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Digital interventions for chronic disease management and prevention in rural South Korea

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Abstract

Motivated by the prevalence of an aging population and the associated increase in medical expenditure for chronic diseases, the Korean government has initiated a pilot project in Pyeongchang-gun, Gangwon-do, a rural area, to implement a “Smart online-to-offline (O2O) digital healthcare model for the management and prevention of chronic diseases”. However, there is limited knowledge regarding the perspective and level of preparedness for digital health among stakeholders at all levels. In-depth focus group interviews were conducted with both elderly and non-elderly community residents and healthcare providers and staff members at Pyeongchang Health and Medical Center.

The study findings indicate the presence of both positive and negative perceptions and a lack of preparedness across different levels. These include low levels of health and digital literacy, compounded by a limited amount of social support at the end-user level. Additionally, healthcare providers exhibit low acceptance of the digital health program. There is a need for more human resources and capacity among health staff members at the area level. It is recommended that a customized design be used for the online and offline service components of the digital health program, considering factors such as age group, occupation, and household type that may contribute to disparities in health, digital, and digital health literacy. Also, we recommend providers establish a platform for sharing their experiences in effectively incorporating digital health into their practices and developing appropriate payment systems. Finally, there is a pressing need to enhance the volume and capacity of healthcare personnel at the regional level.

Background

While advances in digital technology and the use of smartphones have transformed how and what health services can be accessed, the effectiveness of these interventions in improving population health depends on perception of, confidence in, and preparedness for digital health among users, providers, and the healthcare system.[1] Preparedness for digital health can be conceptualized as having the necessary skills and experience to support digital-based care using digital tools.[2] For example, at the individual level, these include the digital health literacy of the user and their belief or perception of the value of digital health interventions in improving their own health. At the healthcare provider level, this is the provider's belief in the effectiveness of digital health interventions in improving the health of their patients, and acceptability of the technologies into their practice. Finally, the system level requires the ability to manage the information collected from digital platforms and link the data to actionable steps. All these factors determine the effectiveness of digital health interventions.

Chronic diseases represent a large and growing burden on the healthcare system in South Korea. The most recent four-year estimates reveal that over 79% of deaths in Korea can be attributed to chronic diseases (79.3%, 79.3%, 80.2%, and 79.6% in 2018, 2019, 2020, and 2021, respectively).[3] The share of the total health care cost for chronic diseases reached 85.0% in 2020.[3,4]

Meanwhile, with up to 95% of the population owning a smartphone, South Korea tops the list of countries with the highest ownership rates. Information and communication technology (ICT) is also highly advanced in Korea. Accordingly, the Korean government has recognized mobile applications as key platforms for effective disease management and is keen to expand the use of mobile applications in healthcare, especially for chronic disease management. As part of this effort, the Korean government launched a program named “Smart Online-to-Offline (O2O) digital healthcare model” for chronic disease management and prevention in Pyeongchang-gun (equivalent to a district), Gangwon-do (equivalent to a province), a rural region with a predominantly elderly population and limited access to healthcare services. The term “Smart online-to-offline” was coined to align with the content of program, as the program utilizes both on-line and off-line applications. It offers comprehensive offline personalized services, encompassing doctors and nurses through bi-directional communication via mobile app platforms and in-person consultations to foster a continuum of care. The “smart” in the program title holds a double meaning, indicating both that the program will use IT and will “smartly” integrate online and offline services.

The ultimate goal of the smart O2O digital healthcare model is to empower chronic disease patients (or individuals at pre-disease phases) to proactively gain awareness of

their own health statuses; to manage them by self-monitoring and recording daily health metrics, such as measurements of biomarkers (blood pressure, blood glucose) and health-related lifestyle factors (diet, exercise, etc.), using mobile applications; and, to achieve a continuum of care for chronic disease by collaborating with providers to use the gathered data to manage patients with chronic conditions. The program was launched as a pilot, targeting primary healthcare in its first phase. Pyeongchang Health and Medical center, equivalent to a district hospital, will function as a data management and care coordination center, offering a range of online and offline multi-disciplinary services, including those provided by nurses, nutritionists, and exercise coaches, in conjunction with clinical services provided by both public and private doctors.

Rural areas in South Korea accounted for more than two-thirds of the country's total land mass (86,793 km^2 out of 99,269 km^2)[5] but comprise only one-tenth of the country's total population (4.28 million out of total 51.6 million)[6] as of 2015. This combination results in low population density and limited access to health care services. Furthermore, rural areas are predominantly populated by the elderly, leading to a high prevalence of chronic diseases. These circumstances make rural areas a pertinent context with the greatest need for a digital technology-based chronic disease management program. However, the level of preparedness in rural settings for the adoption of digital health interventions remains poorly understood.

