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Original article

Utilization of and barriers to a telemedicine system at a rural general hospital in Japan: a mixed methods study

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Abstract

Objective: The initial and operational costs of telemedicine are major barriers to its adoption. We aimed to investigate and identify the barriers to adopting a telemedicine system in a Japanese rural general hospital without incurring setup and operational costs.
Materials and Methods: Our study was conducted between May and August 2018, and included six general practitioners working at a rural general hospital. We extracted data collected from messages (date and time, sender and recipient, and counts and contents of messages) and conducted semi-structured interviews, which were then analyzed using quantitative and qualitative methods.
Results: We quantitatively analyzed the total counted of the 179 messages. The total counts recorded for each physician were 56 (A), 20 (B), 3 (C), 74 (D), 5 (E), and 21 (F). The mean monthly counts were 2.17 (May), 8.50 (June), 11.50 (July), and 7.67 (August). Interview data from the six physicians yielded 13 codes that included various points of dissatisfaction acting as barriers to using our system, which we grouped into mental and physical barriers. Mental barriers included suspicion of carrying, feelings of isolation, and loss, whereas physical barriers included portability, user authentication, internet speed, group chat system, notice, search image, typing, chat system, print facility, and limited function.
Conclusion: The representative barriers to introducing a telemedicine system at a rural general hospital in Japan without initial and running costs could be classified as feelings of isolation and suspicion of carrying (mental barriers); and notice, portability, and user authentication (physical barriers). Continued investigation in this area is warranted, and solutions to these barriers could improve the shortage of medical staff in the context of declining birth rates and aging populations in Japan.

Key words: information and communication technology, qualitative method, remote medicine, rural medicine, telemedicine

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Introduction

Telemedicine—the actions that contribute to healthcare, medical treatment, and nursing care using telecommunication technology[1)]—has attracted worldwide attention in recent years, as evidenced by the growing market size[2)] and the increasing number of studies on the subject. In Japan, the number of older adults requiring medical and nursing care is rapidly increasing, whereas the number of workers is declining. Today, telemedicine is expected to guarantee access to, and quality of, medical care and increase the efficiency of medical staff[3)]. However, this functionality is not popular in Japan, which lags behind other countries in terms of telemedicine development[4)].

When implementing a telemedicine system in a clinical scenario in Japan, the decision makers (e.g., hospital managers) and users (e.g., medical staff) of such a system are sometimes the same people; however, they are predominantly different groups. When decision makers and users of medical devices belong to different groups, one might encounter situations in which targeted users are unwilling to utilize the devices; however, willingness is a prerequisite

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for widespread telemedicine acceptance and use. Some local and international studies on the barriers for decision makers to adopt telemedicine in clinical settings have pointed to initial and operational costs[4, 5]. The average cost of introducing a telemedicine system in Japan is 90,327 USD, and the average operating cost is 8,127 USD per year (given the 110 JPY/USD exchange rate in 2021)[6]. Other major hurdles to the introduction of telemedicine include legal developments, information security, and profitability[4, 5]. However, to the best of our knowledge, although international systematic reviews exist, Japanese studies regarding barriers preventing the adoption of telemedicine systems in clinical settings are scant[4, 7].

In this study, we designed a telemedicine system (hereafter referred to as "our system") for medical personnel (physicians, outpatient nurses, home care nurses, and discharge coordinator nurses) at a rural general hospital. Our system did not incur financial costs for the hospital because the research budget covered all costs required—from the initial to operational phases. Our study aimed to investigate the utilization of a telemedicine system for Japanese physicians and to determine the barriers to adopting a telemedicine system at no cost.

