3) focus on the health digital divide as the main research topic, excluding studies that only briefly mentioned the phenomenon or used it as a concluding finding in digital technology behavior research.

2.2 Basic Characteristics of the Literature

In terms of publication years, English literature on the health digital divide shows three research cycles: low attention before 2015, steady growth from 2015 to 2019, and rapid growth after 2019 as the pandemic stimulated researcher interest in related issues (see [Figure 1: see original paper]). In contrast, Chinese literature on this topic is less numerous than English literature but has also shown an upward trend since 2020, indicating increasing attention from scholars both at home and abroad.

Existing literature analysis reveals that research subjects primarily focus on behavioral actors and health information content. Regarding behavioral actors, studies concentrate on older adults, ethnic minorities, and rural (remote area) populations, likely due to their relatively weaker digital health accessibility and

cognitive abilities. Regarding digital health information content, research covers telemedicine, mobile health, smart healthcare, smart elderly care, patient portals, health codes, and other information services. In terms of disease types, studies can be broadly categorized into chronic diseases, infectious diseases, and healthy populations. Chronic diseases include major chronic illnesses such as cancer, as well as non-major chronic conditions like hypertension, diabetes, and rheumatism. Infectious diseases include acute infectious diseases like COVID-19 and chronic infectious diseases like AIDS and tuberculosis. Some representative research findings are shown in .

3 Research Themes

Literature analysis reveals that existing research on the health digital divide primarily revolves around four themes: performance dimensions, influencing factors, impact outcomes, and intervention measures. These respectively address: (1) What are the performance dimensions of the health digital divide? (2) What factors cause the health digital divide? (3) How does the health digital divide affect health? and (4) What are the intervention measures and governance paths for the health digital divide? Currently, research on the health digital divide in China lacks a mature theoretical system. This study proposes a research framework for the health digital divide based on these questions and conclusions (see [Figure 2: see original paper]) and conducts analysis and synthesis according to domestic and international research findings.

3.1 Performance Dimensions of the Health Digital Divide

The classification and performance dimensions of the health digital divide generally follow research experience from the digital divide literature. Based on different manifestations, it can be divided into three categories: access divide, usage divide, and outcomes divide. Existing research has verified the progressive influence relationship from access divide to usage divide, and from usage divide to outcomes divide.

Specifically, the **access divide** refers to the gap between those who have access to digital health technology and those who do not. For example, different populations may experience disparities in accessing health information services due to inability to obtain internet connectivity or digital health devices. In response, the World Health Organization (WHO) and ITU jointly developed an e-health strategy in 2014, aiming to improve patient health through expanded global internet access, increased network speeds, and encouragement of global information technology adoption. The access divide is often influenced by micro-level factors such as individual income, age, residence, and culture.

The **usage divide** refers to differences in the effective use of digital health skills among populations that all have access to digital health technology. For instance, inability to understand medical terminology or operate digital health devices may prevent some groups from benefiting from health information.

Existing research has verified usage divide issues regarding telemedicine, mobile health, internet-based healthcare, and portable health monitoring devices among different populations. Causes of the usage divide are diverse, including micro-level factors such as digital health literacy, self-efficacy, and attitudinal factors in technology adoption, as well as macro-level factors like technology, society, and policy.

The **outcomes divide** refers to disparities in healthcare utilization or health outcomes produced by digital health technology access and use among different groups. The impact of digital health technology applications on health has not yet formed a unified conclusion. On one hand, some studies suggest that digital health technology use helps bridge the health digital divide at the population level; for example, telemedicine better improves healthcare accessibility in rural or remote areas, thereby reducing health disparities between urban and rural areas. On the other hand, some researchers argue that the general digital divide is exacerbating the health digital divide, as higher education levels, urban populations, and younger people are more likely to accept and adopt digital health technology, potentially reinforcing health and social inequalities among different groups. A Lancet Healthy Longevity editorial in October 2021 noted that unequal access to and use of digital technology was one of the important factors contributing to increased mortality among older adults during the pandemic.

