Hindawi
Health & Social Care in the Community
Volume 2023, Article ID 5573969, 13 pages
https://doi.org/10.1155/2023/5573969

Research Article

The Identification of Advantages and Deficiencies of Current Digital Health Science Popularization in China: A Qualitative Study in Yangtze River Delta Region

Yuhui Ruan,[1,2] **Dongfang Wang**,[3] **and Yue Wu**[1]

[1]*School of Politics and Public Administration, Soochow University, Suzhou 215124, Jiangsu, China*
[2]*Institute of Public Health, Soochow University, Suzhou 215124, Jiangsu, China*
[3]*School of Economics and Management, Tongji University, Shanghai 200092, China*

Correspondence should be addressed to Dongfang Wang; 1410360@tongji.edu.cn

Received 28 March 2023; Revised 25 September 2023; Accepted 28 September 2023; Published 13 October 2023

Academic Editor: Mucahit Aydin

Background. Health science popularization, especially digital health science popularization, is essential for development of the Healthy China Strategy. Current studies have focused on interpreting digital education popularization and confirming its positive function; however, reports regarding the limitations and shortcomings thereof are lacking. We aimed to research the current development of digital health science popularization in China, analyze the existing problems, and explore the methods to resolve these problems. *Methods*. We conducted a qualitative study by mixing in-depth interviews and grounded theory approaches. Participants were recruited according to the inclusion criteria via a snowballing process. Thirty-nine participants, including doctors, nurses, researchers, officers in government, and project leaders, were recruited from the Yangtze River Delta region. Online in-depth interviews with open questions were conducted, and the data were collected. *Results*. Our results revealed that digital health science popularization has the advantages of convenience, swiftness, friendliness, and social links. However, obvious deficiencies were also exposed, including low authenticity, limited audiences, a lack of manpower, and fragmentation. *Conclusions*. Current digital health science popularization needs to emphasize public welfare, promote the dissemination of information with professionalism and authority, cultivate cross-border talent, and develop institutional infrastructure to overcome the deficiencies thereof. This remains important to improve the quality and effectiveness of digital health science popularization.

1. Introduction

China has recently witnessed the proliferation of health science popularization. This is essential for the Healthy China Strategy [1, 2]. As traditional non-digital health science popularization in China has exposed increasing shortcomings, the digital health science popularization has emerged and resolved some encountered problems. But its effect is still not as expected. Thus, developing strategies according to the advantages and deficiencies of current digital health science popularization in China should be necessary and meaningful.

Traditional non-digital health science popularization in China is always theoretical and conceptual in terms of education [3]. Generally, it requires a huge number of providers, especially volunteers and medical staff. It remains a process that includes a range of participants, from governmental to voluntary organizations [4], which is both time-consuming and labor-intensive. Currently, there are increasing other difficulties when higher health education and science popularization aim to achieve coordinated growth [5]. Growing public are demanding more constructive dialogue and engagement with health science in the development of their health [6, 7]; obviously, traditional non-digital health science popularization cannot meet these challenges well. Thus, despite the heavy monetary spending on science communication—which was 16 billion yuan in 2018 [8], nearly 80% of which is from Chinese government funding—the development of traditional non-digital popularization efforts still struggles to meet the diversifying

demands of science, especially in health, within Chinese society [9]. New approaches are required within health science popularization [10].

Actually, new approaches are always being encouraged by the National Health Commission of China to promote health science popularization [11]. With one-fifth of the online users worldwide [12], the development of information technology in China is promoting and benefiting Chinese health science popularization gradually [13]. Compared with the traditional non-digital way, digital health science popularization enables the public to take part in related processes and has the advantages of increasing cooperation with mass digital platforms, professional academic groups, or publishing institutions. Additionally, it demonstrates extraordinary strength in tracking hotspots of social concern, advertising public services, and leveraging new messages.

Increasing attention has been paid to digital health science popularization processes [14]. It is expected to construct a bridge between science popularization units and the public [15]. As is known, it provides more vivid presentations, including science popularization drama, digital animation, and microfilm. Digital posters and books, educative electronic games, and videos are effective approaches which are often used to enlighten the public about health science [16, 17]. The health promotion and science education can be benefited by these approaches, which improve public health finally [18]. Meanwhile, it can impact individuals' understanding and learning, change their participation framework, and even influence their credibility and identity [19]. It plays a potentially important role in science popularization and health promotion related to knowledge, attitude, and behavior [20].

Thus, digital health science popularization is highly regarded. As found, health science popularization via short-video and live video streaming platforms can provide convenience for public health education [21]. Online health science popularization information can meet the health needs of the public at many levels [22]. The efficient dissemination of science popularization knowledge can even be sped up through digital means. In the postepidemic era, digital health science popularization platforms have greatly impacted the public's behavior and engagement [23]. It improves the public's informativity in searching for health science knowledge about viruses and vaccines [24]. Digital health science popularization is, therefore, expected to bridge the gap between technical-scientific and sociolinguistic terms [25].

With health science gradually gaining popularity, the public are becoming increasingly eager to be supported by scientific knowledge in the face of increasing health problems. Then, emergence of digital health science popularization has opened up a new field of health information teaching and learning [19]. It helps the public to improve their lifestyles and increases the public credibility of science communication [6]. It encourages the public to engage in related processes, which enables participation in constructive dialogue for policy making [26]. It facilitates the scientist, experts, and physicians to involve in health science popularization to inform the public about health science as well. Finally, digital health science popularization has been increasingly emphasized [27].

However, as digital health science popularization increases the flow of new information, strengthening the public's trust in science and defending science from misinformation are recognized as increasingly essential for health science popularization as well [28]. Facing the gaps in health knowledge, experts are always more powerful than the public, which can create both opportunities and dysfunctions in health science information popularization [29]. Thus, digital health science popularization has been more challenged in building trust and establishing resonance with the public. While incorporating strong professionalism, the dissemination of digital health science popularization content should be popular within health science, as should originality and keeping up with hot health topics. It is a challenge to keep up with the increasing complexity emerging from the ensuing interaction of knowledge transmission and knowledge circulation practices too [30]. Meanwhile, digital health science includes the paradox of big data monitoring and information leakage [31]. The low accessibility of personal media accounts and imperfect control mechanisms provide a hotbed for rumors.