Materials and Methods

This study was approved by the Ethics Committee of Hirosaki University (approval number 2018-1020) and conformed to the provisions of the Declaration of Helsinki (as revised in Brazil, 2013). Our system is an adequately secured telemedicine system that enables physicians and nurses to use a medical chat system in and out of the hospital for doctor-to-doctor (DtoD) and doctor-to-nurse (DtoN) medical consultations (Figure 1). It was adopted at Oma Hospital, a general hospital in Aomori Prefecture in rural Japan. Before this study, Oma Hospital had no system to exchange medical photos and videos in compliance with the three ministries—the Ministry of Health, Labor and Welfare; the Ministry of Internal Affairs and Communications; and the Ministry of Economy, Trade and Industry—and four sets of Japanese guidelines[8–11]. Therefore, all consultations among medical staff were exclusively conducted using voice processes—for example, via the traditional Personal Handyphone System (PHS) in the hospital and via "private" (personal) telephones beyond hospital premises. The devices used for our system were distributed to all physicians (six general physicians in total) in the hospital, one discharge coordinator nurse, one outpatient nurse, and one nurse who visited patients at home. The study was conducted with six physicians (who were the study participants) over a period of four months (from May to August 2018). The participants were permitted to use the PHS and "private" (personal) telephones during the study period.

Our system configuration is a combination of existing systems and complies with the aforementioned three ministries and four sets of Japanese guidelines[8–11]. It primarily comprised mobile devices and software with text chat, image, and video exchange functions for the exclusive use by medical personnel. The mobile devices used with our system was an iPhone (iPhone®8 Plus, Apple Inc., Cupertino, CA, USA), and the software employed for the chat system was MediLine (MediLine®, Share Medical Inc., Tokyo, Japan). Our system is an on-premises system configured as a closed network for security purposes. The system's server was located on campus at Hirosaki University Hospital, and mobile devices were set up with subscriber identity module (SIM) cards for a virtual private server to ensure that the devices could only connect to the on-campus server. The server was controlled using unique identification codes (ID) and secure passwords situated within a locked enclosure and positioned in a restricted access area accessible only to authorized personnel. These security measures were man-

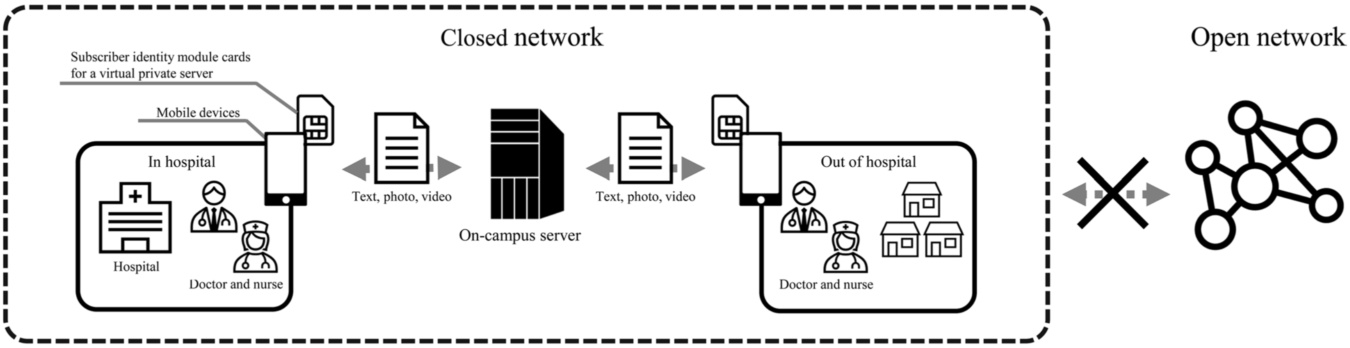

Figure 1 The telemedicine system in this study.
Our system comprised a chat system for all six physicians (doctors) and a select number of nurses, which enabled doctor-to-doctor (DtoD) and doctor-to-nurse (DtoN) medical consultations in and out of the hospital with text, photos, and video data. Additionally, it operated within a closed network in compliance with the regulations from three ministries and four sets of guidelines in effect in Japan at the time of our study. Therefore, our system was unable to connect to any other external servers or open networks.

aged by coauthor TK.

