FIVE-YEAR TECHNOLOGICAL CHANGES OF DISTANT MEDICAL EDUCATION IN ASIA

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Abstract

All physicians would benefit from more comprehensive distance learning. However, the technology is often difficult to use because technological infrastructure is limited in many hospitals in Asia. Since 2003, we have worked to advance international distant medical education implemented through the Internet in Asia. This paper presents an analysis of our activities over the past five years to evaluate the technical transition and its effects on modes of distant medical education. Methods: We analysed distant medical education programmes that we conducted from 2011 to 2015. We used a Digital Video Transport System (DVTS), H.323 and Vidyo, along with commercial and research and education networks (REN) installed in the subject hospitals. Questionnaires were randomly distributed to the audience to evaluate image resolution, image movement, sound quality, and programme content. Results: The number of programmes increased to over 90 per year in 2014–2015. The main system gradually changed from DVTS (58%, 30/52 in 2011) to Vidyo (64%, 67/104 in 2015). The number of new institutions increased to 149 in 2014–2015. Over 92% of the ratings for image resolution and movement were positive. Sound quality was somewhat lower at 83%. Ultimately, 98% of respondents rated the programmes "very good" or "good." Conclusions: Continuous technical development was observed with increasing numbers of sites for each programme. This resulted in expansion of activity involving non-university hospitals. Practical distant medical education, satisfies physicians' need for quality and inclusiveness could be expanded to normal hospitals in Asia and beyond.

Keywords: telemedicine; distance learning; Asia; Internet; research and education network.

Introduction

Over the past decade, the development of information and communication technologies (ICT) has changed our lives.[1] Now, we can easily communicate with friends in other countries using audio-visual telecommunication tools like Skype or Facetime. Although various distant education programmes have been used in the medical field, transmitting medical content is a technical challenge because it requires high image quality. There has been considerable research on image compression for transmitting medical images and video via Internet and teleconference systems in recent years.[2-6]

Distant education is an efficient way to share the latest medical knowledge, and hopefully in the near future all physicians will be connected from their own hospitals. However, distant medical education is often difficult for physicians to use because the complexity of networks, systems, devices, and the need for engineering personnel to maintain hospital technological infrastructure for global telemedicine, especially in developing countries in Asia. Hospital ICT infrastructure differs widely based on factors such as the country, culture, and hospital aims and revenues. Hospitals generally have their own policies regarding networks and devices because of the need for tight security to safeguard patient privacy. Given these conditions, it is essential to establish a standard method for practical distant medical education that is sustainable and expandable.

Since 2003, the Telemedicine Development Centre of Asia (TEMDEC), has proactively worked to advance international distant medical education implemented through the Internet as secretariat of Asia Pacific Advanced Network (APAN), medical working group.[7] During the early years, we succeeded in overcoming problems of transmitting high-quality images at low cost by using the Digital Video Transport System (DVTS) and the research education network (REN).[8] Because of the growing demands for telemedicine, we began to support more physicians who wanted to participate from their own hospitals and clinics by using their own infrastructure and engineering personnel based on the physicians' needs.

With recent developments of Internet technology and innovative changes in teleconference systems, the conditions in telemedicine are changing rapidly. This paper presents analysis of our activities over the last five years, to evaluate technical transition and its effects on modes of distant medical education in Asia and beyond.

Methods

Distant medical education programmes that were conducted from 2011 to 2015 were analysed. The programmes were divided into two categories, teleconferences and live demonstrations. In teleconferences, case presentations and discussions were performed with slides and video clips. Live demonstrations comprised simultaneous transmission of medical procedures such as surgery to other institutions. In the live demonstration programmes, participants could ask questions to the moderator next to the operator in the operating room. Although all programmes were proceeded in English, translators helped communication in some programmes for nurses or medical students. Every effort was made to protect patients' privacy in all of the programmes. Encryption programmes such as IPsec/VPN or AES were used, according to the written informed consent requirements of each hosting hospital.

