

Research on the Impact Mechanism and Collaborative Governance of Digital Health Equity

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Abstract: In the digital age, promoting the modernization of health and wellness and fostering common prosperity in the health sector inevitably involves confronting the issue of health equity. Equity in the health sector is generally divided into health equity, equity in the use of health services, and equity in health financing. To further explore the realization mechanism and policy path of digital health equity, this report investigates the impact mechanisms on the realization of digital health equity. Based on the TOE framework, this report uses 27 provincial governments in China as case studies and employs the fuzzy set qualitative comparative analysis (fsQCA) method to explore the linkage effect of technology, organization, and environmental conditions on digital health equity. The study found that: (1) A single condition does not constitute a necessary condition for digital health equity, but improving the level of technology and environment plays a more universal role in achieving digital health equity. (2) Technology, organization, and environmental conditions “concurrently” form a diverse configuration that drives and promotes digital health equity; that is, the realization path of digital health equity has the characteristic of “different paths leading to the same destination.” (3) The generation path of digital health equity can be summarized into five types: technology-oriented, environment-oriented, technology-assisted, technology-environmental, and organizational-environmental.

Keywords: Digital health; Health equity; Digital technology

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1. Introduction

1.1. Investigation background

Digital health is a topic that needs to be deeply considered as people enter the digital age. The World Health Organization (WHO) released the Global Strategy for Digital Health (2020-2025), which states that digital health is understood as “the field of knowledge and practices related to the development and use of digital technologies to improve health,” including a wider range of smart devices, digital consumers using smart

connected devices, and health services combined with the Internet of Things, artificial intelligence, big data, and robotics ^[1]. Some scholars believe that digital health is “the use of information and communication technologies to improve human health care services, as well as individual and cross-population health” and “the use of digital media to change the conception and delivery of healthcare services” ^[2]. From a practical perspective, some scholars believe that digital health is a practical form that combines digital technology with medical and health content, such as: using information systems to establish electronic medical records, using big data mining to eliminate health risks, and using the Internet to conduct remote diagnosis and treatment. Some scholars have summarized medical information services, online registration and consultation, Internet pharmaceutical e-commerce, Internet hospitals, and other aspects into the content of different development stages of digital health. However, as digital health technology promotes the modernization of health care and promotes common prosperity in the health care field, fairness has also become a focus of attention ^[3].

Efficiency and equity have always been two major values pursued by humankind. In the digital age, the development of health and healthcare should prioritize high-quality development, comprehensively promote modernization, and focus on narrowing the health gap between urban and rural areas, regions, and population groups. The integration of digital technology and healthcare drives the continuous iteration and leapfrogging of health and healthcare research paradigms, service models, and governance methods, with the vision of creating a better life and new opportunities for more efficient and equitable development of the health and healthcare sector. At the same time, the integration of digital technology and healthcare has also produced “byproducts,” triggering new health equity issues. Utilitarian principles are often seen as a way to maximize the overall social benefit, while egalitarian principles for addressing inequality are set aside, and technological innovation cannot narrow the social gap in health. The elderly, people with disabilities, and farmers are vulnerable groups in terms of health and are also vulnerable groups in the digital age, mostly unable to enjoy the “digital health dividend,” and in some cases, digital technology may even cause inconvenience to their lives. This raises a question worthy of consideration and research: while fully enjoying the improved efficiency and effectiveness of health and healthcare services brought about by digital technology, how can people prevent adverse effects on health equity? Against the backdrop of comprehensively advancing the modernization of health and wellness, ensuring that everyone enjoys the fruits of the development of health and wellness in the digital age equally is of profound significance for upholding the public welfare nature of health and wellness and promoting common prosperity in the field of health and wellness ^[2].

1.2. Purpose of the survey

In recent years, health equity has become one of the hot topics in the theoretical research of the health field ^[4]. Now, in the digital age, digital health equity means that all individuals and groups can equally access and utilize digital health information, technology, and services to improve health and quality of life. The importance of digital health equity is reflected in the following aspects: (1) Equal access to health information: According to data from the World Health Organization, nearly 36% of the global population cannot access the Internet, which limits their ability to access health information. Digital health equity emphasizes that by increasing the Internet penetration rate and the application of digital technology, more people can access the necessary health information. (2) Reduce health disparities: The application of digital health technology can reduce the health gap between urban and rural areas and between the rich and poor.

For example, telemedicine technology can enable residents in remote areas to receive the same medical services as urban residents. (3) Improve the efficiency of medical services: Digital health technologies such as electronic health records and mobile health applications can improve the efficiency and quality of medical services, reduce medical errors, and improve patient satisfaction. (4) Promote health decision-making: Digital health tools can help individuals make more informed health decisions, such as predicting disease risks through health data analysis, thereby taking preventive measures in advance. In conclusion, digital health equity is not only a technical issue, but also a social issue. It relates to everyone's health rights and also to social fairness and progress. Therefore, research on digital health equity has important practical significance and social value ^[5].