In China, the development of digital health popularization is relatively short. Thus, on the one hand, most current reports are not based on China's development experience. On the other hand, detailed investigations and analysis of specific facts are insufficient. At present, the effect of digital health popularization in China has not met the expectation. Although increasing researchers are aware of this problem, there are few studies on its specific status. For example, a digital divide exists among older adults in low-income households [32]; however, studies have not discussed this dilemma from the perspective of digital health science popularization. Studies have been conducted on public health education based on WeChat or regarding Internet information on public health events [19, 33]. However, most of these only provide a descriptive interpretation of digital education popularization and rarely specifically analyze the problems thereof. Compared to large studies regarding the positive visions of digital health science popularization, studies about the limitations and shortages thereof are still lacking. Obviously, it is important but still understudied regarding the advantages and deficiencies of current digital health science popularization in China. There is a lack of research that reveals the relevant development shortcomings and a lack of targeted development recommendations.

We, therefore, aimed to research how digital health science popularization has developed in China in the postepidemic era, paying attention to analyzing the problems that have been encountered and exploring the resolution thereof. By uncovering the related questions around this topic, we aimed to contribute further information on how to improve the effect of digital health science popularization.

2. Method

2.1. Study Setting. We conducted a qualitative study by mixing in-depth interview and grounded theory approaches. Participants were recruited via a snowballing process, and the data were mostly recorded from in-depth interviews. We incorporated the grounded theory approach to guide us in modifying the open questions during the interview process. All questions and analysis focused on the advantages and deficiencies of digital health science popularization. Finally, all data were analyzed by the grounded theory method (Figure 1).

As a systematic methodology for developing theories, grounded theory emphasizes inductive analysis [34, 35]. It provides an advantage relative to normative approaches in developing new theories or hypotheses. Thus, grounded theory was deemed appropriate because of its data-driven orientation [36]. Grounded theory approach was adopted in this study to enrich the data of the in-depth interviews and help explore how to recognize and guide the development of digital tools-based health science popularization from the perspective of various providers. In-depth interviews can focus on understanding some special questions [37], such as learning about the experiences, perceptions, and views of samples [38], hence the combination of the two methods.

2.2. Sampling

2.2.1. Inclusion Criteria. Most participants were unfamiliar with the researchers before enrollment in the study. They were first briefed on the methods and aims of the study before deciding whether to be involved or not. The inclusion criteria for the participants were as follows: (1) health science popularization providers with more than two years of experience; (2) without communication difficulties; and (3) with a willingness to share their opinions.

2.2.2. Sampling Process. Participants were recruited via a snowballing process in the Yangtze River Delta region (Table 1) and included doctors and nurses from hospitals, researchers from scientific research institutes and universities, officers in government, and health popularization project leaders from other platforms. The Yangtze River Delta region has been always in the forefront of health science popularization. It has gathered many talents, platforms, and other sources of digital health science popularization. Therefore, it has accumulated various related experience in the past development. Thus, this study was designed to recruit participants in this region. Initial participants were recruited from some familiar companions, mainly members of the Popular Science Committee of Chinese Medical Education Association (Geriatric Bone Health Group). All participants were interviewed by two trained researchers to ensure consistency. Potential participants meeting the inclusion criteria were informed of the purpose and process of the study. After confirming that they understood the related contents fully and were willing to be involved (verbal and written informed consent), they were included in the study.

An online in-depth interview was adopted after negotiating upon an appropriate time. The researchers conducted the interview with each participant in a separate online space, via webcam, and the interviews lasted approximately 30 minutes. Thereafter, the researchers transcribed the progress and simultaneously recorded the interview. When the interview was complete, all participants were encouraged to recommend additional participants to join the study.

Coding, comparisons, memo writing, and immediate data analysis were continuously carried out. When the first round of data was coded, potential participants for the second round were screened, based on recommendations of the former participants and others. Similarly, the following rounds of sampling were conducted, until data saturation.

Participants in this study were required to provide their opinions about the advantages and deficiencies of digital tools-based health science popularization according to their professional judgment. All individuals were recruited from March to September 2021. Anonymous references (both letters and numbers) were adopted to ensure confidentiality.

2.3. Data Collection. The interview was the primary data collection method used, as this approach has been widely employed in qualitative studies based on grounded theory [39, 40]. In-depth interviews can help researchers more clearly describe the meanings of themes central to the lives of the participants [41]. Meanwhile, narrative responses have the advantage of offering a window into the actual experiences of respondents that statistics alone do not [42].

The initial open questions for the in-depth interview used in this study were as follows. (1) Can you describe digital health science popularization tools you have employed at work? (2) What, in your opinion, are the advantages of digital health science popularization? (3) What are the deficiencies of digital health science popularization? (4) What are your suggestions on the development of digital health science popularization?

The open questions were tailored according to the context of the conversation. As the interview went on, the researchers appropriately guided the participants to expand upon their answers. This was done through further questions, such as "Why/how do you say that?"; "Can you explain that?"; and "What do you mean by saying. . .." The participants were encouraged to provide more details about some of their views, using questions such as "Can you talk about more details about. . .."

2.4. Data Analysis. Theoretical sampling and independent data coding analyses were carried out simultaneously by the corresponding authors. All data were analyzed in a cumulative manner. Group discussions were held regularly to exchange information and communicate new ideas. "What are the challenges of digital health science popularization and how do we solve them?" emerged as an elaborating question. Initially, there was no answer to this question.