Programmes were achieved by a combination of the Internet and a teleconferencing system. As it is important in telemedicine that appropriate methods for the specific applications are selected, one of three teleconference systems: DVTS, H.323 and Vidyo was selected, depending on the institutions and purposes.[9-11] DVTS is free software that transfers digital video signals to Internet protocol without any inter-frame compression.[12] DVTS transmits in standard definition (SD) images via the Internet with bandwidth of 30 Mbps. Because it is a terminal type, multipoint control units (MCUs) located at Kyushu University Hospital (Fukuoka, Japan) were used for multiple connections. H.323 is a high-definition compatible standard teleconference system sold by a number of companies, and is the most common system in the medical field.[13] H.323 needs a public IP address, and a network with a bandwidth of 1 to 8 Mbps. An endpoint system installed at each institution, and MCUs for multiple connections were used. Vidyo was developed based on H.264 compression and scalable video coding by Vidyo™ (Hackensack, NJ). It does not need a public IP address, but it requires a network with bandwidth of 1 to 8 Mbps. Because it is a server/client type system, the server located in Kyushu University Hospital was used. For the clients, there are hardware/software systems called VidyoRoom and VidyoDesktop. VidyoDesktop can be used with personal computers (PCs), and it is suitable for interactive communication using the image from a web camera and audio from a speakerphone, as well as receiving video content and sending still images. However, VidyoDesktop is not suitable for sending video content, such as live demonstrations or recorded video. Therefore, when video content was transmitted to other sites, we set up VidyoRoom for preventing image problems such as resolution and framerate.

Two kinds of networks were used: a commercial network, and a research education network (REN) installed at each institution.[8] Companies provided the commercial network under the contract with each hospital, with speeds ranging from 1 Mbps to 1 Gbps. However, the user's bandwidth is not guaranteed because millions of users share the network. The international routing of commercial networks is not symmetrical with regard to incoming/outgoing traffic and it cannot be controlled. REN is the network especially constructed for the purpose of research and education. It provides a network with a higher bandwidth than commercial networks, with speeds ranging from 10 Mbps to 40 Gbps, depending on the country.[14] In Japan, for example, 10 to 100 Gbps of bandwidth is provided by SINET 5. The routing for incoming and outgoing data is symmetrical, and can be controlled.

Questionnaires were randomly distributed to the audience by printed questionnaires sheets or on-line form. The audience evaluated image resolution, image movement, sound quality, and programmes. The answers were classified into four levels: "very good," "good," "poor," and "very poor."

Results

Programmes

During the past five years from 2011 to 2015, 344 programmes were organised with 346 institutions in 51 nations/regions. The total number of connections made to participating sites was 1,969. The annual number of programmes increased, to reach over 90 per year in the two years preceding this report (2014–2015), which was more than 1.8 times the number in 2011 (49 programmes). The connected sites increased to reach 630 per year in 2015, which was more than 3 times the number in 2011 (207 sites). Connected sites per programme increased from 4.2 in 2011 to 7.0 in 2015. (Figure 1)

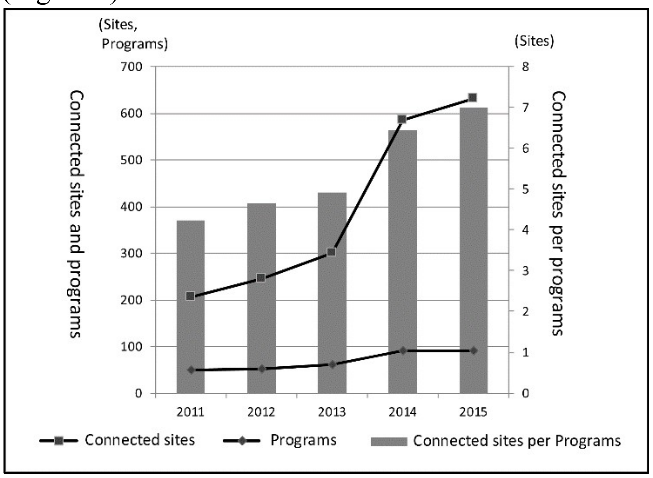

Figure 1. Programmes and sites connected by year.

The programmes were analysed according to the subspecialty of the content. (Figure 2)

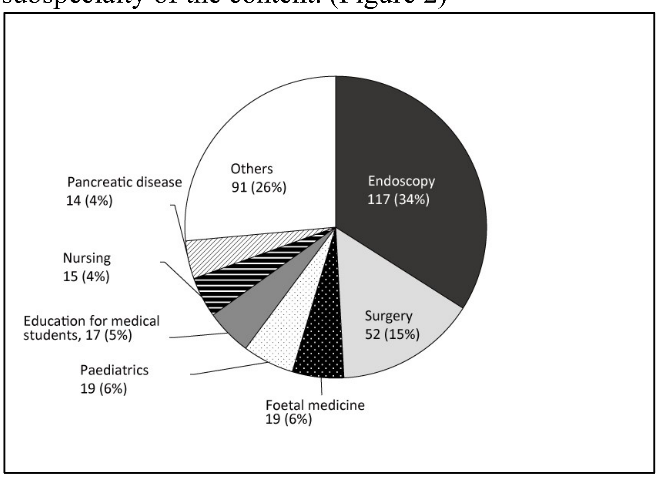

Figure 2. Programmes classified by medical subspecialty.