We adopted an explanatory sequential design of mixed methods[12]. First, we extracted data from messages exchanged through our system (date and time of sending, sender, receiver, and message content). Second, for qualitative data, the first author (TH, who is well-trained in conducting interviews) interviewed the six physicians (Supplementary file 1); five interviews were conducted face-to-face (A, B, C, E, and F) in Oma Hospital, and one (D) was conducted via an online conferencing platform. After data collection, we analyzed the quantitative data using descriptive statistics as part of the quantitative analysis. For qualitative analysis, we transcribed the interviews, recorded them using a voice recorder, and imported the data into NVivo software (NVivo Release 1.5, QSR International Inc., Denver, CO, USA)[13]. We subsequently analyzed the interview transcripts in depth and coded the dissatisfaction content as barriers to the participants' acceptance of our system using the NVivo software. Finally, the coded items were grouped into categories and their validity was confirmed.

Results

We collected the total count of 179 messages sent with our system and four hours of interviews with all six physicians at Oma Hospital.

Regarding the quantitative research findings (Figure 2), the total counts recorded by each physician were 56 (A), 20 (B), 3 (C), 74 (D), 5 (E), and 21 (F). The total count per month was as follows:13 messages in the month of May (a mean of 2.17 per month per physician), 51 in June (a mean of 8.50 per month per physician), 69 in July (a mean of 11.50 per month per physician), and 46 in August (a mean of 7.67 per month per physician). As presented in Table 1, three types of content were identified among the 179 messages analyzed: medical consultations (47.5%), management (50.8%), and others (1.7%). Medical consultations were further classified as related to dermatology (30.2%), orthopedics (12.8%), and respiratory medicine (1.1%). Management was categorized into hospitalization management (38.0%) and attendance management (12.8%).

We now share our qualitative research findings. Figure 3 lists the 13 extracted codes that include various aspects of dissatisfaction categorized as mental and physical barriers. Below, we summarize these categories and their corresponding codes using symbolic narrative data in *italic font*.

The mental barriers category included the following three codes: Suspicion of carrying, feelings of isolation, and loss. The first code, "suspicion of carrying", was confirmed in all six physicians who hesitated to send messages because they thought the message receiver might not have a mobile device. The symbolic narrative data were: *"Everyone else didn't have one, so there was no way to use it"* and *"I thought not many people were using it, and there was a time when I even forgot to turn it on".*

The second code, "feelings of isolation" was confirmed in Physician C who, during his interview, reported experiencing a feeling of isolation as he had received no personal messages during the study period. The symbolic narrative data were: *"When I had it, it didn't ring much after all, so there's that feeling, like, 'Well, it's not ringing anymore, so it's fine, I guess'".*

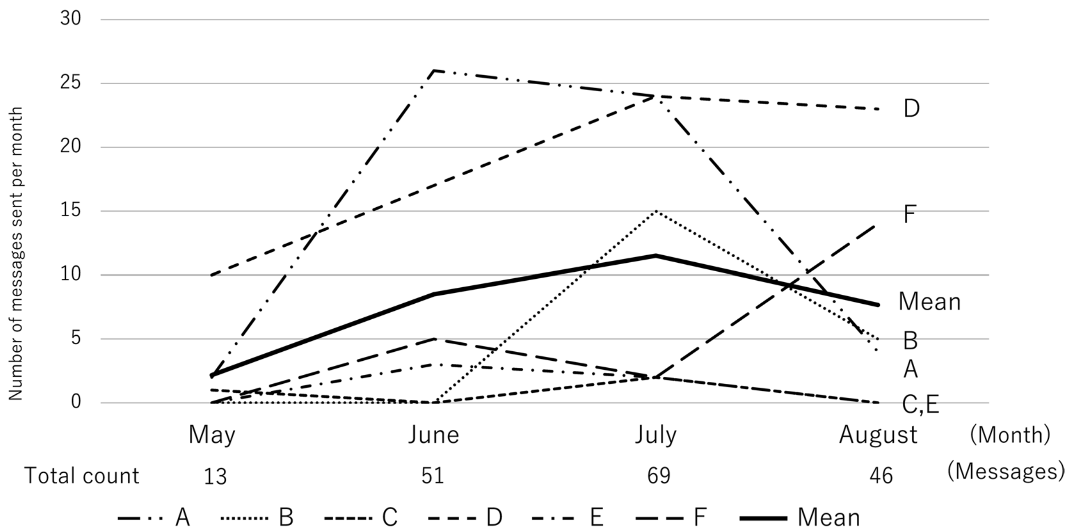

Figure 2 Number of messages sent per month during quantitative analysis.
Our study period was four months (covering 123 days).
The total and mean numbers of messages sent by each physician are provided for each month.
The horizontal axis of the graph indicates the total number of messages per month.