1.3. Survey methodology

The qualitative comparative analysis method (QCA) was first proposed by sociologist Charles C. Ragin in 1987. This method focuses on the causal complexity between conditions and results from the perspective of holism and set theory, and is used to analyze the phenomenon of multiple causes for one result. In QCA analysis, researchers treat cases as configurations, find the logical relationship between the matching patterns of different conditions and the results, find the antecedent combination that produces the results, and answer questions such as "Are there any conditions that are necessary conditions for producing the results? What complex interactions between conditions can lead to the expected results? Which configurations prevent the expected results from occurring?" In this way, researchers can further identify the synergistic effect of multiple conditional variables under the premise of acknowledging the causal complexity ^[6].

Therefore, the QCA method combines qualitative and quantitative approaches. It can be used not only for holistic conditional analysis at the case-level using qualitative data, but also for large-sample analysis using quantitative data, transcending the traditional qualitative-quantitative division in organizational management research. This paper adopts the QCA research method primarily based on the following considerations: First, the influencing factors of digital health equity encompass dimensions such as technology, organization, and environment, and the explanatory variables exhibit complex causal relationships of interdependence, going beyond simple linear correlations. QCA, based on a holistic perspective and configurational analysis, provides a new path for complex causal analysis, better suited to analyzing the complex phenomenon of multiple causes for a single effect in digital health equity. Second, the number of cases selected in this paper is of medium size, unsuitable for large-sample statistical and regression analysis, while the QCA research method, with its advantages in both quantitative and qualitative methods, is very suitable for comparative analysis of small to medium-sized samples.

1.4. Scope of the investigation

QCA is flexible in selecting sample size and can be used for large, medium, and small sample sizes. It is also good at analyzing small and medium sample sizes. When using this method, the selection of cases should meet the principles of similarity, difference, and comprehensiveness of data. According to the case selection principle of the QCA method, the typical case library of all regions of the country is selected and determined: First, 34 provinces of the country are selected as candidate case libraries; Second, the typical case library is selected and determined according to the case selection principle of the QCA method; Finally, the data collection and organization work required for the case study is carried out, and data is collected through

multiple channels as much as possible. The triangulation test is used to compare the collected data to form the final case library of this study ^[7].

The selection of cases primarily followed these criteria: (1) Typicality. The selected cases had significant influence within their respective provinces and even nationwide, receiving widespread attention and recognition. (2) Similarity. The QCA method required that the selected cases be comparable across specific dimensions. (3) Heterogeneity. The selected cases covered multiple provinces in eastern, central, and western China, and their results included both positive and negative outcomes. Furthermore, the cases considered multiple areas such as digital infrastructure construction, the comprehensive index of digital economic development, and digital literacy, satisfying the heterogeneity requirements in terms of category and region, ensuring sufficient comparison between cases and the external validity of the conclusions. (4) Comprehensiveness of Data. The process lasted two months, during which primary and secondary data were acquired through various channels. Primary data included interview data, policy texts, and data obtained from field observations. Secondary data mainly included various forms such as government websites, media reports, Sina Weibo, academic papers, and related videos. Triangulation was used to ensure the credibility of the data. Most case materials had more than five versions, with total supporting materials reaching 80,000 words. Based on the above case selection principles, 27 cases were ultimately selected as the final research subjects.

2. Theoretical basis of digital health equity

2.1. Definition of digital health equity

Gao Jianmin and Yang Jinjuan believe that health equity should include three aspects: equity in health financing, equity in the use of health services, and equity in health outcomes ^[8]. Health equity can be described as every member of society (regardless of their income, social status, race, age, or gender) having an equal opportunity to achieve optimal health in terms of health financing, service use, and health outcomes. Health equity can be understood as creating equal opportunities to obtain health, minimizing the health differences among different groups; it can also be understood as the allocation of survival opportunities should be demand-oriented, rather than dependent on social privilege or income differences; it requires efforts to reduce injustices and undue social disparities in health and health service use among various groups in society, striving to ensure that every member of society can achieve optimal health ^[9]. In the health system, health equity requires all members of society to have an equal opportunity to obtain the highest possible level of health, ultimately achieving health for all, which is a fundamental human right.

Based on the three dimensions of health equity, digital health equity should also include equity in funding, equity in service utilization, and equity in health outcomes. The funding dimension focuses on the sources and allocation of funds for digital health resources and services. This includes ensuring that funding reaches all regions, especially remote and resource-scarce areas, and how these funds are allocated to ensure broad coverage and equity, establishing long-term and sustainable financing mechanisms to support the continued development of digital health projects. The utilization dimension involves the extent and manner in which individuals and groups use digital health services. This includes the accessibility, digital literacy, acceptability, and ease of use of digital health technologies. Technology accessibility refers to increasing the adoption rate of digital health technologies, ensuring that everyone has access to these technologies.