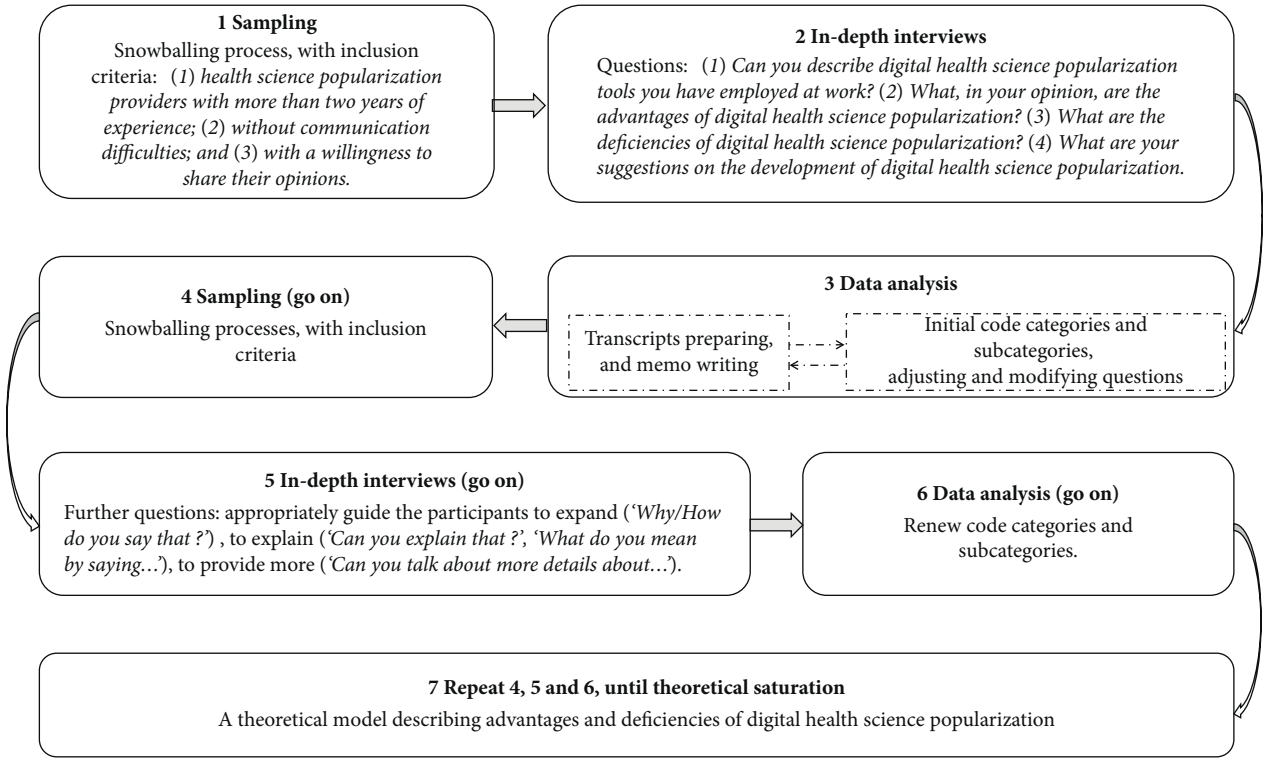

Figure 1: Study design.

Table 1: Basic information statistics of the participants.

	Number	Percentage (%)
Gender		
Female	18	46.15
Male	21	53.85
Education (years)		
Bachelors	9	23.08
Masters	16	41.02
Doctorate	14	35.90
Age		
30–39	20	51.28
40–49	14	35.90
50 and above	5	12.82
Career		
Doctors and nurses from hospitals	22	56.41
Researchers from scientific research institutes and universities	6	15.38
Officers of government	7	17.95
Health popularization project leaders of some platforms	4	10.26

As the analysis went on, various codes emerged, including "advantages" (such as convenience, swiftness, flexibility, timeliness, linkage, size/scale effect, interest, readability, and popularity) and "disadvantages" (such as authenticity, profiteering, lower conversion rates, audience limitation, manpower limitation, financial capacity limitation, material resource limitations, and institution limitations). A series of discussions were held to analyze the constantly emerging initial codes and determine their themes. Further work was carried out concerning merging, splitting, and classifying of related themes during this process. Special experts in the field were even consulted to help handle some disagreements that were encountered. With the final analysis focused on the advantages and deficiencies of digital health science popularization, other information that was not relevant was ignored in the later analysis process.

We focused on developing a theoretical model via subsequent rounds of sampling and analysis. In the later stages of sampling and theoretical coding, by using the constant comparative method (comparing codes against codes and data against data), two themes with their final

codes were identified: advantages and disadvantages. A theoretical model describing the advantages and deficiencies of digital health science popularization was developed, and related suggestions were provided accordingly.

3. Results

Digital science popularization has developed into an important trend in health science popularization with obvious advantages and deficiencies. These are summarized in Table 2.

3.1. Advantages

3.1.1. Convenience. Digital science popularization approaches demonstrated advantages in the dissemination of health science popularization. The most mentioned tools by the participants included digital magazines, digital newspapers, digital radio, cell phone SMS, mobile TV, Internet, digital TV, digital movies, and touch media. A wide variety of digital tools were considered to have expanded the dissemination channels of health science knowledge in various forms, mainly through text, pictures, videos, etc. It is very convenient for the public to understand relevant health information, which can enhance the effect of health science popularization. The following paraphrased comments were made by our respondents:

> *"Nearly everyone has WeChat. Endless amounts of information are received on cell phones or TVs every day. The frequency of the public to get information by computer terminal is drastically increased at present. Therefore, ongoing health science popularization by digital tools is an inevitable path."* (R-M-2).

> *"How many people are still reading traditional science magazines? It is too late to update information through these traditional tools, especially when facing the newly emerged epidemic (COVID-19). Digital health science popularization is convenient for the public to receive health information in a timely manner."* (N-F-1)

Digital approaches of health science popularization can provide convenience to various authorities and providers. Institutions can easily depend on their official digital platforms, such as official website, microblogs, or public numbers from WeChat, to disseminate information and knowledge on health science popularization. Authoritative individuals can conveniently carry out health science popularization activities with the help of self-media platforms. Digital health science popularization allowed a wide range of providers to select applicable tools to develop and publish health science products within their professional scope. This is convenient for the health science popularization providers to disseminate health science information and knowledge combining their own resources and conditions. This is also convenient for the public in the search for health science information.

> *"Nowadays, digital tools make health science popularization much easier. As far as I know, most official institutions have their own websites, microblogs, and WeChat public numbers. It is convenient for most individuals to open an account to popularize health science."* (O-F-5)

> *"Digital tools are convenient for us (health science popularization providers), both individuals and organizations. In the end, it is the general public benefited. We popularize health science conveniently. The general public seek related information convenience as well."* (L-M-2)

The convenience provided by digital health science popularization for the public is multifaceted. Traditional limitations of time and space for the public to receive the required information are broken. Information based on digital tools can be carried out by a variety of tools, such as cell phones, iPads, computers, mobile TVs, and other mobile devices. This mobility is very important and enables the public to be independent of fixed devices or places. This differs from traditional health science popularization approaches. Meanwhile, based on digital tools, the processes of the public to acquire relevant health science information can be synchronized within daily life (e.g., eating, watching TV, and waiting for the bus), at any time (e.g., between work and rest time).

> *"Information is updated at any time. The public are brushing their social circles frequently. Either waiting in line for a bus or a meal, most of the public keep receiving information. If we push health science popularization information properly on their digital terminals, it will be convenient for the public to be educated."* (L-F-4)

3.1.2. Swiftness. The swiftness of digital health science popularization was mentioned by nearly all the participants. Advantages related to digital technology support health science popularization communication by swiftly crossing the gaps between the media and audiences. This crossing was considered to be important as it shortened the time from generating the information to reaching the public. This swiftness was emphasized by most participants as necessary to achieve a rapid response to public health crises.