Table 1 Message content

Message content	Example	
Medical consultation		
Dermatology	Picture of skin, etc.	30.2%
Orthopedics	Image of X-ray of bone, etc.	12.8%
Respiratory medicine	Picture of sputum, etc.	1.1%
Others	Consults not applicable to the above	3.4%
Management		
Hospitalization management	Assignment of inpatients, hand-over	38.0%
Attendance management	Information on physician attendance	12.8%
Others	Messages not applicable to the above	1.7%
Total		100.0%

Category	Code	Definition (dissatisfaction with)	A(a)	B(a)	C(p)	D(a)	E(p)	F(a)
Mental barriers to using our system	Suspicion of carrying	Suspicion of other users' carrying	■	■	■	■	■	■
	Feelings of isolation	Feelings of isolation caused by not receiving messages			■			
	Loss	Concern about losing mobile device						■
Physical barriers to using our system	Portability	Low portability (shape, size, weight)	■	■	■	■	■	■
	User authentication	Complicated user authentication	■	■	■		■	
	Internet speed	Slow internet speed	■					■
	Group chat system	Low usability of our group chat system		■		■		
	Notice	Hard to notice		■			■	
	Search image	Difficult to search images that users want to check immediately		■			■	
	Typing	Unfamiliar with typing	■					
	Chat system	Unfamiliar with chat system	■					
	Print facility	No print facility						■
	Limited function	Unable to access public internet						■

Figure 3 Categories and codes extracted during qualitative analysis.
The codes and their definitions, as used in our study, are provided.
Two categories, summarizing the 13 codes, were identified. Symbols "A" to "F" represent each physician, and the accompanying symbols (a) and (p) indicate active and passive users, respectively. On the right side, the gray boxes represent "Yes" for extraction of the identified codes, and the white boxes represent "No".

The third code, "loss", was confirmed in Physician F who reported feeling dissatisfied because he was afraid of losing the mobile device. Additionally, he was concerned about not knowing what to do when he lost or forgotten our system. The symbolic narrative data were: *"When I lost it or forgot to take it with me, I remember feeling really afraid".*

Regarding the second category of physical barriers, the following 10 codes were extracted: portability, user authentication, internet speed, group chat system, notice, search image, typing, chat system, print facility, and limited function. The first code, "portability", was confirmed in all six physicians who all carried three mobile devices: the one with our system, the in-hospital traditional PHS, and their private smart phones. The interview findings revealed that they felt it cumbersome and stressful to always carry all three devices. The symbolic narrative data were: *"It's big and heavy"* and *"When carrying it around, it definitely feels like a nuisance".*

The second code, "user authentication", was confirmed in four physicians (A, B, C, E) who felt dissatisfied due to the complexity of user authentication. In their interviews, they reported frustration with logging into the system each time they launched the chat system. The symbolic narrative data included: *"I registered my fingerprint; it was annoying having to enter my ID and password once and then do the beep-beep-beep thing before I could use it"* and *"In the end, I'd sometimes forget my password when I had to log in again".*

The third code, "internet speed", was confirmed in two physicians (A, F) who felt frustrated with the time it took to download images. The symbolic narrative data were: *"Downloads do take a bit longer than expected"* and *"Sometimes I'd wait for a few minutes, but it would still be slow. It could be due to bad reception or large image files, but it just wouldn't open, no matter how long I waited"*.

The fourth code, "group chat system", was confirmed in two physicians (B, D) who expressed dissatisfaction with the process of creating groups. The symbolic narrative data included: *"Creating groups was super annoying"* and *"It was also bothersome to make a group for each patient"*.

The fifth code, "notice", was confirmed in two physicians (B, E) who were dissatisfied with the default function and wanted a more accessible notification functionality. If they missed a notification, they had no opportunity to access their mobile device, unless they did so for other reasons. The symbolic narrative data were: *"With a regular personal phone, you're usually checking it all the time, so you don't miss messages like, 'Oh! Dr. So-and-so contacted me!' But with the other phone, you don't use it, so you only check it when it rings. I did end up realizing I had missed messages from a few hours ago sometimes"* and *"If I had it on me, I'd notice when it vibrated or made a sound, but if it was in my bag, I wouldn't notice. That part of not being aware of incoming messages was a bit tough"*.