Improving public digital literacy enables them to effectively use digital health tools and services. The outcomes dimension focuses on the impact of digital health services on health outcomes, including health improvements, reductions in health inequalities, and enhanced health equity. Specifically, this involves assessing and monitoring the impact of digital health services on the health outcomes of different groups, ensuring that services bring equitable health improvements, and using data and evidence to guide policy-making and resource allocation to achieve better health outcomes. These three dimensions of digital health equity are interconnected and together form a comprehensive framework for assessing and promoting equity in the digital health sector. By adopting coordinated strategies across these three dimensions, the equity of digital health services can be effectively improved, ensuring that everyone benefits from digital health innovations.

2.2. Development and popularization of digital health technology

Digital health technology refers to the development and application of digital technologies to improve the quality and efficiency of health and healthcare ^[10]. Digital health technology uses new infrastructure such as 5G, big data centers, artificial intelligence, blockchain, and cloud computing as important carriers, including but not limited to mobile applications, remote monitoring devices, virtual reality, and other tools. These technologies have been widely used in the field of medical care, covering multiple areas such as chronic disease management, telemedicine, continuing care, mental health, health education, disease prevention, and epidemic monitoring. They have received consistent praise from medical staff and patients in many aspects such as health management of chronic disease patients, postoperative patient rehabilitation, and psychological support for cancer patients. Compared with traditional face-to-face intervention methods, intervention through digital health technology has the advantages of being convenient, fast, time-saving, efficient, low-cost, and able to overcome geographical barriers. It is suitable for elderly patients with chronic diseases, adolescents, and people with mental illnesses.

2.2.1. Digital health technology enables precise and personalized health services

Digital health services based on data and using digital technology have improved the efficiency and level of services throughout the entire life cycle of the health industry ^[11]. For example, IoT technology connects with medical devices through sensors, enabling real-time dynamic recording of user health data, providing refined health services, and providing more comprehensive data sources. Artificial intelligence technology can monitor the user's treatment, prognosis, and rehabilitation progress through modeling based on the user's historical health data, providing more personalized health services ^[12]. Smart drug logistics and distribution robots can provide drug delivery services between nurse stations and pharmacies, saving not only labor costs but also improving the accuracy and scientific level of drug delivery. In addition, big data technology can statistically analyze the specific characteristics of a specific region, a specific population, and a specific disease, providing strong data support for the prevention of diseases for all. For example, Yifan Pharmaceutical Co., Ltd. relies on the extensive patient population of the Waterdrop Crowdfunding platform to innovatively carry out clinical CRO and pharmaceutical marketing business using digital methods, improving the efficiency of clinical research and marketing of pharmaceutical companies. In the field of clinical research and development, Yifan Pharmaceuticals has created a unique end-to-end digital pharmaceutical R&D service. Through a series of digital services and products, such as

intelligent recruitment, remote visits, remote monitoring, and electronic payment for participant subsidies, it significantly improves the efficiency and quality of clinical trials. In the field of pharmaceutical marketing, Yifan Pharmaceuticals provides pharmaceutical companies with innovative digital marketing solutions through services such as intelligent operations, public education, AI follow-up, and data insights. This helps more patients enhance their understanding of diseases and drugs, improving their health and quality of life. The innovation and application of digital technology have added new impetus to the development of the health industry.

2.2.2. Digital health technologies promote the optimal allocation of medical resources and improve service accessibility

On the one hand, digital technology has further optimized medical resources at the patient level and improved the efficiency of diagnosis and treatment. For example, online diagnosis and treatment systems can obtain relevant patient information and treatment needs in advance, realize the advance scheduling of doctor resources, reduce the time cost of patients, and optimize the experience of seeking medical treatment. On the other hand, digital technology has improved the allocation efficiency of medical resources at different levels of medical institutions, improved the overall medical level of the whole society, and promoted social equity. Digital diagnosis and treatment methods such as telemedicine and online consultation enable patients to break through the time and space restrictions to obtain medical resources, which greatly improves the convenience of residents in areas with scarce medical resources to obtain high-quality medical services. According to the “Statistical Report on Internet Development in China,” as of December 2023, the number of Internet medical users in China reached 414 million, an increase of 51.39 million from December 2022, accounting for 37.9% of the total number of Internet users^[13]. More importantly, based on digital technology and platforms, medical institutions in areas with scarce medical resources can learn and share high-quality resources, narrow the regional gap, promote the coordination and cooperation of resource utilization between regions, and realize the “secondary allocation” of high-quality medical resources.