Of the 24 kinds of medical content, endoscopy and surgery accounted for nearly half (49%, 169/344) of all programmes. Endoscopy accounted for 34% (117/344), surgery for 15% (52/344), followed by foetal medicine, paediatrics, education for medical students, nursing, and pancreatic disease. The number of subspecialties with programmes conducted annually increased from 9 in 2011 to 20 in 2015. Teleconferences accounted for 86% (296/344) of programmes, and 14% (48/344) were live demonstrations. When the live demonstrations were subdivided according to subspecialty, endoscopy made up 50% (24/48), and surgery made up 29% (14/48).

Scales and Systems

Although 79% (38/49) of programmes were performed with fewer than five sites in 2011, the number of connected sites per programme increased steadily. More than half (54%, 49/90) of the programmes were shared with five or more sites and 22% with 10 or more sites in 2015 (Figure 3).

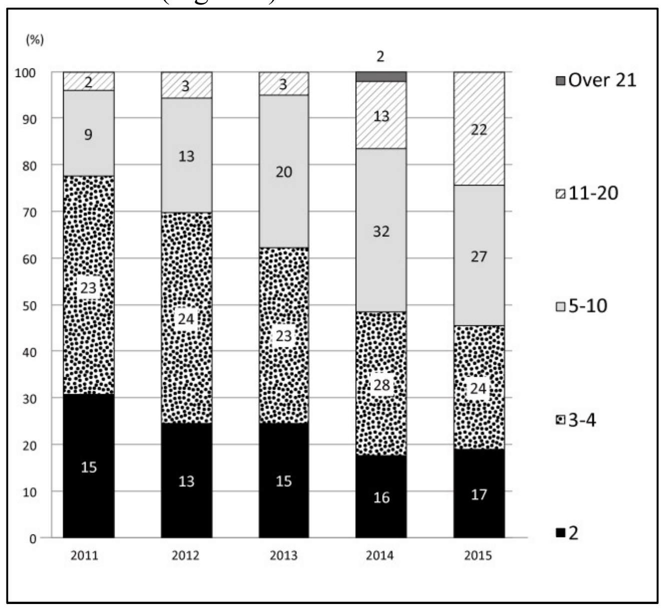

Figure 3. Changes in the number of connected sites.

As shown in Figure 4, DVTS was the most often used technology in 2011 (58%, 30/52), but its share decreased to 5% (5/104) in 2015.

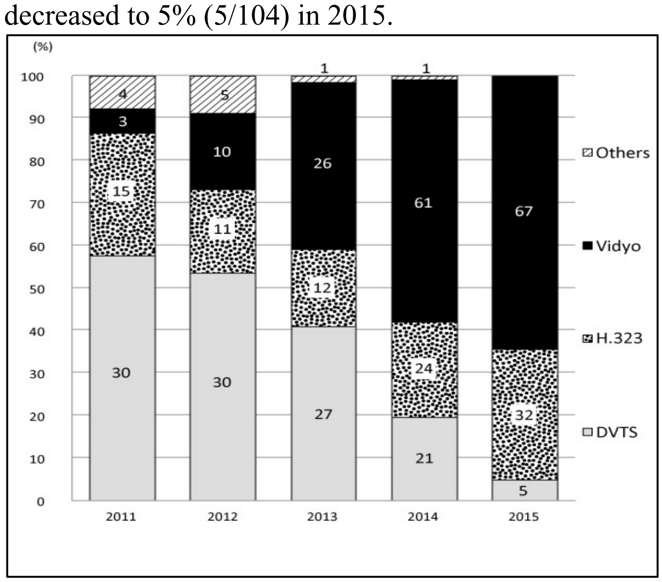

Figure 4. Changes in teleconferencing systems.

In contrast, Vidyo was used 6% (3/52) of the time in 2011, but this increased to 64% (67/104) in 2015. H.323 was more or less stable between 18% (12/66, in 2013) to 31% (32/104, in 2015).