Existing research on the access divide is relatively abundant and consistent. As internet penetration and usage rates rapidly increase, the access divide in digital health technology will gradually narrow across countries, regions, and populations. However, due to factors such as health information literacy, self-efficacy, and usage attitudes, residents' ability to use digital technology to obtain health information cannot be compensated for or eliminated in the short or long term, leading to the long-term existence of the usage divide. Current research lacks consistent conclusions regarding the impact effects and formation mechanisms of the outcomes divide. Since health outcomes are influenced by multiple factors including environment, biology, lifestyle, and healthcare services, digital health technology often affects residents' health outcomes indirectly through healthcare provision or lifestyle changes, requiring further exploration to verify its effects.

3.2 Influencing Factors of the Health Digital Divide

Domestic and international research has identified numerous factors influencing the health digital divide, often acting in combination. This paper categorizes the main factors influencing the digital divide into six types: individual factors, economic factors, cultural factors, technological factors, social factors, and policy factors. These factors have similar but not entirely consistent meanings at individual or group levels, with specific classifications and literature sources shown in .

3.2.1 Individual Factors At the individual level, demographic factors, digital health literacy, digital self-efficacy, and usage attitudes are major influences

that scholars have explored using theories from psychology, communication, and sociology. First, demographic factors including age, gender, race, and residence are the most studied influences, manifested as age divide, gender divide, racial divide, global divide, and urban-rural divide. Second, **digital health literacy** (also called e-health literacy) refers to the extent to which individuals can obtain, understand, and apply digitally delivered health information and services. Access to and use of digital health technology does not equate to absorption and utilization of health information; gaps in personal digital health literacy and skills affect effective acquisition, evaluation, and use of health information, further expanding the health digital divide. In healthcare, digital health literacy is not only an information skill but has been incorporated into basic public health services. Third, **self-efficacy** is also an important factor affecting digital health technology use behavior and consequent health digital divide. Self-efficacy is an individual' s confidence in completing tasks related to obtaining, using, and evaluating health information. People with higher self-efficacy have stronger confidence in obtaining needed health information and will exert greater effort and spend more time searching for and using health information, while those with lower digital self-efficacy are more likely to reject digital health technology use. Fourth, **usage attitudes**: existing research has used innovation diffusion theory and technology acceptance models to predict digital health technology use behaviors across populations. Beyond perceived usefulness and perceived ease of use, trust is also an important factor affecting health technology use. Different levels of trust in medical institutions, healthcare providers, and platforms lead to variations in digital health usage behaviors among populations.

3.2.2 Economic Factors At the micro level, the health digital divide exists between high-income and low-income groups. Compared to low-income groups, high-income individuals can more easily afford access to and use of digital health technology, promoting improved digital health literacy and consequently leading to differences in health outcomes. Socioeconomic status, reflecting personal or family economic strength and position, is also an important factor. At the macro level, national or regional economic environments and government investment in infrastructure indirectly affect digital health technology use. On one hand, indicators such as urbanization and GDP levels reflect economic development environments and consumption levels, contributing to the health digital divide. On the other hand, government financial investment in infrastructure or digital health applications and subsidy policies for low-income populations also affect technology use. In the UK, due to limited payment capacity for digital healthcare and insufficient government financial support for low-income groups, approximately 25% of adults over 65 and 40-45% of households with incomes below £2.5 have foregone video consultations with general practitioners.

3.2.3 Cultural Factors Education level is closely related to the health digital divide. Lower education levels correlate with lower comprehension and cognitive abilities, lack of digital technology skills, and inability to correctly identify

health information. Language and cultural differences also create health digital divides. Research shows that people with limited English literacy face barriers in accessing health information and resources; for example, most mental health websites lack multilingual translation functions, increasing usage barriers for non-English speakers.