Despite Korea having a high average penetration of mobile phones, the perception and preparedness to adopt the digital technologies in healthcare is uneven and context-dependent. For instance, digital literacy, health literacy, and digital health literacy (e-health literacy), which refers to an individual's ability to access, understand, evaluate, and use health information to make decisions related to health care in daily life from digital interventions and tools,[7,8] are prerequisites for achieving positive health outcomes in the digital interventions. However, these vary by age group, place of residence, and socioeconomic status.[8-10] Previous studies suggested that societal improvements in health literacy requires a comprehensive approach in all areas and at all levels,[11] and this is likely the case for digital health literacy as well. Therefore, it is crucial to have a comprehensive and deep understanding of gaps in perception and preparedness for digital health interventions, especially for digital interventions for chronic disease management, and stakeholders' perception at multiple levels and the challenges and opportunities to fill in these gaps.

In light of this, qualitative research was performed with three aims: 1) to examine the perception of the "smart online-to-offline (O2O) digital healthcare model" interventions for chronic disease management and prevention and assess preparedness for its implementation at various levels, including end user-, provider-, and area-levels; 2) to

identify the obstacles and potential avenues for addressing identified gaps in preparedness; and, 3) to suggest key considerations for designing the digital intervention to effectively overcome these challenges.

Analytic framework

Inspired by earlier works on digital health interventions, we developed an analytical framework (Figure 1). This framework considers three key dimensions: the end-user (current and potential chronic disease patients) level, the healthcare provider (doctors) level, and the area (Pyeongchang-gun) level.

At the end-user level, health literacy and digital literacy have emerged as critical factors influencing the effectiveness of digital health interventions.[12] *Health literacy* involves the capacity to access, comprehend, evaluate and apply health-related information for making informed decisions concerning their daily health matters, including disease prevention or management.[7,8] *Digital literacy* refers to the ability to access, analyze, and exchange information through ICT, requiring both technical as well as cognitive skills.[12,13] *Digital health literacy*, often seen as the convergence of digital literacy and health literacy, is a prerequisite to interpreting and utilizing digital health information. However, certain competencies of digital health literacy may not be covered by neither digital literacy nor health literacy.[8,9,14]

Additionally, the users' perception of and confidence in digital technologies can influence their compliance, thereby contributing to the success of the program. Individual social capital, which refers to cognitive and structural elements related to social relationships, is anticipated to play a positive role in expanding digital access by improving health literacy, digital literacy, and digital health literacy, and also by influencing perceptions and confidence in digital health.[1,15]

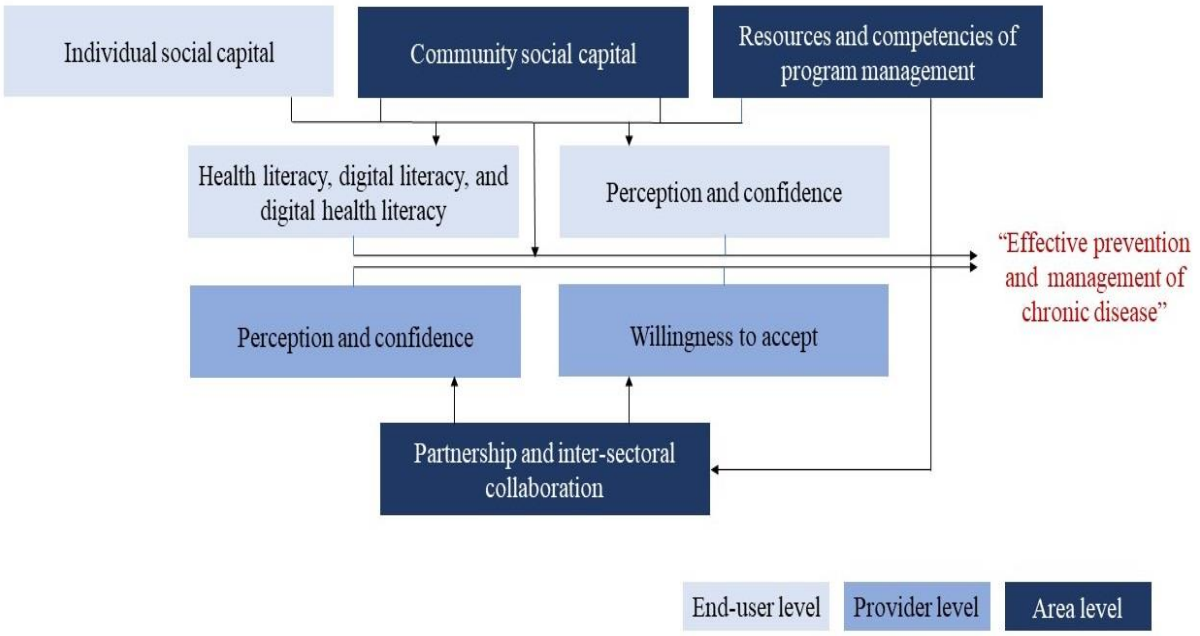
At the provider level, doctors' perceptions of and confidence in the utility of digital health, as well as their willingness to incorporate it into their routine clinical settings, are crucial factors determining the efficacy of the program. While it is acknowledged that both provider organizations and individual providers may wield influence in digital healthcare, we included the individual provider level in our framework because the current "Smart O2O digital healthcare model" focuses on primary care, and primary care in Korea is characterized by predominantly independent practices.