New institutions

Newly connected institutions in each year were analysed according to the institution's network, REN or commercial network, and university or non-university hospitals. (Figure 5)

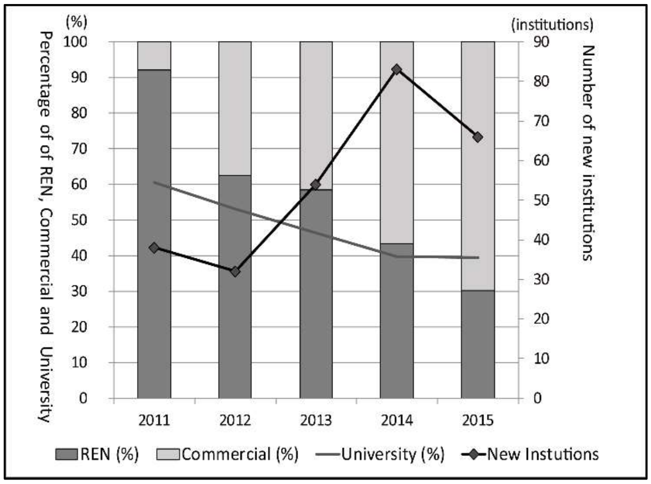

Figure 5. Analysis of newly participating institutions by network and university.

The number of new institutions increased throughout the period analysed. In 2014–2015, 149 institutions were newly connected, more than double the number connected in 2011–2012, when 70 institutions were connected. From the viewpoint of university or non-university hospitals, including smaller hospitals, university institutions showed a downward trend, being 61% (23/38) in 2011, and 39% (26/66) in 2015. In contrast, non-university institutions increased to 61% (39/66) in 2015. Regarding networks, 92% (35/38) of new institutions were connected to REN in 2011, but this had decreased to 30% (20/66) in 2015. In contrast, commercial networks, which accounted for 8% (3/38) in 2011, increased to 70% (46/66) in 2015.

The 273 institutions that were newly connected in 2011–2015 were analysed by region. (Figure 6) Asian institutions accounted for the most (74%, 201/273), followed by Latin America (13%, 35/273). Institutions from Japan accounted for a large share (34%, 93/273), but many developing countries in Asia and Africa also joined.

Questionnaires

Questionnaire responses were collected from 2,045, 1,573, 1,853, and 1,947 participants for questions on image resolution, image movement, sound quality, and programmes, respectively. In total during 2011-2015, more than 92% responded that image resolution and movement were "very good" or "good." Somewhat fewer respondents (83%) responded that sound quality was "very good" or "good." Finally, 98% commented that the programmes were "very good" or "good."

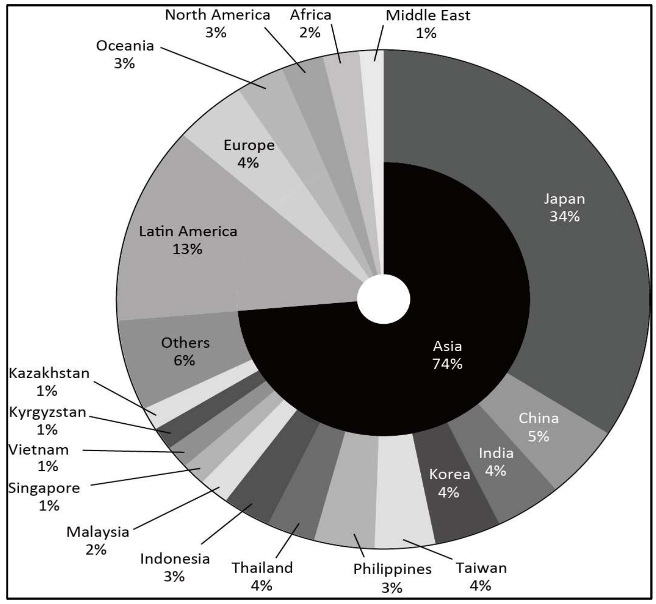

Figure 6. Regions of newly participating institutions.

The annual results are shown in Figure 7. In all years, more than 96% commented that the programme was "very good" or "good." Likewise, with the exception of image resolution in 2013 (79%, 320/378), over 80% responded that image resolution and movement were "very good" or "good" in all years. Over 79% reported that sound quality was "very good" or "good" in all years except 2011 (67%, 83/123) and 2013 (60%, 177/294). Poor results for 2013 were due to one programme that had technical problems with the computer device for DVTS. It was marked by 84% (48/57) and 95% (20/21) of respondents as having "poor" or "very poor" image resolution, and 58% (56/97) and 65% (13/20) of respondents rated it "poor" or "very poor" for sound quality. Poor results were also noted in 2011, with 85% (29/34) and 100% (6/6) of respondents from one programme rating the sound quality "poor" and "very poor."