> *"This* (digital health science popularization) *communicates very quickly. This process allows effective health science popularization information to be pushed to the public as soon as it is produced. It has fewer intermediate processes that are time-consuming and laborious like traditional health science popularization tools."* (R-M-2)

The unique dynamism of digital health science popularization was also considered as important to enhance swiftness. It is supported by the focus on issues and social concerns through digital technology and helps providers to disseminate health science information accurately and in a timely fashion. Digital tools can refine the classification of health science information, which is helpful to improve the relevance of products to the public's needs. Meanwhile, digital health science popularization supports a swift public feedback mechanism. The public can give their feedback on

Table 2: Theoretical and focused codes.

Theoretical codes	Focused codes	Initial codes
Advantage of digital health science popularization	Convenience	Of time; space; place; and tools
	Swiftness	Crossing gaps; rapid response; focus; refine information; feedback; time-sensitive
	Friendly	Various forms; vivid and interesting content; various levels of content
	Linkage	Integrate information; demonstration effect, combining advantage; integrating authority
Deficiencies of digital health science popularization	Low authenticity	Misleading and misjudgment; quality varies; duplicated; indiscriminate; wrong contents
	Limited audiences	Scarcity of resources; limited quality audiences; vulnerable groups; unavailable groups
	Manpower-lacking	Lack of enthusiasm; existing talent shortage; attracting new talent is difficult
	Fragmentation	Lacking scale; depth and breadth insufficient; incoherent content

relevant health science popularization content through comments, private messages, etc. Such interactions can optimize health science popularization and also help the public to form proper health behaviors.

"Digital health science popularization is flexible. It is actively optimized as well. It is no longer a one-way dissemination of health knowledge, but is interactive. For example, all the comments on Weibo articles can be counted and analyzed as real responses of the public to certain health concerns. Then, the popularization information can be adjusted accordingly. Thus, a feedback loop is completed." (L-M-1)

"The swiftness of digital health science popularization is no longer just about being responsive in the traditional sense. Rather, it can proactively identify social concerns and focal issues through precise calculations and big data analysis." (O-M-3)

Digital health science popularization can accumulate and analyze a large amount of data about society. This helps popularization providers to organize and filter relevant health science information swiftly. It supports the providers and can highlight time-sensitive data swiftly when arranging relate content, such as in the following comments from respondents: *"displaying in more obvious positions," "increasing its exposure frequency," "improving the frequency of pushing,"* and so on. This improves the public's ability to receive needed information in the process of "being popularized" and improves the effect of health science popularization.

"Important health science information that the public needs to know quickly can be put on the front page, and can be pushed several times. In this way, the public can get important health science information passively but timeously." (O-M-6)

3.1.3. Friendly. Compared with traditional health science popularization, digital health science popularization was more friendly. Usually, the public know little about professional health knowledge and obscure terminology. Thus, it is difficult for them to accept health science information that was complicated and professional. Digital health science popularization breaks this status quo by providing a wide range of presentations and forms of products that can meet the multilevel needs of the public. This ensures that more of the public can find information that is easily understandable from the wide range of health science popularization products.

"Health science popularization should be in an easy-to-understand language. Most traditional health science popularization is too professional and tedious to remember. In comparison, digital health popularization is much more friendly for the public to accept." (D-M-1)

Visualization achieved by digital tools was found to be helpful to enhance the degree of friendliness, which was helpful for the public to generate appropriate health behavior. This can dynamically demonstrate relevant information through non-textual forms, such as cartoons, films, short videos, and public service announcements, which are considered to be vivid and interesting. Well-produced videos, with fun styles and high-quality content, can attract the attention of more of the public and stimulate greater engagement. Health science popularization products presented in visual and verbal forms are considered to be friendly and enhance the public's comprehension of health science knowledge, promoting their memory and recognition of relevant information and improving the reception rate and service quality of health science information.

"Obviously, the effect of digital health science popularization is better. Making a video or telling a story is more friendly for the public to understand. The public are easy to accept an animation as it is interesting or vivid. It can explain basic health science information to the public in a more acceptable way." (D-M-8)

3.1.4. Linkage. Participants mostly believed that digital health science popularization was an important way to educate the public, as it can achieve a linked social effect. Professional popularization institutions can integrate universal health information first, before it is transmitted and popularized on their digital platform. Meanwhile, the actions of providers can result in a demonstrative effect, which more public health science popularization providers are driven to invest in. The influence of health science popularization can then be expanded, and the effect can be improved. Considering this, digital health science popularization was believed to be helpful to combine advantages among multiple groups and produce a general linkage effect.

"Digital health science popularization is quite promising. Many local government departments, disease control agencies, hospitals, etc., are involved. Once some good works emerge, you can just forward it. Or, simply join in and do it jointly. In this way, a linkage effect can soon be formed." (L-M-3)

Digital tools are also considered to be a link between the power of health science popularization and the wider mainstream media. This link expands upon and creates channels for the public to seek health information. Participants generally believed that integrating the authority of official media can compensate for some uncertainties in health science popularization. This integrated linkage realized the two-way advantages of authority and freedom, stability, and immediacy.

"The effect of health science popularization can be magnified by joining hands with official media. You can see how influential the cooperation is between 'Dingxiangyuan' and the People's Daily." (D-M-2)

"Facing the unknown, especially public health events, the public tends to trust the authority more. In this context,

once digital media and authoritative institutions form a link, their health science popularization effect will be well magnified." (O-F-1)

3.2. Deficiencies. Digital health science popularization remains under development. Furthermore, through our interviews, we discovered several deficiencies.

3.2.1. Low Authenticity. An obvious inequality remains between providers and the public regarding professionalism and complexity of health science popularization. The providers often dominate the process of popularization because of its obvious advantages in knowledge, which can result in difficulty for the public to be satisfied by the information. An extensive constraint mechanism has not yet been formed for digital health science popularization; health information providers may pursue or even create "hotspots," excessively driven by their own interests. They may choose some content to sell and to attract the reader's attention. As a result, erroneous health information spreads rapidly, misleading the public and even leading to misjudgment of some health facts, which greatly damages the credibility of digital health science popularization.

"Many digital platforms are profit-oriented. Therefore, they need to attract the public's attention and capture their psychology. Considering this, they might choose to one-sidedly amplify or even distort some information in order to meet the public's curiosity demand or to cater to certain tastes of the public. This will lower the authenticity of digital health science popularization." (N-F-7)

"Numerous digital platforms are for-profit. Therefore, having a 'selling point' is important for the chosen content. Compared with this, pure and justified health science information is often not as attention-grabbing. So, there is a potential trade-off, which will result in less dependability of the public, and more profit-making." (O-F-2)

Most participants believed that the quality of current digital health science popularization varies, and the existing auditing methods are still backward. On the other hand, there is a lack of auditing talent in terms of professional health knowledge. The existing auditing systems are unable to screen the large amount of information. As a result, there is a great number of duplicated, indiscriminate, or even wrong content, which is detrimental to the public. Moreover, because of the immediate spread of information in the social circles of digital platforms, the negative consequences of such inaccurate health information will rapidly expand. This will reduce the accuracy of the public's health knowledge and the effectiveness of spreading high-quality health science information.