Finally, area-level factors, where the "area" pertains to Pyeongchang-gun or smaller community units, refer to distinctive characteristics of an area that might have an influence on the efficacy of digital interventions. These factors include the formation of "bonding" and "bridging" social capital between neighbors, the human and financial

resources of the Pyeongchang Health and Medical Center, which functions as a center for care coordination, and their ability to manage the entire program. “Bonding” social capital refers to tightly-knit communities characterized by shared similarities, whereas “bridging” social capital refers to connections formed within communities between individuals of diverse backgrounds.[16]

In South Korea, the health care delivery system is dominated by the private sector, and public and private services are delivered in parallel and in distinct silos, resulting in a lack of collaboration. However, since the program involves a multi-disciplinary care team comprised of both public and private sector healthcare professionals, including doctors and nurses, partnership and inter-sectoral collaboration among them in Pyeongchang-gun would affect the program's effectiveness, both directly and indirectly, by influencing the healthcare providers’ perception, confidence, and willingness to accept digital health.

Figure 1. Analytic framework



Methods

Study setting and data collection

The study was conducted in Pyeongchang-gun, located in Gangwon-do, South Korea. Encompassing an area of 1,464km^2, it is inhabited by a population of 40,722, among whom 32.5% are aged 65 years or older, as reported in the year 2022.[17] Pyeongchang-gun is one of the areas with severely limited healthcare accessibility due to a shortage of medical facilities and healthcare practitioners. The doctor-to-resident ratio stands at 1.6 doctors per 1,000 residents, which is notably lower than the corresponding ratio in Seoul (4.8 doctors per 1,000 residents) and falls below the average ratio of 2.6 within Gangwon-do, as indicated by Statistics Korea.[18]

The interview sample was collected using purposive sampling strategy and composed of four groups, each assumed to offer a distinctive and significant perspective on our research questions: 1) elderly community members aged 65 years or older residing in Pyeongchang-gun, both with and without chronic conditions, 2) non-elderly community members (younger than 65 years), 3) health care providers, including doctors practicing in private and public primary care and nurses employed at Pyeongchang Health and Medical Center, and 4) healthcare staff members at Pyeongchang Health and Medical Center who have previously or are currently involved in managing digital-based health programs. All digital health programs are administered via Pyeongchang Health and Medical Center. Since the authors did not have direct access to information about potential interviewees, we asked the health staff in Pyeongchang Health and Medical center to recruit interview subjects. We intentionally balanced gender representation and prior exposure to other digital health intervention programs when selecting the community member interviewees.

Four rounds of in-person In-depth Focus Group Interviews (FGIs) and one round of online FGIs were conducted with the aforementioned four participant groups between mid-April and early May, 2023, by four authors (HYL, MJ, MK, JC and HL) using a semi-structured questionnaire (Appendix file). The in-person interviews lasted for approximately two hours while online interview sessions lasted for one hour. We obtained signed informed consent from all participants, which provided full information about the study, including the explicit mention of audio recording, and promises of confidentiality and anonymity.

Data analysis

All interviews were tape-recorded and transcribed verbatim by one researcher (MJ). Participants were de-identified and numbered in the transcripts. A thematic analysis was conducted. To maximize the robustness of the analysis, three authors (HYL, MJ, MK) who conducted interviews independently read randomly-allocated batches of interview transcripts and coded line-by-line using grounded theory methodology until thematic saturation was achieved and consensus was reached among the authors regarding the identified themes.[19] Utilizing the constant comparative method through multiple stages, we inferred perceptions and preparedness, and identified challenges and opportunities associated with digital-based interventions for chronic disease management and prevention. In the beginning, analysts code each word and sentence into as many categories as possible, comparing themselves within and between categories. Following this, categories and properties are combined to form a theory.[20]

Results

Characteristics of participants

Table 1 shows the interviewees' characteristics. The community member interviewees were selected using an age-stratified sample, with eight participants aged 65 or older and eight participants younger than 65. From the department of health promotion and community health at Pyeongchang Health and Medical Center, potential program administrators of the "Smart Online-to-Offline (O2O) digital healthcare program" were sampled. The eight health care provider interviewees included six who previously had worked or were currently working at a health facility or health post as part of their compulsory military service, and two that were working in private clinics.

Table 1. Summary of interviewee characteristics.