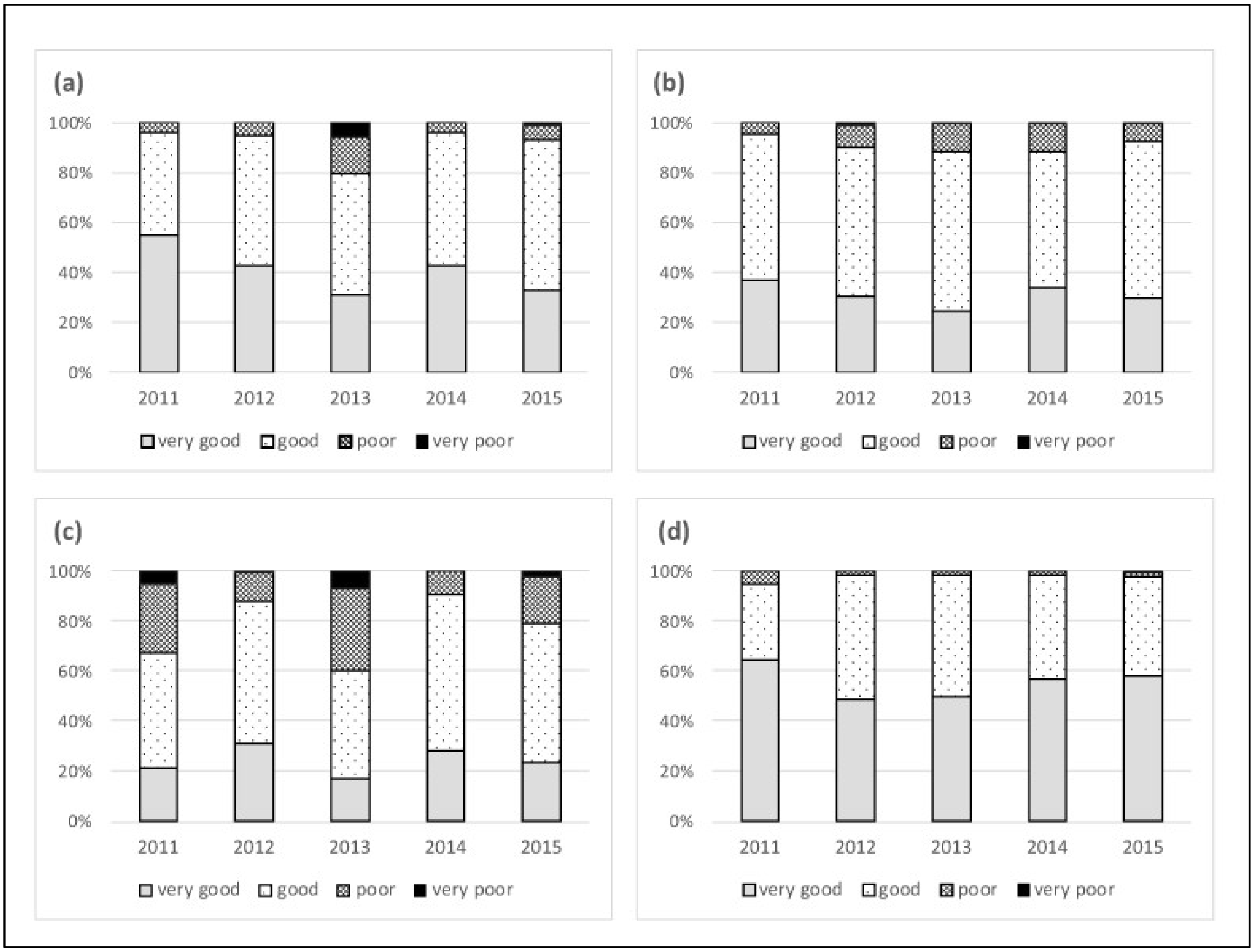

Figure 7. Questionnaire results on (a) image resolution, (b) image movement, (c) sound quality, and (d) programme by year.

Discussion

As shown in the results, the technical changes over the past five years are readily apparent. First, the most widely used system changed from DVTS to Vidyo. Second, the number of connected sites per programme increased. Third, more non-university hospitals with commercial networks installed were involved.