"Providers from different digital platforms have disseminated a variety of health science information, which has resulted in great confusion and disorientation. Misunderstandings among the public result. Once this has fermented, it can lead to misinformation and misrepresentation. Too much useless information also makes it difficult for the public to find the right information. This is also an important reason why lots of correct health science information cannot effectively guide the public's health behavior; it is drowned in a huge amount of invalid information." (RM-3)

3.2.2. Limited Audiences. Digital health science popularization is still limited by a lack of infrastructure. At present, remote areas are the places with the most scarcity of health resources in China. Meanwhile, these areas are also the places where gaps exist in China's information technology coverage. Digital health science popularization is difficult to promote in the relevant areas. The number of members of the public who are able to effectively use digital health science information remains very limited, and the number of groups who actively participate in this field is even smaller. These factors have greatly limited the size of the digital audience.

"Digital health science popularization must be based on digital infrastructure. Those poor and remote areas and places with insufficient information infrastructure coverage are weak links." (D-M-6)

"Health science popularization dissemination can be achieved based on digital tools. But how do we promote it in those places where it is not possible? Remember, those places without information infrastructure are often the places where health resources are most lacking." (R-F-4)

The complex composition of the public poses a great problem for digital health science popularization. A significant portion of vulnerable groups "do not know" or "are not good at" using digital health science popularization information. This is an important factor that limits the scope and effectiveness of related health science popularization. Most participants believed that the existing digital health science popularization tools were not friendly to these vulnerable groups and were not designed for them. Thus, current digital tools-based health science popularization is lost to these audiences. Moreover, the carriers of digital tools-based health science popularization are mobile devices and the Internet. Those who do not have access to these devices are disadvantaged by the unavailability of such health science popularization. According to the participants, this loss of audience consists mostly of the older adults, poor, less educated, and so on. This can exacerbate the vulnerability of this group.

"Digital health science popularization is seemingly open to all. But only on some levels in actuality. Remember that there are still many older adults and/or lower educated people around us. They have a limited ability to gain access to such health science information. This situation will result in the weak becoming weaker. This is an exacerbation of inequality." (N-F-9)

Authoritative public health service institutions and various public hospitals are the main suppliers of digital health science popularization and rely excessively on traditional methods when disseminating information, which greatly reduces the communication interactivity between them and the public. This restricts the amount of relevant information dissemination and reduces the audience size. Moreover, many professionals remain accustomed to traditional teaching and lecturing modalities and use a great amount of professional jargon. This results in the presentation of many health science popularization works that are "not lively enough." Such digital health science popularization has difficultly in attracting a greater audience.

"If it is too professional, the audiences won't like to learn. But some professional terms are just like that. We don't have that much time to be like professional anchors, right? So, though some of the health science information is very good, the audiences do not necessarily like it. That's it." (D-M-4)

"We are more used to giving lectures and want to make related knowledge clearer from a scientific point of view. But we may not be able to make what we are going to talk about palatable to wide audiences." (D-M-5)

3.2.3. Lack of Manpower. Many potential information providers of digital health science popularization are not motivated. Professional health science popularization providers, especially those in medical service institutions, are often very busy with their daily work and work under heavy pressure. Therefore, most of their energy is focused on disease treatment, and health science popularization is not that important. In many cases, health science popularization was even considered to be a burden. The traditional concept of "emphasizing clinical aspects rather than prevention" still has a profound impact upon practices. Thus, professionals lack the initiative to participate in the dissemination of health science popularization information. Moreover, although China had formulated health science popularization policies, the results of are not linked to performance assessments and title evaluations, due to the lack of an appropriate system. This leads to a lack of enthusiasm of the majority of professionals, especially physicians and nurses (especially young and middle-aged), who are the main suppliers of information, to participate in the work of health science popularization.

"We, the healthcare workers, are straining our nerves in treating various diseases. The task before these eyes is much more urgent than health science popularization. Besides, to be honest, most young health care workers are working on getting promoted, about which health science popularization can help them little. You can't ask them to do more 'useless' work like this. Their practical work is heavy enough." (D-M-11)

"It is an old problem that 'emphasis is placed on clinical aspects rather than prevention.' Neither health care providers, nor the public, nor even the disease control departments before the epidemic (COVID-19), have given enough attention to health science popularization." (R-F-4)

Professional digital health science popularization talent is in serious shortage. At present, the talent resources still rely on experts and professors from research institutes and graduates of relevant majors from universities. In practice, it will take a very long period for the social system to cultivate professional talents in this area. Meanwhile, it is difficult to attract more professional talent due to the characteristics of strong public interest and long return period of science popularization self-publishing media. This shortage can affect the long-term development of digital tools-based health science popularization.

"Many experts who are active now in digital health science popularization are, as far as I know, experts and professors in the institutions. They can only do some interpretations about their own profession for some special reasons. However, they are not specifically dedicated to health science popularization." (O-F-7)

3.2.4. Fragmentation. The scale effect of authoritative digital health science popularization has not been formed. In the opinion of most participants, the current health science popularization content was still mostly presented in "point pattern," which leads to fragmentation. Limited content can become a series. In other words, most of the contents come across as somewhat incoherent. This increases the difficulty of effectively integrating high-quality digital health science popularization resources.

"Hospitals still engage with hospitals; associations engage with associations; and the government engages with the government. Often, we all do our own thing and have our own petty ideas. As for whether there is a waste of resources, or duplication of infrastructure, individuals do not care." (R-F-1)

Science popularization in most platforms remains too fragmented. This increases not only the difficulty of using existing digital technology to realize integration but also the difficulty for the public to screen out authoritative scientific health science information from the mass of information with which they are bombarded. Though digital tools-based health science popularization platforms can help to enhance interactivity between the public and the information providers, interactivity is still lacking. This results in fragmentation and limits the use of these platforms. Meanwhile, the depth and breadth of relevant health science popularization is insufficient and inconsistent, which results in difficulty in integration. This reduces the popularization of generating integrated health science information.