Variables	Categories	N	(%)	N	(%)
		>65yrs		≤65yrs	
Community member					
Sex	Female	4	(50%)	4	(50%)
	Male	4	(50%)	4	(50%)
Job	Office/management/professional	0	(0%)	6	(75%)
	Manufacturing/technician/labor	0	(0%)	2	(25%)
	Agriculture/Forestry/Livestock/Fishing	4	(50%)	0	(0%)
	Non-employed	3	(37.5%)	0	(0%)
	Others	1	(12.5%)	0	(0%)
Education	≤ Primary school graduate	2	(25%)	0	(0%)

Variables	Categories		N	(%)	N	(%)
			>65yrs		≤65yrs	
	≤ High school graduate		3	(37.5%)	5	(62.5%)
	≤University graduate		3	(37.5%)	2	(25%)
	>University graduate		0	(0%)	1	(12.5%)
Chronic disease that lasted >3 mon	No		1	(12.5%)	6	(75%)
	Only hypertension		2	(25%)	0	(0%)
	Hypertension and DM[†]		2	(25%)	2	(25%)
	Hypertension, DM, and Hyperlipidemia		3	(37.5%)	0	(0%)
Previous participation in digital health program	No		4	(50%)	4	(50%)
	Yes		4	(50%)	4	(50%)
Providers			N		(%)	
Age (yrs.)	≤30		5		(50%)	
	31-40		0		(0%)	
	41-50		5		(50%)	
Sex	Female		3		(30%)	
	Male		7		(70%)	
Qualification	Nurse[‡]		3		(30%)	
	Physician	private clinic	2		(20%)	
		public health center	5		(50%)	
Health staff members [‡]			N		(%)	
Age (yrs.)	≤30		1		(12.5%)	
	31-40		3		(37.5%)	
	41-50		2		(25%)	
	>50		2		(25%)	
Sex	Female		6		(25%)	
	Male		2		(75%)	
Position	Team leader		2		(25%)	
	Officer		6		(75%)	

[†] DM: Diabetes Mellitus, [‡]All were from Pyeongchang Health and Medical Center

End user-level findings

Health literacy, digital literacy, and digital health literacy

The primary goal of digital interventions for chronic disease is to enhance patients' (or potential patients') self-management in their daily lives by encouraging them to engage in self-measurement of vital health indicators (such as blood sugar level or blood

pressure) and inputting this data into a designated application. This also allows healthcare providers to continuously monitor their patients' condition between office visits. However, most community-member participants, elderly or not, were not well-informed about chronic disease management. For example, many had the misconception that daily measurement of blood pressure or blood sugar were unnecessary, believing that periodic measurement, such as at office visits or once a month, was sufficient.

> *"It's challenging to find the right time for checking blood sugar because it should only be done before meals. So I don't measure it every day. It seems fine to me. I am not a very high-risk person." (A7)*

One participant who had prior experience with digital health programs said he had stopped measuring at one point because he believed he would receive similar results as the day before. Similar patterns of behavior were also observed regarding medication adherence; some believed that postponing the administration of hypertensive medication when blood pressure readings did not indicate elevated levels was inconsequential.

> *"My doctor gives me prescription for my hypertension every three months and advise to keep taking blood pressure medicine every day. But I don't feel the need to take medicine when measured blood pressure is low. So I only took it when measured BP is high." (A4)*

In addition to a lack of health literacy, significant gaps in digital literacy were also evident. There was substantial variation among individuals regarding ownership of digital devices and proficiency in navigating the information environments enabled by these devices. As expected, age was the most significant factor in this digital divide. Each interviewee under age 65 possessed an up-to-date mobile phone and had no trouble using applications on digital devices. In contrast, more than half of the elderly interviewees lacked experience with advanced digital devices. According to interviewees, most of the elderly in Pyeongchang-gun, particularly those who work in agriculture and have a low level of education, still use outmoded 2-G or 3-G cell phones without apps. Even those who own modern smartphones rarely use apps. A small percentage of the elderly could use digital technologies, predominantly those who had previously held office jobs or resided close to their children.

> *"I don't have a smartphone. But it doesn't bother me at all." (A6)*

> *Interviewer A: "Do you use any other function than making calls or sending texts using your smartphone?" Interviewee: "No. I don't really need to use it because my job is farming" (A5)*

In the meantime, a deficiency in a distinct form of literacy, namely digital health literacy, may arise even among the health-literate and technologically-aware when particular categories of health information are disseminated via digital platforms. For instance, due to its automated functionality, the application emits a warning alarm whenever an input measurement deviates from the established normal range. Consequently, those whose values fluctuate near thresholds would frequently be subjected to warning alarms, even if their results lacked clinical significance. This situation caused participants to feel uneasy, as they were uncertain how to respond. As a result, a few individuals chose to deactivate the device to avoid further discomfort.

This also imposes an increased burden on healthcare providers, who must allocate time to respond to unnecessary inquiries.

> *"During AI-IOT program (a digital health interventions that was previously implemented in Pyeongchang-gun), we noticed that they were overly concerned when their measured blood pressure or blood sugar was high. When we contacted participants who had not reported their measures for a few days in a row, it turned out that they did not measure it because they were stressed out from the constant alarm whenever their measurement exceeded the threshold." (C3)*

We found a positive sign that health literacy improved among former participants through the "learning-by-doing" process during the previous program. For example, several interviewees noted that they identified a correlation between a specific health behavior and blood sugar or blood pressure level.