The sixth code, "search image", was confirmed in two physicians (B, E) who expressed dissatisfaction with finding and managing the images taken by our system. The symbolic narrative data were: *"It takes a really long time to find the old image"* and *"Since there isn't a separate category for each patient, it's a bit difficult to compare them in the first place"*.

The seventh code, "typing", was confirmed in Physician A, who was dissatisfied with typing text on a mobile device. Before our study, he had a cell phone (primarily supporting call and text functions) but not a smartphone (with advanced features such as internet access). Therefore, it took him time to become familiar with typing. Symbolic narrative data included: *"What operation? Flick? I've never done flick before, so it was really challenging"*.

The eighth code, "chat system", was confirmed in Physician A who had never used a similar chat system prior to our study and hence expressed confusion about it. The symbolic narrative data were: *"Since I had never used LINE* (Line®, Line Corp, Tokyo, Japan) *before, I was initially confused by the so-called chat method"*.

The ninth code, "print facility", was confirmed in Physician F who felt it cumbersome to print images to export to another system. Our system configuration does not allow connections to printers in our closed network. The symbolic narrative data included: *"It was frustrating that even though I took the pictures and could share the information, I couldn't print them or attach them to the electronic medical records. It felt like I had to take another picture with a digital camera on top of that"*.

Finally, the code "limited function" was confirmed in Physician F who felt inconvenience as they could not install other applications. This was because we opted to use a closed high-security network with no open internet connection (e.g., Google search). The symbolic narrative data were: *"I thought that being able to communicate normally over the internet would be really powerful if it were possible. But I did think that would be a pretty big deal"*.

Discussion

Active and passive users

The count of sent messages increased significantly from May to June, as indicated in Figure 2. We believe this was the result of physicians becoming familiar with our system over time. However, the number of sent messages decreased in August, probably because the physicians were aware that the study was ending. Additionally, we observed that the use of our system differed among physicians. Although there are no criteria for evaluating the usage of a chat system such as social networking services[14] in our system, the number of messages sent was used as an indicator to evaluate the usage of the telemedicine system. We categorized physicians with a higher number of sent messages as active users (those who sent more than the average number of messages per month at any time), and those with a lower number of sent messages as passive users (those who sent fewer than the average number of messages per month). Physicians A, B, D, and F were active users, whereas Physicians C and E were passive users.

Furthermore, as indicated in Table 1, medical consultation messages included those related to dermatological diseases, followed by those related to orthopedic diseases. The fields of interest of Physicians F (dermatology) and B (orthopedics) could have affected the number of sent messages (Supplementary File 2). Additionally, regarding message content, the higher number of management messages sent might be related to the high number of messages sent by Physician A, who had a longer post-graduate period and was, thus, responsible for administrative tasks in the hospital. However, while interest in specialty or administrative tasks indicates the possibility of active users, they do not explain the reasons for being a passive user.

Thirteen codes and two categories: mental and physical barriers

We extracted 13 codes from the results, which led us to identify the following two categories of barriers to using our system: mental and physical barriers (Figure 3). We discuss the codes related to passive users in order to identify user barriers.

The code "suspicion of carrying" could be extracted from the data of all interviewees. It is possible that some users did not have the opportunity to send messages and became passive users because they were unable to determine whether the other person owned a device and, thus, contacted them using their existing medium of communication. This could become a personal barrier for passive users, affecting their use of our system.

The only code that was exclusive to the group of passive users was "feelings of isolation", which was, therefore, considered a specific barrier in that group. Physicians often use chat systems as a part of telemedicine systems. Therefore, if physicians receive no personal messages, it could result in a sense of isolation, leading to passive telemedicine use. Physician C might have sent messages voluntarily if he had not felt psychologically removed from our system.