3.2.4 Technological Factors Regarding infrastructure, global digital health technology has evolved from general internet to fixed broadband and mobile networks. Lack of adequate digital technology infrastructure—such as internet access, broadband speed, mobile network signals, and mobile device penetration —can create health digital divides between regions and populations. Regarding software design, if digital health software, platforms, or mobile applications lack adaptive considerations for digitally disadvantaged groups during development, this may transform into a health digital divide between them and digitally advantaged groups. Regarding algorithmic bias, as medical big data, machine learning, and artificial intelligence algorithms are increasingly applied, different underlying data sources may lead to biased results. For example, in the US, a vaginal birth after cesarean risk calculator set lower algorithmic estimates for African American or Hispanic women, resulting in higher cesarean section rates among women of color.

3.2.5 Social Factors Social factors consider the relationship between individuals and digital health technology. Based on social capital theory, existing research has examined how social support, social norms, and implicit technology bias affect the health digital divide. Social support may promote patients' willingness and ability to use digital health technology and services, including support from family and friends in overcoming usage barriers, physician support and recommendations for using digital health services, and information and emotional support among patients. Social norms, derived from social identity theory, suggest that when people perceive value as members of a group, they comply with that group' s behavioral standards or exhibit certain group characteristics. **Implicit technology bias** refers to clinicians' one-sided views of certain patient groups based on preconceived judgments about patients' digital literacy, technology adoption willingness, and cognitive habits. Implicit technology bias is widespread in healthcare; for example, clinicians may prioritize digital health interventions for populations they believe are more receptive to digital technology. Such bias may lead to incorrect, incomplete assessments, judgments, and decisions about patients, negatively affecting communication and interaction, influencing patients' perceptions, judgments, and trust in healthcare providers, and consequently leading to differences in health outcomes.

3.2.6 Policy Factors Policies or technical standards may limit some people' s ability to access and utilize digital health technology and services, creating health digital divides. These policies and standards affect equity in service access among different populations through inclusion and exclusion mechanisms.

On one hand, differences in health insurance policies and privacy protection policies create disparities in service utilization. In China, due to varying medical insurance reimbursement policies across regions, patients seeking medical care outside their home areas cannot achieve real-time online settlement of medical expenses, limiting access to needed services for migrant populations. In the US, different state and regional privacy protection policies (such as HIPAA) restrict health information sharing. On the other hand, government differences in developing medical technology standards also create variations in service utilization behaviors; for example, non-unified standards for electronic medical records and data sharing limit some regional residents' effective use of digital health technology, thereby expanding health disparities and creating health digital divides.

3.3 Impacts of the Health Digital Divide

The health digital divide produces direct or indirect impacts on groups unable to access or effectively utilize digital health technology and services. Direct impacts include effects on healthcare service utilization, such as patient satisfaction, service quality, and efficiency. Indirect impacts include effects on physical and mental health.

3.3.1 Direct Impacts The health digital divide creates barriers to effective use of digital health technology and services, affecting healthcare service utilization. First, it directly hinders access to digital medical services such as appointment scheduling, telemedicine, health education, and online disease consultation. Second, it affects patient satisfaction with medical services, as cumbersome offline procedures and long waiting times create poor experiences. Third, it impacts service quality and efficiency for providers. The use of electronic medical record (EMR) systems, hospital information systems (HIS), electronic health records (EHR), and precision medicine directly affects healthcare delivery effectiveness. While EMR implementation can improve service quality and reduce medication errors and adverse drug events, non-uniform standards and lack of interoperability may hinder information transmission and sharing.

3.3.2 Indirect Impacts With rapid information technology development, digital technology is recognized as a new factor affecting population health and is playing an increasingly important role. The health digital divide also impacts physical and mental health, exacerbating health disparities between groups.