2.2.3. Digital health technology accelerates the transformation and upgrading of the health industry

The technological foundation of digital health is not simply information transmission technology, but a combination of technologies centered on cloud computing, big data, the Internet of Things, blockchain, and artificial intelligence, capable of aggregating and utilizing data. New technologies have improved data perception and acquisition capabilities. First, the application of digital technology in the medical field is accelerating, with more efficient and intelligent diagnostic tools continuously emerging. Examples include the application of intelligent medical devices, robotic surgery, and virtual reality. In electrocardiogram (ECG) examinations, due to differences in experience, doctors’ interpretations can vary, leading to risks and problems in subsequent diagnosis and treatment. AI-based ECG-assisted decision support systems offer diagnostic capabilities equivalent to 5–10 years of experience as a senior ECG doctor, with over 90% of the system’s diagnostic suggestions being adopted by doctors, significantly reducing interpretation time. To some extent, the intervention of digital technology has revolutionized the service efficiency of the medical industry. Second, the service scope of digital health is constantly expanding, with the “health+” industry rapidly emerging. New business models such as fitness live streaming, daily fitness apps, and fitness social networking are continuously capturing public attention at low or even zero cost, enriching and diversifying

the connotation of the digital health industry. Third, the health prevention industry is making continuous breakthroughs with the help of digital technology. For example, commercial health insurance, based on users' historical health data, utilizes big data and big model technologies to design more precise and personalized insurance products. For instance, Waterdrop Insurance conducts deeper needs analysis on people with pre-existing conditions, mothers and infants, and the elderly, and collaborates with insurance companies to provide more innovative, customized, and cost-effective products and services. To date, Waterdrop Insurance has launched more than 40 insurance products for people with pre-existing conditions, providing claims services to 2,742 users with pre-existing conditions and 823 elderly people in 2023, the oldest of whom was 94 years old.

2.3. Current status of research on the health digital divide

Digital health technologies have permeated multiple fields such as medical informatics, mobile healthcare, smart healthcare, and telemedicine. However, the speed of technological development and the scope of application vary across different regions and groups, leading to an exacerbation of the digital health divide^[14]. Cui Ao's research is based on the 2020 China Family Panel Studies data and empirically analyzes the impact of the digital divide on the physical and mental health of the elderly. The study found that the digital divide significantly reduces the physical and mental health of the elderly, while intergenerational support has a moderating effect and can weaken the negative effect of the digital divide on the physical and mental health of the elderly. The digital divide has a stronger negative impact on the physical and mental health of the elderly with lower health levels, and has a "Matthew effect"; compared with urban elderly, rural elderly are more likely to be affected by the digital divide. Therefore, the government should further improve digital inclusion policies, strengthen digital education for the elderly, encourage children to play a full role in intergenerational digital support, solve the problem of the digital divide for the elderly, and help achieve digital equity and healthy aging^[15]. Ren Xinyi et al. analyzed the factors that form the digital divide, including differences in Internet access, differences in digital technology application, differences in data information resource enjoyment, and differences in data thinking. The digital divide manifests in the form of an intergenerational digital divide, an urban-rural digital divide, etc. The digital divide is a new wealth gap in the digital economy era, which brings new inequalities in the digital economy era and has an important impact on fairness, data resource sharing, enterprise technological innovation, and regional coordinated development^[16].

3. Research framework and data collection

3.1. TOE Framework Based on Digital Health Technology Application Context

The TOE framework provides a comprehensive analytical perspective that can simultaneously consider the three dimensions of technology (T), organization (O), and environment (E), which helps to fully understand the complexity of digital health equity. The framework allows for the systematic identification and analysis of key factors affecting digital health equity, including technology accessibility, organizational responsiveness, and environmental support^[17]. Through systematic analysis, the interaction and influence between different factors can be revealed, providing a theoretical basis for developing effective intervention measures. The TOE framework is the theoretical starting point of this paper. Under the guidance of this framework, it is determined that the technology dimension, organization dimension, and environment dimension all affect

digital health equity, as shown in **Figure 1**. Since the TOE framework does not specify the specific variables for each influencing dimension, specific variables are selected based on literature induction and empirical summarization. Literature induction refers to determining specific influencing factors by referring to the conclusions of existing studies, while empirical summarization is used to comprehensively set specific variables by conducting field surveys on digital health construction in various provinces, conducting in-depth interviews with relevant personnel, and conducting comparative analysis between multiple pilot projects^[18].

Ultimately, six conditional variables were set: two in the technology dimension (digital infrastructure and digital supply chain index), two in the organization dimension (leadership attention and the proportion of health resource supply), and two in the environment dimension (public demand and informatization level); digital health equity was used as the outcome variable.