"There is still a long way to go before a scale effect is formed. After all, such an atmosphere is currently lacking. Neither the policy nor the system has created the right environment for the formation of a scale effect of epidemic prevention science." (R-M-6)

4. Discussion

Health science popularization has benefited greatly from digital technology. This is due to the convenience, swiftness, friendliness, and the links that are provided, and, therefore, digital health science popularization can perform well in the dissemination of health knowledge. However, current digital health science popularization in China also exposed obvious deficiencies, including low authenticity, limited audiences, the lack of manpower, and fragmentation of the information. To overcome these deficiencies, a greater amount of attention should be paid to emphasizing public welfare, promoting the dissemination of information with professionalism and authority, cultivating talent, and developing institutional infrastructure. These are important to improve the quality and effectiveness of digital health science popularization.

As our results reveal, digital health science popularization plays an important role in the construction of the public's health understanding and behavior in China, which is considered to be important for the Healthy China Strategy [1]. It promotes the rapid development of health science popularization because of its advantages of convenience, swiftness, friendliness, and links. This not only makes the public's ability to receive this knowledge more convenient, swifter, and friendlier but also has the same effect on suppliers to provide the public with the information that they need. Furthermore, links are created within the information, as well as between the public and providers. These advantages have led to the widespread popularity and development of digital health science popularization.

However, the exposed problems also limit the high-quality development of health science popularization, requiring measures to mitigate the deficiencies. Digital health science popularization should emphasize public welfare. The foremost factor to be considered is to maintain public interest and the manifestation of social responsibility [43, 44]. As the results revealed, many current health science popularization platforms were easily motivated by profits, without any regard for public welfare. This is extremely harmful for these platforms to uphold impartial scientific attitude [45]. Therefore, a great deal of distorted and even false health science information may emerge and rapidly spread. The impartiality, authenticity, and objectivity of digital science popularization are reduced as a result [46]. Thus, avoiding being swayed by perverse interests is essential to maintain public interest. Digital health science popularization should always adhere to the attitudes of science and truth. Providing the public with timely, scientific, and standardized health science popularization information should be the focus, and providers should be encouraged to adhere to their social responsibility to disseminate accurate health knowledge.

Though digital health science popularization is convenient, swift, friendly, and socially linked, there remains a great deal of work to be done to promote the professional dissemination thereof. Health science popularization is a synthesis of science, rigor, and professionalism [13, 47]. It requires providers to adopt correct views based on a scientific world view and use proper methods to disseminate the knowledge to the public in a timely manner [48]. As our results reveal, the public are generally not professionally trained. Health science information that is too professional, or full of jargon, or less interesting, is less acceptable, which challenges the professionalism of the providers. Thus, we should be focus on promoting the dissemination of information with professionalism, with an understanding of the public's real needs, and providers should advocate the use of simple, easy-to-understand words.

Health science popularization should be interesting and popular. That is to say, digital health science popularization facing the public needs to reflect vivid and interesting content by rigorous, professional, qualified, and responsible providers [49]. This should be the professional connotation of digital health science popularization in the new era.

The authority of digital health science popularization requires further promotion. As found, the effective dissemination of health science popularization relies upon the authoritative providers [24, 50]. Such authority is associated with authenticity and the scientific nature of the information by the public [3]. The influence of the information is promoted in various ways and includes an association with authoritative people or institutions in health fields, such as government health committees, centers for disease control, health education centers, other institutions at all levels, hospitals, and other providers. Thus, the authority of digital platforms can also be developed by strengthening the immediate synergy between the government, scientific community, official mainstream media, online media, self-publishing platforms, and content producers of each subject [24]. It remains helpful to make full use of the open, instant participation and extensive interaction of the Internet to form an authoritative mechanism for collaborative and combined health science popularization and to form an efficient supply of information to the public.

To build on it advantages of convenience, swiftness, friendliness, and social links, more attention should be paid to cultivating cross-border talent with both digital communication and health science popularization [51]. On the one hand, effort should be put into enhancing the familiarity of health science popularization talent with digital communication technology, so that the health science products can adapt to the digital communication requirements, especially those of timeliness, better. On the other hand, the sensitivity of the providers to scientific issues of health science news should be strengthened, as should their ability to disseminate popular knowledge in an in-depth and simple manner. Digital health science popularization providers need to be capable of secondary coding and decoding of professional health science knowledge in order to transform it into comprehensible information [52]. Only in this way can the public avoid being misled by information of varying quality [20]. Thus,

focusing on improving the production quality of digital tools-based health science popularization works by cultivating the cross-border talent with both digital communication and health science popularization is needed.

Additionally, institutions reviewing health science popularization content, managing its dissemination, and supervising digital platforms will guarantee the healthy development of digital health science popularization [48, 51]. Thus, a set of management standards to review health science popularization dissemination providers and the standardization of related productions needs to be formulated, to regulate and guide the production and dissemination of information. Incentive policies should be improved to stimulate the enthusiasm of various providers, especially doctors and nurses, in China. The social responsibility and assessment mechanisms for each region and department to fulfill their health science popularization also need to be enhanced. Institutional infrastructure is necessary to ensure that various providers pay enough attention to scientific propaganda [53]. Government should also formulate and introduce industry guidelines for science popularization self-publishing as soon as possible, to regulate the creation and dissemination of information.

As found, some existing works on digital health science popularization have also discussed relevant content from different levels [3, 13, 43, 44, 47, 48, 51]. However, there is still a lack of studies that are designed to search for strategies by analyzing its advantages and deficiencies. This study tries to overcome these limitations. It is a study that focused on reflecting the advantages and deficiencies of current digital health science popularization based on a qualitative study. According to these experience results from China, strategies are recommended to enhance the advantages and make up for the deficiencies. By this way, the results of this study are hoped to target on promoting digital health science popularization in China more.

Although this study has some strengths, it also has several limitations. First, the snowball sampling list was derived from the participants. Sample size and sample heterogeneity may be limited. As a result, the representativeness of the conclusions might be affected. Second, limited by the inherent inadequacies of qualitative research methods, possible bias could have led to inappropriate conclusions if the participants tried to emphasize some too subjective opinions or if they focused on their own interests. Finally, to identify the advantages and deficiencies of digital health science popularization, a study conducted from both the experts and public's perspectives is needed. However, the present study was designed to examine the problem only from the perspective of the experts. Thus, additional studies with an expanded sample size, and/or conducted by some objective methodologies, and/or considering the perspective of the public, are needed. However, these limitations do not impact the insights generated by the study with regard to clarifying the advantages and deficiencies of digital health science popularization.