Physical health impacts manifest in health status, chronic disease management outcomes, and quality of life. First, the health digital divide affects physical health status; those unable to integrate into digital health lifestyles have poorer health than those with advantages in digital health technology use. Second, it affects chronic disease management effectiveness, as seen in hypertension and diabetes control rates. While digital health technology enables real-time monitoring of vital signs, continuous health management, and improved doctor-patient communication, differences in technology accessibility widen disparities

in management effectiveness among chronic disease groups. Third, it affects quality of life. Healthcare inaccessibility due to the health digital divide may indirectly impact activities of daily living (ADL), instrumental activities of daily living (IADL), cognitive function, and mortality risk, reducing quality of life. To assess digital technology' s impact on health-related quality of life (HRQoL), Lockl J proposed a technology-affected HRQoL (TA-HRQoL) model, with results showing that digital technology support can reduce the negative impact of functional limitations on overall health perceptions.

The health digital divide also affects mental health. On one hand, difficulties in accessing medical services due to the divide can cause psychological anxiety, imbalance, and increased stress, leading to poor mental health. On the other hand, the digital divide may result in insufficient social support, such as reduced opportunities for online administrative procedures and continuing education, further affecting mental health. Research found that older adults' inability to receive pensions online during the pandemic created psychological stress that affected their mental health. Meanwhile, physical and mental health often interact reciprocally; according to the "circular cumulative causation amplification effect," the negative impacts of the digital divide on physical and mental health may continuously amplify.

3.4 Intervention Measures and Governance Paths for the Health Digital Divide

The driving factors behind the health digital divide are complex and cannot be solved through single actions or from single organizations. To promote accessibility and equity of digital health technology and services and prevent technology use from further expanding health inequalities, existing literature proposes governance measures from economic, technical, social/cultural, and policy interventions.

3.4.1 Economic Interventions Economic interventions include increased government investment, tax reductions, and subsidies for digitally disadvantaged populations. First, enhanced government investment targets imbalances in digital health technology allocation by increasing fiscal input in remote or impoverished areas, improving digitalization levels in healthcare, and strengthening technology popularization. For example, to narrow the internet access gap between rural and urban areas, the US Federal Communications Commission (FCC) established the Rural Digital Opportunity Fund, allocating $20.4 billion to expand broadband infrastructure to rural areas. Second, reducing or exempting taxes and fees related to digital health technology applications encourages more active use by enterprises and individuals. Third, providing subsidies for digitally disadvantaged populations improves access to digital health technology, such as government subsidies for broadband for low-income groups and data charges for mobile health applications, helping reduce cost barriers to technology access.

3.4.2 Technical Interventions Technical interventions include unified data standards, enhanced data privacy and security protection, and software design that meets special population needs. First, unified data formats and standards form the basis for data sharing and exchange between different health institutions and applications. Designing standardized open data application programming interfaces (APIs) facilitates data sharing and interaction between health applications and institutions, improving data value and utilization. Second, strengthening health data privacy and security protection—ensuring data encryption, storage, and transmission security, regulating health data use and sharing, and enhancing supervision and management—facilitates data sharing and utilization. Third, digital health software, platforms, and applications must fully consider special population needs. On one hand, digital health literacy screening tools can identify special population needs, enabling targeted training for basic digital skills. On the other hand, encouraging developers to increase color contrast, enlarge fonts, improve interface design, and provide multilingual translation can create universal service tools for different cultures, languages, and regions, achieving barrier-free access for all groups.

3.4.3 Social and Cultural Interventions Social and cultural interventions focus on creating a "family-medical institution-society" digital health support environment. First, encouraging family members, other caregivers, and health agents to actively engage with digital health technology promotes more effective patient use of internet technology to obtain health information through family and friend encouragement and assistance. Family-centered digital health services should be promoted to fully leverage the role of family and friends in improving patient health. Second, medical institutions are important application scenarios for patients using digital health technology. Promoting the application and development of digital health technology and services in medical institutions provides more convenient and efficient digital medical service support for doctors and patients, with emphasis on monitoring service coverage and accessibility for at-risk populations. Educational training on digital equity for medical staff should be conducted to promote awareness and understanding of digital health technology norms and equity issues. Finally, establishing a digital health social support environment—such as health education and information dissemination—is crucial for maintaining community older adult health. Creating a community internet-friendly health support environment and actively responding to population aging can improve older adults' digital literacy.

