

ORIGINAL ARTICLE

TELEMEDICINE IN PRACTICE IN ARKHANGELSK REGION, RUSSIA: FROM A BLANK PAGE TO ROUTINE OPERATION

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ABSTRACT

Objectives. This article describes the telemedical activities in the Arkhangelsk region of north-west Russia from 1996 to 2004, and some of the outcomes of introducing telemedicine in health care.

Study design. The study acquired statistical data between 1996 and 2004 from the telemedical network in the Arkhangelsk region. The network was intended to be low cost and to function using existing communication systems. We tried to answer several questions such as: How were teleconsultations organized between the sender and recipient? What information was transferred and in which cases? How would the system develop over time?

Methods. Medical data such as still images of patients, test results and medical documentation were transferred from the rural areas to two regional health institutions. The general information, the medical and the technical parts of consultations were recorded, summarized annually and analysed.

Results. After only one year, the project resulted in an expansion of the network and in a greater number of stations. Teleconsultations contributed to better and closer cooperation between health care institutions and to better levels of health care in the region. A total of 1,092 consultations were performed.

Conclusions. Our experience shows that regional telemedical networking can be successfully established in methodology and communication where no dedicated infrastructure has previously existed. At the same time, we demonstrate that telemedicine can be introduced in areas lacking a highly developed infrastructure (*Int J Circumpolar Health* 2007; 66(4):335-350).

Keywords: telemedicine, north-west Russia, infrastructure creation, international collaboration, experience exchange

INTRODUCTION

Telemedicine activities in the Arkhangelsk region started in the 1990s as a collaborative project with the Norwegian Centre for Telemedicine (NST). The project received government funding in both countries, primarily from the Barents Health Programme, and was intended to improve communication and the exchange of information between health professionals. Better communication between the health institutions in the Arkhangelsk region was intended to contribute to better health services for the population in the rural areas. The interesting practical part of the project was the launch of the still-image network to support remote medical consultations within the region. This area became the most important in the project, and aroused considerable professional interest and technical creativity among the users in Arkhangelsk (1). The same kind of activity is continuing, with ongoing development many years after the project has ended.

The Arkhangelsk region lies in the northern part of Russia's European area. The territory, covering 587,400 sq km, has a population of about 1,318,000 distributed between 14 cities, 38 rural towns and about 4,000 rural villages. Of the region's population, 25.5% were living in rural areas at 1 January 2004 (2). The public health service in the region is organized in the same way as in Russia's other regions. The health care system consists of 3 levels. The first level includes primary health care centres and small rural hospitals, which provide health care services to patients who do not need specialized medical help. Such centres are located in small settlements served by doctors/GPs or *feldshers* (physician's assistants) and nurses. If necessary, patients receive

intensive treatment and specialized care in district hospitals on the second level. The third level provides highly specialized medical care. Health care institutions at this level consist of a network of specialized hospitals organized under the Public Health Department of the Arkhangelsk Regional Administration (3). The hospitals at the third level are critical for providing systematic and consultative aid to hospitals and to medical personnel at the first and second level.

The scattered population and long distances between cities and villages in the Arkhangelsk region are typical characteristics. For many settlements, the year-round transportation is only by air. The Regional Emergency Centre (REC) organizes air ambulances for transferring emergency patients and/or specialists; this is often the only practical option. There is great heterogeneity in providing regions and districts with highly qualified medics. Thus, the "equalization" of patients' access to high-quality medical help in various regions of Russia and in Arkhangelsk, in particular, is necessary (4).

The communication network was planned for internal use by the regional health care network to help compensate for the shortage of specialized health services in outlying districts and provide expert support to local health staff on demand, especially when it was not possible to transport patients physically. The network was intended to be low cost and to function using existing communications. To achieve these objectives, collaborators strove to answer several questions, such as: How should teleconsultations be organized to achieve satisfactory communication between the sender and recipient? How could the network be used? What information could be transferred and in which

cases? How would the system develop over time? This article describes the progress of this project as experienced by the collaborators.

MATERIAL AND METHODS

The concept of a telemedicine network comprises the whole service: the communication network and organizational efforts as well as economics, hardware, software and human resources. The conditions (mainly communicational) prevailing in the region during these years heavily influenced the network design. In the design of the telemedical stations, emphasis was placed on choosing simple, available equipment that could communicate via analogue copper landlines. A standard remote station includes a personal computer, analogue modem, frame grabber, video camera and specialized software. The lack of infrastructure resulted in the unavailability of videoconference services for the remote stations, so dial-up over telephone lines was used. The communication network was planned for internal use by the regional health care network and was intended to be low cost and to function using existing communications. The solutions used may be seen as low-tech nowadays, but were in fact low in cost and universal, based on PCs and information transfer over copper telephone lines, which were suitable for every hospital in the region, including even the smallest ones.