> *"I learned when my blood sugar level rises. My sugar level spikes when I eat rice cake. It also goes up when I eat out, but remains within the normal range when I eat at home." (A2)*

In addition, some interviewees stated that they acquired the ability to identify independently when a reading required medical attention, as a result of engaging in an iterative cycle of posing questions based on documented health information and learning the responses. Nevertheless, it appears to be more difficult to surmount a lack of digital literacy than a lack of health literacy. Despite education and training as a strategy to address digital illiteracy, health staff members were skeptical of its efficacy

among the elderly, particularly those with limited educational backgrounds who were engaged in agriculture. Moreover, elderly interviewees who had never participated in digital health programs and were not using any applications did not express a desire to acquire digital skills or participate in future digital health interventions.

> *"We had a long session to explain to participants how to use the app in the beginning of the program (in the prior digital health program), and also extra sessions during the program. Many participants get used to it to some extent. However, some people, particularly the elderly, still couldn't do it." (C5)*

> *"For the elderly, implementation of the program itself was a significant challenge, let alone the effectiveness of the intervention." (C3)*

Perception of digital health program

Experiences with digital health programs in the past influenced attitudes and receptivity toward these programs. Those who had previously participated in digital health programs were confident that future programs employing digital technologies, such as the "Smart O2O digital healthcare program," would benefit their health management. Notably, previous participants demonstrated a strong self-motivation to manage their health based on their health data proactively instead of relying solely on medical care. Even in recalling their most recent blood pressure and blood sugar levels, they demonstrated high accuracy.

> *"They become more interested in their health while self-monitoring their measurements. This motivates them to think 'I'm going to walk one more time today' or 'I'm going to try not to smoke, just for today'." (D5)*

> *"I input my data saved in my app to Excel file to make it easier to see at a glance." (A3)*

Several participants conveyed their personal affiliations and inclinations towards digital health programs and tools. When asked to give the device a nickname, one participant replied, "My beloved son" and another said, "It's better than my child". Nicknames such as "health helper" and "health keeper" were also suggested.

We observed that interviewees with positive experiences with previous digital health interventions had higher self-efficacy and were acting as advocates, speaking out about the benefits of the program and encouraging interviewees who were unsure of its value to try out the future program.

On the other hand, some interviewees mentioned that they felt like they were under scrutiny or surveillance with regard to their health behaviors. When asked to give the device a nickname, they responded “diabetes watchdog”. They appeared to perceive the digital tool more as a surveillant than a helper, and thus were afraid to report their measurements on the apps when they failed to properly observe health behavior.

> *“They are watching us whether we are following it or not…” (A4)*

Social capital

Both elderly and non-elderly people were selective about sharing their own health issues, or any useful information on health or health programs they are participating in, with their family members or friends.

> *“Although I sometimes talk with friends about my health issue when I meet them, most of the time, I discuss it with my wife.” (A3)*

> *“I don’t tell my son even when I’m sick because I don’t want them to worry. But, I often talk how sick I am when I meet my friends.” (A1)*

> *Interviewee: “We check (health status) each other…especially when we go out to exercise together, we talk a lot” (A2) Interviewer: “Do you mean your friends who participated in the same program by ‘we’?” Interviewee: “We talk even if they are not. Sometimes, I show it (the app) to a friend to tell how it appears when I eat something” (A4)*

It has been demonstrated that having access to social capital, such as friends and family, can be a powerful instrument for altering habits and improving health or digital literacy. However, the elderly had low social capital. Many households comprise only elderly couples or individuals living alone, without a support network to provide assistance and share information.

> *“Pyeongchang-gun, in particular Daehwa-myeon (village), is aging and there are a lot of elderly living alone. For them, even preparing their own meal on time is challenging.” (C5)*

Provider-level findings

Perception of and confidence in the digital health program

The providers did not believe that a digital intervention would significantly alter the health behaviors of digital health program participants.

> *"Most people in Pyeongchang-gun work in agriculture, which is a labor-intensive job. They are more inclined to depend on alcohol or smoking as a way to relieve their stress from work." (D4)*

Also, most providers expressed reservations regarding the reliability of self-measurement by users. They pointed out that many people are unaware of or do not adhere to proper blood pressure measurement protocols, drawing from experience with their own patients.

> *"Blood pressure should be measured before breakfast and before going to bed. But patients frequently fail to observe this. When we asked the patients whose blood pressure is high when they had their blood pressure measured at our clinic, they revealed that they smoked before coming. Similarly, blood sugar readings can vary greatly depending on the condition of the measurement stick, for example, whether it has been in a place with high humidity…I don't think patients are well aware of this." (D4)*

Providers stated that they will not be able to modify a patient's treatment plan based solely on self-measured scores, and that nurses or other health professionals must assist with measurement during an in-person visit.