3.4.4 Policy Interventions Policy interventions for the digital health divide involve clarifying goals, strengthening supervision, encouraging innovation, promoting health literacy improvement, and fostering multi-sectoral collaboration. First, clarifying digital medical and health development directions and goals encourages and supports digital technology application and development in health. For example, China's 14th Five-Year Plan and 2035 Vision Goals released in 2021 specified requirements for actively promoting public health informatiza-

tion and medical insurance informatization. The 2022 Key Tasks for Deepening Medical and Health System Reform issued by the State Council pointed out the goal of promoting information sharing among national medical and health institutions and expanding telemedicine services to cover 95% of districts and counties. Second, strengthening supervision of digital health technology applications promotes healthy and sustainable development. In 2016, the US released the 21st Century Cures Act to track how internet devices enable better patient outcomes through continuous support outside the home, as well as privacy and security protection. The FCC' s Connect2Health task force monitors broadband accessibility nationwide to support digital health universalization. Third, encouraging digital health technology innovation and R&D improves accuracy, reliability, and safety while focusing on sustainability and scalability to ensure technologies meet future healthcare needs. WHO' s Sustainable Development Goals encourage digital health technology use. Fourth, promoting digital medical and health technology popularization and application through improved public digital health literacy and awareness encourages technology adoption in healthcare. Fifth, strengthening multi-sectoral public cooperation across different fields and institutions improves overall digital technology application levels in health.

4.1 Data Acquisition Methods

Data acquisition methods for health digital divide research primarily include questionnaire surveys, public database collection, and interviews, with a few studies also using observation and case analysis methods (see). Questionnaire surveys are mainly used to study influencing factors of the health digital divide, including on-site surveys and online surveys targeting older adults, rural residents, and other groups. Public databases commonly used include HINTS, CFPS, CHARLS, and China Regional Economic Statistical Yearbooks. Interview methods include structured interviews and focus group interviews, primarily conducted face-to-face.

4.2 Data Analysis Methods

summarizes commonly used data analysis methods in existing literature. For quantitative research, studies have used descriptive statistics to analyze sample distributions; t-tests, chi-square tests, and non-parametric tests to examine significant differences between groups; regression analysis to explore impacts of multiple variables on digital health usage behavior; structure equation modeling to test effects of sociodemographic variables on mobile health usage; and K-means clustering to categorize population digital capabilities. Common statistical software includes SPSS, R, Stata, and SAS. For qualitative research, methods include content analysis and grounded theory. Content analysis systematically measures and quantitatively describes themes in various information forms (such as literature). Grounded theory is a top-down inductive analysis method for theory discovery, constructing influence factor models for digital

health usage from the bottom up to deepen understanding of health digital divide mechanisms.

5 Summary and Outlook

Through domestic and international literature analysis, we find that as digital health technology develops and becomes more deeply applied, the health digital divide no longer primarily manifests as an access divide. Increasingly, scholars are focusing on the formation of usage and outcomes divides. The health digital divide is influenced to varying degrees by individual, cultural, economic, technological, social, and policy factors. Existing research on individual and economic factors is relatively abundant, while research on other factors remains limited. Due to these influences, persistent differences in accessing and using digital health technology will exist among individuals and populations. Those who maximize digital technology capabilities often more easily obtain relative advantages, while groups most in need of medical services may be at a digital disadvantage, consequently affecting their physical and mental health. Overall, current research on the health digital divide remains in its early stages. The theoretical models of the health digital divide and the relationships and mechanisms between different influencing factors and health outcomes require further investigation. Since the health digital divide results from multiple combined factors, bridging it requires comprehensive governance measures designed from economic, technical, socio-cultural, and policy perspectives to ensure the broadest possible population has access to accessible, equitable, and sustainable digital health services, thereby narrowing health inequality gaps.

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Note: Figure translations are in progress. See original paper for figures.