Software systems like DVTS and Vidyo are attractive for telemedicine because the cost is not high for the client. Recently, Vidyo has surpassed DVTS in terms of usership because Vidyo is easier to set up than DVTS, and because of its scalable system, which fits a commercial network.[15,16] For example, Vidyo does not have special requirements such as a network with high bandwidth, a public IP address, converters, or old-fashioned IEEE1394 interfaces. Vidyo works with a regular PC and webcam and a speaker phone.

This transition from DVTS to Vidyo has resulted in a vast expansion of activities that used to be limited to university hospitals with a high-bandwidth connection to REN. Now, thanks to new technologies, non-university hospitals, including small hospitals in rural areas or in developing countries, can join medical teleconferences via commercial Internet with acceptable quality of transmitted images and sound. (Figure 8) This indicates that in a practical sense, distant medical education has moved towards the realisation of satisfying physicians' needs for quality and inclusiveness in Asia and beyond.

Regarding the content, physicians' desire for distant education in various fields increased because of the

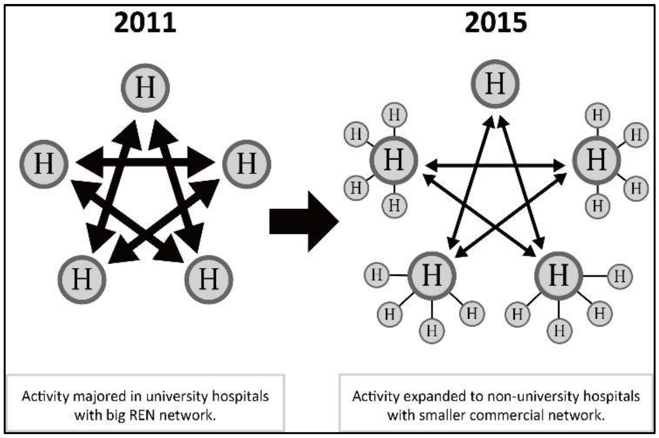

Figure 8. Technological change in the last 5 years in practical distant medical education. (H= Hospital)

technological development mentioned above. Accordingly, the number of programmes increased while the number of connected sites per programme increased markedly during these five years. However, endoscopy and surgery remained a large portion of the programme as a whole, so the wide availability of these telecommunication systems in hospitals and their potential for use in other kinds of programmes should be widely promoted.

Most of the programme expansion has been domestic, or into neighbouring countries in Asia. However, these activities have also spread beyond Asia, and especially into Latin America, where there has been a more marked increase in new institutions than in other regions. Despite being far removed from Asia, these programmes are attractive in Latin America because of common interests in medical topics such as early gastric cancer diagnosis and endoscopic surgery. Because the two regions are geographically far apart, making travel difficult, distant education is particularly effective.

Several issues must be considered to further improve the quality of the programme. First, the recurrence of technical problems must be prevented. For example, some hospitals joined without testing the system because VidyoDesktop is easy to use. However, problems such as no audio from the remote site, poor quality of audio and video, not knowing how to share slides, and disconnection problems sometimes occurred at these hospitals. Remedies such as careful testing, communication among engineers, preparing backup facilities, and training engineers are required to solve these problems. Sound problems have been pointed out as a recurring issue with Vidyo because VidyoDesktop does not include audio devices, and microphones attached to the PC are often used.[15] Because appropriate device selection is important for preventing problems, adequate microphone selection and position must be considered, and testing of each microphone should be done to match the system.[17] While VidyoDesktop can be used via Wi-Fi, the system connection often becomes unstable and, a wired connection is strongly recommended.

Limitations of the study are that the results for audio and image quality were taken via a simple four-grade questionnaire, and statistical analyses were not performed. More logical measurements using objective evaluation methods or subjective assessment or evaluation should be taken. The second limitation is that although the programme has expanded to many institutions, there are some “non-active institutions” who have participated only a few times; therefore, analysis of continuous participation is also recommended.

Increasing technical development has brought surprises, with some physicians participating from their homes or on business trips because of the sometimes large time differences when the programme is used globally. Currently, this works well sometimes, but at other times it does not because of technical bottlenecks. However, these situations are likely to improve soon because of the continuous development of network infrastructures, computer processing power, and system usability. In the near future, increasing numbers of physicians will be able to participate in distant medical programmes from anywhere with adequate conditions. Development of technology has accelerated distant medical education in practice, and it is expected to grow and become increasingly standardised in worldwide medical knowledge and practice.

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