5. Conclusion

We found that digital health science popularization has the advantages of convenience, swiftness, friendliness, and social links. However, obvious deficiencies were exposed as well, including low authenticity, limited audiences, a lack of manpower, and fragmentation. To overcome these deficiencies, we suggest that current digital health science popularization emphasizes public welfare, promoting the dissemination of information with professionalism and authority, cultivating cross-border talents, and developing institutional infrastructure.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Additional Points

Highlights. (1) Digital health science popularization was examined regarding both advantages and deficiencies. (2) Low authenticity, limited audiences, a lack of manpower, and fragmentation were revealed as its main deficiencies. (3) Emphasizing public welfare, promoting the dissemination of information with professionalism and authority, cultivating cross-border talent, and developing institutional infrastructure are considered as important measures to overcoming its deficiencies. (4) Overcoming the deficiencies is important for the high-quality development of digital health science popularization.

Ethical Approval

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Consent

Informed consent was obtained from all participants included in the study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Each author has made an important scientific contribution to the study and is thoroughly familiar with the primary data. All authors listed have read the complete manuscript and have approved the submission of the paper. YR and DW contributed to conception and design of the study and performed the statistical analysis. YR organized the database and wrote the first draft of the manuscript. YR, DW, and YW

wrote sections of the manuscript. All authors contributed to manuscript revision.

Acknowledgments

The authors wish to thank all participants of this study for their selfless participation and dedication. We also thank the following fundings, Jiangsu University Philosophy and Social Science Research, 2023 (Project No.: 2023SJYB1385); Humanities and Social Science Research Project of Soochow University, 2022 (Project No.: 22XM0014); Youth Interdisciplinary Research Project in Humanities and Social Sciences of Soochow University, 2022 (Project No.: NH33714622); and the National First-class Undergraduate Administration Major Construction Point of Soochow University, Soochow University young teacher training and incentive program, 2022 (Project No.: 5031500722)

References

[1] L. Tang, "Study on coupling coordination degree between regional sports industry development and healthy China construction," *Journal of Healthcare Engineering*, vol. 2022, Article ID 7785267, 5 pages, 2022.

[2] Q. Zhuang, Y. Peng, J. Zhou, and P. Coyte, "Research on the child healthcare system in China from the perspective of equal health benefits: Beijing as the case study," *Child: Care, Health and Development*, vol. 48, no. 4, pp. 513–520, 2022.

[3] L. Xu, B. Huang, and G. Wu, "Mapping science communication scholarship in China: content analysis on breadth, depth and agenda of published research," *Public Understanding of Science*, vol. 24, no. 8, pp. 897–912, 2015.

[4] F. Liu and X. Zhang, "Who are volunteers in urban China?" *Voluntas: International Journal of Voluntary and Nonprofit Organizations*, vol. 32, no. 6, pp. 1359–1374, 2020.

[5] Y. Geng, Y. Yan, and Y. Yan, "Higher education and science popularization: can they achieve coordinated growth?" *PLoS One*, vol. 16, no. 9, Article ID e0256612, 2021.

[6] D. He, Y. Pan, Z. Ma, and J. Wang, "Sustainable growth in China's communications field: trend analysis of impact of China's academic publications," *China Communications*, vol. 10, no. 3, pp. 157–163, 2013.

[7] Y. Ruan, J. Luo, and H. Lin, "Why do patients seek diagnose dis-accordance with hierarchical medical system related policies in tertiary hospitals? A qualitative study in Shanghai from the perspective of physicians," *Frontiers in Public Health*, vol. 10, Article ID 841196, 2022.

[8] J. Qiu, "Science communication in China: a critical component of the global science powerhouse," *National Science Review*, vol. 7, no. 4, pp. 824–829, 2020.

[9] V. Schall, "Science education and popularization of science in the biomedical area: its role for the future of science and of society," *Memorias Do Instituto Oswaldo Cruz*, vol. 95, no. 1, pp. 71–77, 2000.

[10] A. Scalari, "From popularization to participation communicating science in the knowledge society," *Recenti Progressi in Medicina*, vol. 108, no. 1, pp. 14–17, 2017.

[11] C. Li, X. Xu, G. Zhou et al., "Implementation of national health informatization in China: survey about the status quo," *JMIR Med Inform*, vol. 7, no. 1, Article ID e12238, 2019.

[12] Z. Xiong, L. Zhang, Z. Li, W. Xu, Y. Zhang, and T. Ye, "Frequency of online health information seeking and types of information sought among the general Chinese population: cross-sectional study," *Journal of Medical Internet Research*, vol. 23, no. 12, Article ID e30855, 2021.

[13] L. Lu, J. Zhang, Y. Xie et al., "Wearable health devices in health care: narrative systematic review," *JMIR Mhealth Uhealth*, vol. 8, no. 11, Article ID e18907, 2020.

[14] W. Xi and M. Tan, "Effects of science popularization of first aid knowledge and skills using new media among community residents," *International Journal of Clinical and Experimental Medicine*, vol. 12, no. 5, pp. 5269–5278, 2019.

[15] X. Zhang, W. Dong, X. Jiang, S. Shi, and T. Chi, "Digital earth in support of an online oceanic educational public service and popularization," *Acta Oceanologica Sinica*, vol. 32, no. 5, pp. 82–86, 2013.

[16] X. Li, T. Duan, Y. Lai et al., "Status of medication literacy and its related factors among undergraduate students in Shanxi Province, China: a cross-sectional study," *Journal of Clinical Pharmacy and Therapeutics*, vol. 47, no. 8, pp. 1201–1211, 2022.

[17] J. Luo, R. Cheng, L. Lei, L. Cheng, Y. Yang, and T. Hu, "Science popularization education regarding oral health-general health for nonmedical undergraduates applying a SPOC teaching model," *Disease Markers*, vol. 2022, Article ID 3439509, 9 pages, 2022.

[18] E. Deccache-Maia, G. M. Pires-Santos, A. M. S. Fontes, and T. Fernandes, "Science popularization for preventing endemic diseases," *Revista da Sociedade Brasileira de Medicina Tropical*, vol. 43, pp. 13–23, 2010.

[19] X. Wang, X. Zhu, J. Lin, and J. Ye, "Application of virtual reality technology in adolescent mental health science education," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 8783355, 11 pages, 2022.

[20] Y. Zhao, X. Yu, Y. Xiao, Z. Cai, X. Luo, and F. Zhang, "Netizens' food safety knowledge, attitude, behaviors, and demand for science popularization by WeMedia," *International Journal of Environmental Research and Public Health*, vol. 17, no. 3, p. 730, 2020.

[21] S. Pant, A. Deshmukh, K. Murugiah, G. Kumar, R. Sachdeva, and J. L. Mehta, "Assessing the credibility of the "YouTube approach" to health information on acute myocardial infarction," *Clinical Cardiology*, vol. 35, no. 5, pp. 281–285, 2012.

[22] I. H. Campbell and I. Rudan, "Effective approaches to public engagement with global health topics," *Journal of Global Health*, vol. 10, no. 1, Article ID 01040901, 2020.