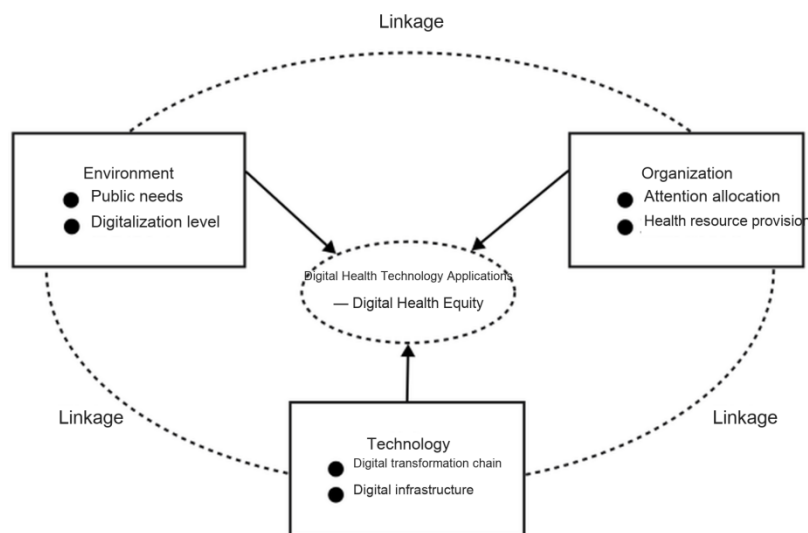


Figure 1. Analysis framework

3.2. Variable setting and assignment

3.2.1. Result variables and assignments

Digital health equity. This report measures digital health equity based on the concept of three dimensions of health equity. According to the measurement standards of health equity by Gao Jianmin and Yang Jinjuan, digital health equity is obtained by using the entropy method to obtain the digital health equity of each province through three indicators: digital literacy, online medical insurance coverage rate, and health literacy level^[8].

However, when quantifying evaluation indicators, there are few indicators available. This paper selects two primary indicators, basic digital literacy and professional literacy, in accordance with the principles of scientificity, relevance, and availability. Basic digital literacy is based on basic education literacy, i.e., the illiteracy rate. Digital professional literacy is measured by the ability to deeply utilize digital resources, i.e., per capita Internet traffic. The entropy method is used for calculation, as shown in **Table 1**^[19]. In addition, the increase in online medical insurance coverage makes medical services no longer limited to geographical location. Especially for areas with uneven distribution of medical resources, online medical insurance can

enable more patients in grassroots and remote areas to obtain high-quality medical services and achieve fair access to medical services. Finally, health literacy refers to the ability of individuals to obtain and understand basic health information and services, and to make correct decisions using this information and services. Digital health equity requires everyone to obtain and utilize health information fairly, and the level of health literacy directly affects the individual's ability to utilize digital health resources.

Table 1. Digital literacy evaluation indicators

Primary indicators	Secondary indicators	Level 3 indicators	unit	property
Digital literacy	Basic Educational Literacy	illiteracy rate	%	burden
Digital professional competence	Deep utilization of digital resources capabilities	Average internet traffic usage per person	GB/person	just

3.2.2. Condition variables and assignment

First, digital infrastructure. The digital infrastructure index in the Digital Health Equity Index released by the New Rural Development Research Institute of Peking University was selected as the data source. In the process of digital health technology development, the construction of digital infrastructure is an important foundation for big data to promote health equity. Only by strengthening the construction of information and knowledge exchange infrastructure, optimizing and updating communication networks, focusing on the construction of shared knowledge pools, and building various network sharing platforms can the government ensure that big data technology plays an effective role in improving health equity (**Table 2**)^[20].

Second, the digital supply chain index. The digital supply chain index is an important indicator for measuring the development level of the digital supply chain. It covers multiple aspects, including key areas such as logistics, capital flow, and information flow^[21]. The realization of digital health equity requires information exchange through digital platforms to reduce information asymmetry among all parties in medical and health services, realize the accessibility and fairness of telemedicine services, improve the allocation of medical and health resources, and thus promote the realization of health equity. Therefore, this study selects the digital supply chain index in the “China Digital Economy Index” as the data source.

Third, the degree of importance attached by leaders. The degree of attention and support of leaders is an important factor affecting the implementation of a policy and project^[22]. According to the measurement method of Tan Haibo et al., the provincial governments implement the central government's policy guidelines by issuing local implementation opinions on the implementation of the central government's guiding documents^[23]. The State Council issued the “Guiding Opinions on Actively Promoting the ‘Internet+’ Action,” pointing out that it is necessary to accelerate the development of emerging services such as medical care, health care, elderly care, and social security on the Internet. The development of information technology and Internet technology has provided a good platform and opportunity for the development of digital health. Information technology and Internet technology have improved the sharing of digital health information and freed it from geographical restrictions. All citizens in the country can use the resource-sharing platform to obtain digital information, which not only improves the government's information disclosure service capabilities, but also improves administrative efficiency. Therefore, when comparing the provincial governments horizontally, the longer the time interval between the issuance of implementation documents, the lower the priority of the issue. Therefore, people use the time interval between the issuance of local implementation documents by provincial governments to indirectly measure the government's importance

attached to digital health.