The code "portability" was confirmed for all physicians of both groups. Poor portability may have discouraged them from carrying their devices and prompted them to use other communication tools to contact each other, thus turning them into passive users. We deduced that portability is an important factor when sending messages. While it would be ideal to consolidate multiple mobile devices and use only one device for business or medical use, the resources available at a rural general hospital are limited, and numerous Japanese physicians use their in-hospital PHS and private smartphones at work.

The code "user authentication" was confirmed with Physicians A, B, C, and E from both groups. Multifactor authentication using data, such as memory, biometric, or physical information is recommended as per Japanese guidelines[15]. In our system, two-factor authentication uses either memory information (individual user ID and password) or biometric information (fingerprint) during device start-up, after which our system software would run. However, frequent authentication could lead to a reluctance in using telemedicine systems.

The code "notice" was a barrier in both groups, notably for Physicians B and E. In our study, physicians were able to contact their remote colleagues using the PHS or their personal cell phones, and the telemedicine system. If the receiver missed the notification or needed time to check the message, the sender would contacted the receiver again using other communication tools. This resulted in the system not being utilized.

The code "search image" was confirmed for Physicians B and E, users from both groups. Our system had no "album" function that could collect image files for each individual patient. While this led to physicians' dissatisfaction with the handling of the received images, it could not be construed as a barrier to sending images.

Further suggestions

We recommend the following solutions to facilitate the acceptance of telemedicine systems in clinical settings in Japan: we suggest providing an opportunity to send personal messages to other physicians using this system to manage feelings of isolation. Notification function issues could be resolved by synchronizing with other devices, such as smartwatches. User authentication is a system requirement; therefore, users must bear with the authentication process to avoid privacy or security issues. Regarding the suspicion of carrying and portability, bringing your own device (BYOD) could be a solution in Japan as many physicians use their personal smartphones for work. Some countries have formulated BYOD policies and allowed the use of BYOD[16, 17]. In Japan, BYOD was permitted for limited use for the first time in March 2022[15], subject to strict legal and appropriate management.

Strength and limitations

Although our study has several strengths, it has some limitations as well. First, our study excluded cost barriers to adopting telemedicine systems in medical institutions, which allowed us to specifically investigate the clinical barriers experienced by physicians (both mental and physical barriers). Second, the physicians' average age in our study was lower (mean age 30.3 years) than the average age of Japanese physicians (mean age 50.1 years)[18]; therefore, our findings do not represent all physicians in medical institutions across Japan. Older users may require more time to familiarize themselves with our system, and barriers to its use could therefore be more prevalent. Third, analyzing the number of messages received may have proven useful; however, this was not evaluated because of the small number of messages and the real operational features of our system, which was used as a group chat system and not just as a one-to-one chat system. Fourth, as mentioned earlier, the total number of messages in this study was limited. This may be owing to the small number of facilities and physicians targeted, in addition to the short study period. Additionally, the small number of facilities and physicians may have caused selectivity bias, which cannot be ruled out. Future long-term studies involving multiple facilities and large numbers of physicians would be desirable. Finally, our study period was only four months, which was inadequate to thoroughly examine the long-term use of our system.

Conclusion

The representative barriers to introducing a telemedicine system at a rural general hospital in Japan without initial and running costs could be classified as follows: feelings of isolation and suspicion of carrying as mental barriers; and notice, portability, and user authentication as physical barriers. We hope that solutions to these barriers would improve the issues surrounding the shortage of medical staff in the context of managing the declining birthrate and aging population which, in turn, warrants continued investigation into this area.

Conflict of interest: None.

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Ethics approval and consent to participate: This study was approved by the Ethics Committee of Hirosaki University (approval number 2018-1020) and conformed to the provisions of the Declaration of Helsinki (as revised in Brazil, 2013).

Consent for publication: All the participants provided informed consent for the publication of their anonymized information.

Data availability statement: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author contributions: TH conceived the idea and drafted the original manuscript. TH, TK, HM, and TA were responsible for the data acquisition and analysis. TH and TK developed the theory and TA and HK derived the findings of our study. All the authors discussed the data and commented on the manuscript. TH, TK, HM, and TA revised and edited the manuscript. All authors have approved the final manuscript before submission.

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