[23] J. Ye, "Health information system's responses to COVID-19 pandemic in China: a national cross-sectional study," *Applied Clinical Informatics*, vol. 12, no. 02, pp. 399–406, 2021.

[24] J. Fan, X. Wang, S. Du, A. Mao, H. Du, and W. Qiu, "Discussion of the trust in vaccination against COVID-19," *Vaccines*, vol. 10, no. 8, p. 1214, 2022.

[25] X. Sun, W. Yan, H. Zhou et al., "Internet use and need for digital health technology among the elderly: a cross-sectional survey in China," *BMC Public Health*, vol. 20, no. 1, p. 1386, 2020.

[26] H. Jia, "More engagement but less participation: China's alternative approach to public communication of science and technology," *Public Understanding of Science*, vol. 31, no. 3, pp. 331–339, 2022.

[27] H. Jia and L. Liu, "Unbalanced progress: the hard road from science popularisation to public engagement with science in China," *Public Understanding of Science*, vol. 23, no. 1, pp. 32–37, 2014.

[28] L. Scharrer, V. Pape, and M. Stadtler, "Watch Out: Fake! How Warning Labels Affect Laypeople's Evaluation of Simplified

Scientific Misinformation," *Discourse Processes*, vol. 59, no. 8, 2022.

[29] C. Gonzalo, "Challenges and perspectives in the biomedical information ecosystem," *Profesional De La Informacion*, vol. 28, no. 2, 2019.

[30] M. Bondi and S. Cacchiani, "Knowledge communication and knowledge dissemination in a digital world," *Journal of Pragmatics*, vol. 186, pp. 117–123, 2021.

[31] N. G. Choi and D. M. Dinitto, "The digital divide among low-income homebound older adults: internet use patterns, eHealth literacy, and attitudes toward computer/Internet use," *Journal of Medical Internet Research*, vol. 15, no. 5, p. e93, 2013.

[32] L. Pengpeng, Z. Fangqi, and Z. Qianru, "Communication mechanisms and implications of the COVID-19 risk event in Chinese online communities," *Frontiers in Public Health*, vol. 10, Article ID 809144, 2022.

[33] J. Wang, Y. Zhou, W. Zhang, R. Evans, and C. Zhu, "Concerns expressed by Chinese social media users during the COVID-19 pandemic: content analysis of sina Weibo microblogging data," *Journal of Medical Internet Research*, vol. 22, no. 11, Article ID e22152, 2020.

[34] A. Strauss and J. Corbin, *Basics of Qualitative Research: Grounded Theory Procedures and Technique*, Sage, Newbury Park, CA, USA, 2001.

[35] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, 2006.

[36] K. Charmaz and N. K. Denzin, *Grounded Theory: Objectivist and Constructivist Methods*, Y. S. Lincoln, Ed., Sage, Thousand Oaks, CA, USA, 2003.

[37] N. M. Deterding and M. C. Waters, "Flexible coding of in-depth interviews: a twenty-first-century approach," *Sociological Methods & Research*, vol. 50, no. 2, pp. 708–739, 2018.

[38] M. Kendall, F. Harris, K. Boyd et al., "Key challenges and ways forward in researching the good death qualitative in depth interview and focus group study," *BMJ*, vol. 334, no. 7592, p. 521, 2007.

[39] A. Jamison, S. C. Quinn, and V. S. Freimuth, ""You don't trust a government vaccine": narratives of institutional trust and influenza vaccination among African American and white adults," *Social Science & Medicine*, vol. 221, pp. 87–94, 2019.

[40] K. Sahoo, K. R. S. Hulland, B. A. Caruso et al., "Sanitation-related psychosocial stress: a grounded theory study of women across the life-course in Odisha, India," *Social Science & Medicine*, vol. 139, pp. 80–89, 2015.

[41] A. Moser and I. Korstjens, "Series: practical guidance to qualitative research. Part 3: sampling, data collection and analysis," *The European Journal of General Practice*, vol. 24, no. 1, pp. 9–18, 2018.

[42] W. Davis Hicks, E. Schmeidler, C. Kirchner, and C. Kirchner, "Investigating question meaning and context through in-depth interviews," *Quality and Quantity*, vol. 38, no. 4, pp. 367–379, 2004.

[43] L. Heim, "Identifying and addressing potential conflict of interest: a professional medical organization's code of ethics," *The Annals of Family Medicine*, vol. 8, no. 4, pp. 359–361, 2010.

[44] S. Szreter and M. Woolcock, "Health by association? Social capital, social theory, and the political economy of public health," *International Journal of Epidemiology*, vol. 33, no. 4, pp. 650–667, 2004.

[45] A. Dudo and J. C. Besley, "Scientists' prioritization of communication objectives for public engagement," *PLoS One*, vol. 11, no. 2, Article ID e0148867, 2016.

[46] J. Zhang, T. Zhao, and P. Zhu, "Analysis method of motion information driven by medical big data," *IEEE Access*, vol. 7, pp. 174189–174199, 2019.

[47] M. Sokół, ""Have you wondered why sportspeople die?" The medical weblog as a popularisation tool," *Discourse, Context & Media*, vol. 25, pp. 13–24, 2018.

[48] D. Grynszpan and T. C. Araújo-Jorge, "Education for science and science for education: more than a play upon words," *Memorias Do Instituto Oswaldo Cruz*, vol. 95, no. 1, pp. 49–52, 2000.

[49] M. Alcibar, "Information visualisation as a resource for popularising the technical-biomedical aspects of the last Ebola virus epidemic: the case of the Spanish reference press," *Public Understanding of Science*, vol. 27, no. 3, pp. 365–381, 2018.

[50] E. Szu, J. Osborne, and A. D. Patterson, "Factual accuracy and the cultural context of science in popular media: perspectives of media makers, middle school students, and university students on an entertainment television program," *Public Understanding of Science*, vol. 26, no. 5, pp. 596–611, 2017.

[51] X. Liu and H. Wang, "Research on the training Strategy of aerobic physical education talents under the background of artificial intelligence era," *Applied Bionics and Biomechanics*, vol. 2022, Article ID 1102760, 7 pages, 2022.

[52] J. Shen, L. Xu, J. Wang, and M. Zong, "Investigation and analysis of public's demands on health science popularization: a cross-sectional study," *Asian Journal of Surgery*, vol. 45, no. 10, pp. 1900-1901, 2022.

[53] A. Szabo and R. Ruotsalainen, "In the boardroom: how do cognitive frames shape American and Dutch hospitals' responses to the pressure of adopting governance best practices?" *Journal of Management Inquiry*, vol. 310, 2022.