Despite these concerns, there was consensus among provider interviewees that, even if they do not anticipate a dramatic effect, digital health programs would facilitate the delivery of optimal care for their patients with chronic diseases, particularly by enabling regular monitoring of the blood pressure and blood sugar levels between doctor's appointments.

> *"I think it would be absolutely helpful. Hypertension or diabetes is not a disease in itself, but complications it causes are a big problem. I think the [digital health program] intervention can reduce the frequency of blood pressure or blood sugar level soaring to the point where complications occur." (D4)*

> *"Some patients claim that their blood pressure is high only when it's taken at the doctor's office, but I have no way of verifying it. In that case, information from routine measurements taken at home might be useful." (D6)*

Acceptance

In the "Smart O2O digital healthcare program", providers are supposed to monitor the daily measurement of patients' or potential patients' biometrics and health behaviors related to chronic diseases between appointments—and to intervene, if necessary. This would add to the providers' workload. Although all providers, private or public, acknowledged the potential positive impact of the program on patients with chronic conditions and those at pre-chronic disease phase, they were unsure either of how their daily practice would be affected by the integration of digital health or how the program could be linked to their practical interests. They responded that, at this point, it is not easy to weigh in on the pros and cons of participating in the program. However, it appeared that the interviewees were more skewed to a concern about increased workload, which makes them hesitant to actively participate in the program.

> *"I don't have a clear picture at the moment of how I can manage to integrate app-based program into my daily practice. I think I have to check the information from the app whenever I have time during work but, if it doesn't work, I think I'll have to do it additionally after hours. I think I can figure out how much my workload will be only by actually doing it." (E1)*

Providers showed a willingness to participate if adequate payment was given corresponding to the additional amount of time they must spend and the workload added due to the program.

> *"Specific requirements in the digital health program can be set up for rewards, like requiring them to provide participating patients with feedback at least once a week." (E1)*

> *"I think that doctors' extra efforts put in an intervention should be assessed and be adequately rewarded." (E2)*

Area-level findings

Resources and competencies for program management

Digital health interventions introduce new tasks previously absent in the traditional healthcare model, engaging current and potential patients, physicians, and healthcare

personnel in both public and private sectors. However, the allocation of responsibilities among individuals or entities involved remains ambiguous. One home-visit nurse noted that she experienced heavy workloads during the program dealing with diverse issues, especially technical issues raised mainly by the elderly users. While the responsibility for resolving problems caused by defects in the device or software lies with the manufacturer of the devices, it remains unclear who should be responsible for addressing difficulties stemming from lack of experience in using the device. Previously, home-visit nurses were assigned the responsibility of providing care for those individuals, even though it fell outside the scope of their professional duties.

> *"The app needed to be updated frequently…several times a year. Many participants, even young participants, do not update every time because it takes almost an hour, and because they are afraid of any trouble that might occur doing it. Occasionally, users are required to give consent for the use of personal information. These procedures all…are very challenging for participants….So we had to update it for them." (D1)*

The capacity of health staff members managing programs at Pyeongchang Health and Medical center to motivate participants to actively engage in the program is also very important. Even participants who initially exhibited high motivation often lost interest and gave up midway. Financial incentives such as gift cards have been tried to motivate participants, but the approach inadvertently had the unintended consequence of relying on external rewards, rather than encouraging intrinsic motivation towards self-directed health behaviors. Health staff members involved in program management mentioned difficulties regarding this.

> *"When some participants did not show any change, despite our best efforts, we felt frustrated and thought that this program is very challenging to do. Our manager advised us that we don't need to forcefully bring them into the program. He said that it could be more effective to focus, say, 20% of our efforts on five people who are more compliant than spend 100% of our efforts on them." (C1)*

Community social capital

The level of health or digital literacy, as well as how actively they engage in the health program, seems to depend on whether or not participants can seek support from a network of friends or neighbors. This is especially true for those who are old and live alone. There was a high level of bridging social capital between healthcare providers and community members. For example, the tenure of the health center director is relatively long, which facilitates the building of trust and bonding with locals. Health staff

members in Pyeongchang Health and Medical center also remain in their positions for a longer amount of time compared to urban areas, which enables close observation of the residents to provide customized efforts for everyone.

We observed a high level of bonding social capital as well. The "health committee", a voluntary, community member-led group, engages in various health-related advocacy activities with an aim to make a healthy community. Although its activities were suspended during the COVID-19 pandemic, we observed that there was a desire among community members for a resumption of vibrant engagement.