Fourth, the supply of health resources. The fair supply of health resources is the foundation for ensuring that the public can obtain basic medical and health services fairly. The government bears an important responsibility in the supply of basic medical and health services. By ensuring the fair supply of resources, fair access to resources can be achieved; that is, everyone has the right and the ability to obtain basic medical care ^[24]. Therefore, the per capita general health public budget expenditure of provincial governments in 2022 is used as a measurement indicator to measure the level of government health resources. The data comes from the “Statistical Bulletin on the Development of National Health and Wellness Undertakings in 2022” issued by the National Health Commission.

Fifth, public demand. This paper follows the approach of existing research and uses the proportion of the number of Internet users in each province to the total population in 2023 as the basic indicator for measuring the external demand for digital health information. If the proportion of Internet users is high, it proves that the public in that province has a greater demand for accessing digital health information through the Internet ^[25].

Sixth, the level of informatization. The data on the level of informatization comes from the comprehensive index of digital economic development of each province in the “China Digital Economy Development Index Report (2024).” This report is an index system that measures the relative progress of informatization in each province (autonomous region and municipality) in China in the form of an index ^[26].

Table 2. Selected variables and assignment settings

Variable name		Variable Description	Data source
Outcome variable	Digital health equity	Based on the concept of three-dimensional health equity, digital health equity is measured. According to Gao Jianmin and Yang Jinjuan’s measurement standards for health equity, digital health equity is measured using three indicators: digital literacy, online medical insurance coverage, and health literacy level. The entropy method is applied to obtain the digital health equity of each province.	National Bureau of Statistics, “Per Capita Flow Usage in All Provinces of China” The Seventh National Population Census Bulletin The Sixth National Health Service Statistical Survey Report
	Digital infrastructure	In the development of digital health technologies, the construction of digital infrastructure is a crucial foundation for big data to promote health equity. Only by strengthening the infrastructure for information and knowledge exchange, optimizing and updating communication networks, focusing on building shared knowledge pools, and constructing various network sharing platforms can governments ensure that big data technology plays an effective role in improving health equity.	Digital Rural Index
Condition variables	Technical dimension	The digital supply chain index is an important indicator for measuring the development level of digital supply chains. It covers multiple aspects, including key areas such as logistics, capital flow, and information flow. Achieving digital health equity requires reducing information asymmetry among parties in healthcare services through information exchange on digital platforms, improving the accessibility and fairness of telemedicine services, and refining the allocation of healthcare resources, thereby promoting health equity.	China Digital Economy Index

Condition variables	Organizational Dimension	Leadership's level of attention	The level of attention and support from leaders is a crucial factor influencing the implementation of a policy or project. Attention allocation is measured using the methodology of Tan Haibo et al., and provincial governments implement central government policies and guidelines by issuing local implementation guidelines that embody the spirit of central government directives.	Government website and related media reports
		Proportion of health resource supply	The equitable supply of healthcare resources is fundamental to ensuring that all citizens have equal access to basic medical and health services. The government bears a significant responsibility in providing basic medical and health services, ensuring equitable access to these resources by guaranteeing their equitable supply—that is, everyone has the right and the ability to receive basic healthcare.	Statistical Bulletin on the Development of National Health and Wellness Services in 2022
	Environmental dimension	Public demand	The proportion of internet users to the total population of each province in 2023 is used as a basic indicator to measure the external demand for digital health information. A higher proportion of internet users indicates that the public in that province has a greater demand for accessing digital health information through the internet.	Government website and related media reports
		Information technology level	Using the comprehensive index of digital economy development as a benchmark, it is an index system for the relative progress of informatization.	China Digital Economy Development Index Report (2024)

4. Empirical results presented

4.1. Single-factor necessary condition analysis

According to the general steps of the QCA method, before performing configuration analysis, it is necessary to perform single-factor necessary condition testing. This paper combines mainstream QCA research and first examines whether a single condition (including its non-set) constitutes a necessary condition for digital health fairness. In QCA analysis, the necessary condition is mainly judged by consistency. Antecedent conditions with a consistency result greater than 0.9 can be regarded as necessary conditions for the occurrence of the result, and antecedent conditions with a consistency result greater than 0.8 can be regarded as sufficient conditions for the occurrence of the result. However, the analysis focuses more on the interpretation of necessary conditions. At the same time, in QCA analysis, the explanatory power of antecedent conditions or configurations on the outcome variables can also be judged by coverage. For example, when the coverage is 0.8, it means that antecedent conditions or configurations can explain 80% of the cases ^[27]. **Table 3** shows the results of the necessary condition test for high-level and non-high-level digital health fairness using fsQCA3.0 software. It can be seen from the table that the consistency level of all conditions is less than 0.9. Therefore, there are no necessary conditions affecting digital health fairness.

Table 3. Necessary condition analysis

condition variable	Digital health equity		Non-digital health equity	
	consistency	Coverage	consistency	Coverage
Digital supply chain	0.67 8	0.7 30	0.59 6	0.583

Non-digital supply chain	0.613	0.625	0.72 4	0.671
Digital infrastructure	0.555	0.61 8	0.57 2	0.578
Non-digital infrastructure	0.62 1	0.614	0.622	0.5 60
Attention allocation	0.57 9	0.6 80	0.56 5	0.603
Non-attentional allocation	0.66 3	0.62 6	0.70 1	0.60 2
Health resource supply	0.693	0.689	0.65 4	0.591
Non-health resource supply	0.589	0.65 2	0.65 6	0.660
Public demand	0.65 3	0.73 9	0.58 2	0.600
Non-mass demand	0.646	0.630	0.74 7	0.66 2
Information technology level	0.618	0.715	0.600	0.63 1
Non-information level	0.681	0.65 2	0.729	0.63 5

4.2. Configuration analysis of digital health equity

Unlike the analysis of necessary conditions described above, configuration analysis attempts to reveal the sufficiency of the results produced by different configurations consisting of multiple conditions. From a set theory perspective, it explores whether the set represented by the configurations consisting of multiple conditions is a subset of the result set. Consistency is also used to measure the sufficiency of configurations, but the acceptable minimum standard and calculation method differ from the analysis of necessary conditions.

The truth table was analyzed using fsQCA3.0. Considering the case distribution characteristics and balancing the consistency and coverage of the obtained solutions, the original consistency threshold was set to 0.8, and the case frequency threshold was set to 1, resulting in three forms: complex solutions, intermediate solutions, and simplified solutions. Based on the advantages of these three solutions and existing research, the complex solution, which can more completely present the combination of antecedent conditions and exclude counterfactual condition combinations, was selected for configuration analysis. The analysis results (**Table 4**) show a total of 5 condition configurations. The overall consistency of the solution is 0.807, indicating that the condition configuration has strong explanatory power for the result of high-level digital health fairness; the overall coverage of the solution exceeds 0.5, indicating that the overall result has strong explanatory power for the selected cases.

Table 4. Digital health equity QCA configuration analysis based on the TOE framework

	Configuration 1	Configuration 2	Configuration 3	Configuration 4	Configuration 5
Digital supply chain	⊗		●	●	⊗
Digital infrastructure	●	⊗	⊗	●	⊗
Attention allocation	⊗	⊗		⊗	●
Health resource supply	⊗	⊗	⊗		●
Public demand		●	●	●	●
Digitalization level	⊗	●	●	●	●
consistency	0.821	0.866	0.823	0.962	0.231

Original coverage	0.240	0.246	0.286	0.376	0.030
Unique coverage	0.037	0	0.010	0.143	0.951
Consistency of solutions			0.807		
Solution coverage			0.574		

- (1) Technology-Oriented. Configuration 1 indicates that the existence of digital infrastructure plays a central role. This means that when digital infrastructure exists, other conditions are irrelevant to high-level government public health governance. This indicates that digital infrastructure (technology) is particularly important for high-level digital health equity governance compared to other conditions; hence, the study names this configuration “technology-oriented.” This means that technological support can effectively overcome the constraints of environmental, organizational, and other conditions on provincial governments’ ability to improve public health governance performance in order to achieve digital health equity. The consistency of this configuration is 0.821, the uniqueness coverage is 0.037, and the original coverage is 0.240. This path can explain approximately 24% of the cases, and approximately 3% of the cases can only be explained by this path.
- (2) Environment-Oriented. In Configuration 2, the existence of public demand plays a core role, while the level of informatization also plays a certain auxiliary role. Since this driving path consists of public demand (environmental) conditions and informatization level (environmental) conditions, the study names it “Environment-Oriented.” The consistency of this configuration is 0.866, the unique coverage is 0, and the original coverage rate is 0.246%. This path can explain approximately 24.6% of government cases.
- (3) Technology-Assisted Type. In Configuration 3, the existence of public demand plays a core role, while the digital supply chain and information technology level also play a certain auxiliary role. Since this driving path consists of public demand (environmental) conditions, information technology level (environmental) conditions, and digital supply chain (technology) conditions, the study names it “Technology-Assisted Type.” The consistency of this configuration is 0.823, the unique coverage is 0.010, and the original coverage rate is 0.286. This path can explain approximately 28.6% of government cases. In addition, approximately 1% of cases can only be explained by this path.
- (4) Technological Environment Type. In Configuration 4, the existence of public demand plays a core role, while digital supply chains, digital infrastructure, and informatization levels play supplementary roles. Provinces with high-level digital supply chains and digital infrastructure can achieve digital health equity even when attention allocation and health resource supply are insufficient, provided by technological conditions. Since this driving path consists of digital supply chain (technology) conditions, digital infrastructure (technology), public demand (environment), and informatization level (environment) conditions, the study also name it “Technological Environment Type.” The consistency of this configuration is 0.962, the uniqueness coverage is 0.143, and the original coverage rate is 0.376. This path can explain about 14% of the cases. In addition, about 3% of the cases can only be explained by this path.
- (5) Organizational Environment Type. In Configuration 5, the existence of public demand still plays a core role, while attention allocation, health resource supply, and informatization level play a supplementary role. Since this driving path consists of public demand (environmental) conditions, informatization level

(environmental) conditions, health resource supply (organizational) conditions, and attention allocation (organizational) conditions, the study names it “Organizational Environment Type.” The consistency of this configuration is 0.231, the uniqueness coverage is 0.951, and the original coverage rate is 0.030. This path can explain about 3% of the cases.