> *"There is one committee for each community in Pyeongchang-gun. Pyeongchang Health and Medical Center manages the committees and meets them regularly. Committees send newsletters once a month about what activities were done. They take the lead and coordinate health campaigns in the communities and sometimes offer advice to the Health and Medical Center." (D1)*

> *"They [committee members] are relatively young and highly educated, so I think they can be mobilized to increase the program's effectiveness. I think they would work hard if invited, and given a specific roles inside the program." (D2)*

Partnership and inter-sectoral collaboration

The "Smart O2O digital healthcare model" emphasized the importance of collaboration between public and private healthcare providers. A notable concern was the limited experience in establishing formal partnerships between public and private healthcare providers. However, the public and private providers expressed their assurance in the feasibility of collaborating based on their experiences during the COVID-19 period. During that time, patients diagnosed with COVID-19 in private facilities were documented and subsequently transferred to the public healthcare system, where measures such as contact tracing, isolation, and assignment of a bed were arranged.

> *"We had never had a chance to communicate with private clinics. But during COVID, elderly patients with chronic disease that we were monitoring could not go to doctor to get drug prescription due to nationwide shutdown. So, we [home-visit nurses] contacted the private clinic to get a prescription and delivered it to patients' homes." (D2)*

Table 2. Current perception and preparedness for digital health interventions and suggestions to overcome gaps

	Current perception and preparedness	Suggestion for enhancing perception and preparedness
End-User level	Low health literacy, digital literacy, and digital health literacy, especially in the elderly	Adequate education before and during the program to ensure a clear understanding of their disease and the ultimate goal of the intervention. Tailored design of the online and offline program according to the age group, job and household type
	Generally favorable, but perception as a watchdog by some interviewees	Sufficient communication with users on importance of honest and faithful observance of the protocol and to make sure that the program is not for penalizing their misbehaviors.
	Low individual-level social capital	Arrangement of assistance services for users with technical difficulties, and enhancement of capacity of care coordinators to motivate them to stay on the program
Provider level	Generally, positive perception but concern regarding uncertainty surrounding changes in their practice and adequate compensation.	In the short term, creation of platforms that facilitate opportunities for providers to share their experiences and insights regarding integration of new services into their practices and to collaboratively work to navigate toward achieving the most optimal practice environment. Also, proper payment mechanism needs to be prepared. In the long-term, academic research on these subjects.
Area level	Insufficient human resources and a lack of clearly defined job description for program management	Ensuring a sufficient number of capable personnel and establishing a clear job description. Ex) development of a manual listing all potential technical and managerial errors, along with corresponding responses for reference and guidance during the program.
	Generally high level of bridging and bonding social capital	More encouraging area-level activities and promoting the exchange of experience and knowledge through them
	Limited experience of public-private partnership	Program managing team facilitating a smooth coordination between the public and private providers

Discussion

Our qualitative study synthesizes narratives from a diverse group of stakeholders: potential end-users of digital health program, including those in optimal health, in the pre-chronic disease stage, or already diagnosed with chronic diseases; healthcare providers from both public and private sectors; and public healthcare staff members from Pyeongchang Health and Medical Center that would coordinate the "Smart online-to-offline (O2O) digital healthcare model". We investigated their perceptions and preparedness to adopt the model and barriers to overcoming the gaps in preparedness. The results from our thematic analysis (summarized in Table 2) indicated the presence of a mix of favorable and unfavorable perceptions of digital health interventions and varying levels of preparedness across multiple dimensions at the individual, provider, and area levels.

We propose a few recommendations to address identified deficiencies in preparedness uncovered in our study. While well-designed measures are anticipated to mitigate certain preparedness gaps, others necessitate a broader, macro-level approach in order to be overcome.

First, we found limited general health literacy about chronic diseases among the community members. Even non-elderly individuals who are relatively well-educated lacked accurate knowledge of the nature of chronic diseases and self-management protocols. The proposed interventions do not aim to drastically reduce blood pressure or blood sugar levels to achieve full cures of chronic disease or cessation of medication usage among patients. The key to chronic disease management is to prevent the blood sugar or blood pressure level from deviating from the normal range to reduce the risk of complications. The intervention needs to be preceded by sufficient health communication and education to equip users with a clear understanding of their diseases and the ultimate goals of the intervention.

Second, as has frequently been found in earlier works conducted across diverse settings, a substantial proportion of the elderly exhibited a lack of digital literacy and a notable reluctance to acquire these skills. The gap in digital literacy matters because digital illiterates who are, mostly, marginalized, can be further marginalized as a result of digital literacy. As mentioned, rural areas in South Korea, including Pyeongchang-gun, are undergoing a population aging process, primarily attributable to the country's declining fertility and population concentration in metropolitan areas.

Although social support from family members can mitigate a lack of digital literacy, the prevalence of elderly persons living alone or in households with only elderly couples with no other support was notably high in those areas. As of 2022, 36 out of 246 districts exhibited a solitary elderly population rate exceeding 20%, all of which are exclusively rural areas.[22] This situation presents a significant paradox because rural areas, due to their limited access to

healthcare services, have the highest demand for digital health interventions. Yet they are also the most challenging places to implement them primarily due to low digital health literacy.