5. Countermeasures and suggestions

The synergistic effect of technology, organization, and environment demonstrates the complexity of digital health equity. Focusing on a single factor is unlikely to achieve the desired results. People should pay attention to the adaptability of multiple factors from a “holistic perspective,” adopt institutional policies “tailored to local conditions,” and form differentiated digital health equity paths.

Based on the configuration analysis, the study found that: First, the influencing factors of digital health equity do not operate independently, but rather are interconnected and synergistic. These include digital infrastructure and digital supply chains at the technological level, attention allocation and healthcare resource supply at the organizational level, and public demand and informatization levels at the environmental level. Second, the paths to achieving digital health equity have a “different paths leading to the same goal” effect. Nationwide, the paths to achieving digital health equity can be summarized into five types: technology-oriented, environment-oriented, technology-assisted, technology-environmental, and organizational-environmental. Third, various stakeholders must collaborate and implement differentiated measures to coordinate the technological, organizational, and environmental elements. The construction of digital health equity requires the joint participation of multiple dimensions—technology, organization, and environment—to form a government-led, multi-party participatory mechanism for achieving digital health equity, ensuring the dynamic flow, reasonable authorization, and secure use of data resources.

- (1) Building a sound digital infrastructure is an inevitable choice to promote the healthy development of the medical and health service industry into the digital age and thus achieve digital health equity [28]. In accordance with the national digital strategy, new digital infrastructure such as 5G, cloud computing, and artificial intelligence have become public basic capabilities in the digital age. The health industry should make full use of technologies such as the Internet, intelligent technology, and big data to improve the basic capabilities of digital health and achieve full coverage of digital health. Specifically, this includes strengthening the research and development and application of digital health technology, improving the quality and security of digital medical services, using digital technology to optimize medical service processes, ensuring service quality and data security, and enhancing public trust in digital health services.
- (2) Optimize the supply of digital services. In the digital age, data, computing power, and algorithms have become new production factors. They not only expand the scale of the original production factors of the medical and health service system, but also upgrade and integrate other production factors, ultimately promoting the improvement of total factor productivity [29]. This includes the factor upgrading mechanism and the factor interaction mechanism. The former involves the embedding and upgrading of digital and intelligent elements in the basic layer, support layer, and integration layer, while the latter is reflected in digital and intelligent integration, business integration, model integration, and value integration. Digital empowerment of health equity construction is mostly carried out through the

inclusive effect of digital empowerment and the macro level of digital technology promoting regional integration and development, using digital elements to empower digital production and life, bridge the digital divide, and promote digital health equity.

- (3) Improve the matching degree between digital services and public needs. The government uses digital technology to optimize the public service supply mechanism and provide more cost-effective, continuously iteratively innovative, and convenient services. Meet the personalized needs of the public, improve satisfaction with digital services, and enhance the sense of fairness in digital services.

6. Summary and outlook

The theoretical contributions of the study are twofold: First, it shifts the research on digital health equity from a single perspective focusing on infrastructure and financial resources to a holistic perspective involving the interconnectedness of technology, organization, and environment, revealing the “complex causality” behind digital health equity. Second, it introduces fsQCA into the study of the development path of digital health equity, which is not only an innovation in research methods and enriches the toolbox of research on digital health equity, but also builds a bridge for macro-level research based on micro-cases, providing ideas for the construction of future research theories^[30].

Of course, this study also has limitations. First, due to limitations in theoretical perspective and data acquisition, this paper may not have included some relevant factors in the assessment. For example, factors such as technical personnel and individual technical levels in the technology dimension may affect the fairness of digital health; organizational factors such as staffing and changes in power structure may also be relevant; and the construction of cooperative networks in the environmental dimension will directly affect the application of digital technology. In the future, appropriate measurement indicators or questionnaire surveys can be selected to explore the impact of the above factors on the level of digital health fairness. Second, the conclusions of this paper are based on a qualitative comparative analysis of 27 samples. There is a lack of quantitative research with a larger sample to test the conclusions, as well as a lack of in-depth description of single or multiple cases to track richer local practices and construct local theories.

In the future, achieving digital health equity will require interdisciplinary collaboration, including joint efforts from fields such as technology, law, ethics, and sociology. With technological advancements and policy improvements, digital health equity is expected to be better realized, thereby promoting the development of global health initiatives.

Disclosure statement

The author declares no conflict of interest.

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