Given different levels of digital health literacy, different lifestyles (such as physical activity level and diet), and different levels of social support based on age group, occupation, and household type, we recommend grouping target populations based on these variables and approaching sub-groups with custom-designed programs. For example, we propose developing a modified version of the application, which is more intuitive, simplified, and easier to use, for the elderly who are currently unfamiliar with digital technology but are anticipated to be able to pick up the necessary skills through education or training sessions. Also, there is a need to enhance the intervention strategy by focusing on offline in-person visits for them. There are also technical ways to resolve the confusion caused by lack of digital health literacy. For example, for users whose biometrics are close to borderlines and, as a result, receive frequent but clinically irrelevant warning alarms, alarms could be sent at less frequent intervals, such as after properly processing the collected data during a certain amount of time in clinically meaningful ways.

Third, although it was not a dominant view, a few respondents reported feeling that they were being surveilled, rather than being supported, by the program. This perception led to the behavior of skipping reporting their measurements when they did not adhere to the advised lifestyle as they were afraid of blame. We need to ensure ongoing communication and education, before and during the program, to foster a clear understanding among participants that the program is for their own benefit, not to penalize them for misbehavior, and that only honest and faithful observance of protocol can result in practical help for their health.

Fourth, providers were hesitant to actively jump on the digital health interventions due to uncertainty surrounding what their practice would be like in the new care ecosystem, both in financial terms and in other broader aspects of the clinical environment. Few providers will enthusiastically embrace new changes in their practice if they believe it will increase their workload. From a long-term perspective, how they can integrate digital health into daily practice, what gains and losses might result, and how they can be compensated appropriately, all warrant further academic investigation. Although there is an extensive amount of research on digital health, the majority of studies focus on users, with only a few concentrating on the provider side. Even these studies have been limited to perceptions or confidence regarding digital health, which provides only part of the full picture.[23,24] In the short term, it is important to create platforms to facilitate opportunities for providers to share their experiences and insights regarding integration of new services into their practices and to collaboratively work to navigate toward achieving the most ideal practice environment.

Fifth, the aim of the digital intervention for chronic disease management is not to replace traditional offline services with online services, but to provide complementary services between

in-person doctor visits, which is expected to increase the workload for health personnel. Although digital interventions are increasingly introduced, the size and capacity of program management personnel in local health authorities has remained the same. In addition, job descriptions within the program, especially technical work, are not yet clearly established. All these are increasing the workloads of current local healthcare staff. The health system needs to be prepared to secure sufficient and capable personnel for these technology-based interventions and provide a clear statement of who does what. One way to minimize the administrative burden is to develop a manual that lists all potential technical and managerial errors and corresponding solutions, which can be referred to during the program.

Our qualitative research design allowed us to collect rich data about preparedness to adopt the model and barriers to overcoming the gaps in preparedness. A potential limitation of qualitative research arises from non-participation of those who could have contributed new perspectives to the narratives. Digital health is not generally perceived as a topic that makes interviewees reluctant to candidly express their viewpoints, however, so we avoided one common challenge of interviews on sensitive issues.

However, several limitations of our study are still acknowledged. First, our interviewee pool did not entirely encompass all relevant stakeholders. For example, the payer, the National Health Insurance Service in Korea, serves as the entity that determines suitable remuneration for healthcare providers involved in digital health services and will significantly influence the landscape of digital healthcare. However, payers were not included in the interviews; this is potentially a topic warranting further investigation. Second, the community member interviews were conducted using a sample of 16 elderly and non-elderly people from Korean rural settings. Although we attempted to include a diverse range of individuals, the results from our research alone are not sufficient to make population-level summaries. It should be noted that our study did not investigate the inclusion of interviewees from diverse socioeconomic backgrounds. However, we made a concerted effort to employ triangulation techniques in order to verify the information obtained from community members by reengaging with providers and health staff to ensure that we obtained a thorough understanding of the topic.

Conclusion

Amidst a big wave of digital technology in the healthcare area, most efforts have concentrated on developing innovative and fancy digital technologies, rather than on exploring how society members at various levels perceive and are prepared to adopt them. In the coming years, digital technologies will expand in all healthcare areas and alter the healthcare environment. Therefore, it is essential that end-users, providers, and area-level systems are well-prepared for these novel approaches to service delivery.

Our analysis found a possible role for digital health in chronic disease prevention and management in rural remote areas with low accessibility to healthcare services. On the other

hand, we confirmed that a mix of positive and negative perceptions exist and that there is a lack of preparedness at various levels, including low health and digital literacy. These challenges are reinforced by a low level of social support, low acceptance among providers, and insufficient human resources and implementation capacity at area level. We explored the potential avenues available to address these deficiencies, with implications for other rural settings with similar contexts aspiring to introduce digital health in the near future.

Ethics Approval and Informed Consent

This study was approved by the institutional review board (IRB) of Seoul National University Hospital, Seoul, South Korea (No. E-2303-122-1414)

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