It was decided that teleconsultations would be based on the transfer of still images and textual information. These included images of patients, wounds, test results, electrocardiography (ECG), electroencephalography (EEG), echocardiography, X-ray images (including computer tomography), images

produced with the help of light microscopy examination (sections and smears) and medical documentation (case summaries, referrals).

The medical information for the first teleconsultations was sent over the modem-modem-direct connection when PCs were set in terminal mode. Since the most important task was to send data files with information relevant for diagnostic purposes, the staff of the regional telemedical network tried to use most of the communications available in the region: since 2000, when the Internet became available within the region, they have been sending requests for teleconsultation attached to email messages.

Software supporting the telemedical process in the region was changed over time as well: two Norwegian software products were sequentially localized and approved for use in the network. The second of these was issued in at least 3 major releases during its lifespan in the Arkhangelsk region. The absence of large integrated hospital-wide information systems in any hospital of the region – a common situation at that time – made it unnecessary to integrate telemedical software in such systems, but meant that the telemedical software functioned as a stand-alone application. So, such software was intended to support the whole life cycle of the telemedical consultation: creation, transfer, dissemination of the documents for second opinion/conference of specialist doctors, tracking, version control, encryption/decryption, non-modification and source proofing, and finally maintenance of the archives. After all, software made it possible for registrars to browse the secured archives of consultations and to extract data used in this article.

At the beginning of the project, telemedicine stations were placed at the second level

in the health service, which is responsible for gynaecology, obstetrics, surgery and internal medicine of adults and children. Recently, 4 of the newly established GP offices at the primary healthcare level were equipped with telemedical units. Teleconsultations were to be used if necessary for specialized medical assistance, that is, when local health staff did not have adequate knowledge and competence or when they simply asked for help. The people responsible for remote telemedical stations are doctors within various specialities.

During the project period, from 1996 to 2001, the central telemedical station was located at the Regional Emergency Centre (REC) at the Arkhangelsk Regional Hospital (RiA). REC provides acute medical support to local hospitals by receiving all emergency telephone calls from district health institutions that are unable to handle a problem locally and evaluating the situation immediately on the basis of the information communicated. REC decides whether patients need emergency transfer to the RiA or not and also provides transportation between local clinics and regional hospitals. One critical aspect is the considerable shortage of specialists at the central hospital where patients need medical care by the same specialist at the same time. For the RiA, this means the frequent unavailability of specialists in a variety of medical fields: traumatology, neurosurgery, anaesthesiology, and so on. REC can track and contact the specialists needed during the hours they are on duty.

The central telemedical station in Arkhangelsk functions around the clock and telephone contact is always possible. For emergency cases, the specialists on duty at RiA are contacted for acute medical assistance (5). The

response time for acute consultations is less than 2 hours. For planned consultations, an appointment is booked to suit the doctors both in Arkhangelsk and in the rural areas, usually within 2 days. Appropriate specialists are called in for each case. Right from the start, telemedicine was intended as a supplement to the standard health services.

Consultations take place only between doctors. The responsible doctor at the local hospital assesses the need for teleconsultations and the content of referrals. Doctors and specialists on duty at RiA and other hospitals in Arkhangelsk reply to the referrals. The consultation procedure is as follows: the doctor responsible for the patient calls the contact telephone number and provides a summary of the information about suspected pathology, the problem and degree of urgency. The time that the session should start and the list of the consultation participants are discussed at the same time. While preparations are made in Arkhangelsk, the illustrative images are taken at the remote site and transferred to Arkhangelsk. At the agreed time, representatives on each side are ready for the discussion over the speakerphone.

Data collection

This article is based on data collected in the Arkhangelsk region. Since discussions between doctors often play an important role in the process of diagnosis and treatment, it was necessary to record medical data in the same way it is recorded during face-to-face consultations between specialists. In addition, it was necessary to record some technical data. In 1997, routines were developed for documenting telemedicine activities. What data was to be considered during each consultation

was discussed repeatedly at the joint conferences between all project participants. The main documentation consisted of electronic spreadsheets collected at RiA. They were filled in with the time of the request and the answer, whether it was the primary consultation or a check-up, the patient's gender and age, and the name/hospital/department of the inquiring party and the consultants. The medical part was used for recording the medical field and problem formulations as well as the number and type of images. All the professional disciplines and participating specialists involved were noted along with their positions, the results of the consultation and the practical implications of the consultation for the requesting party. The most important outcome of the specific consultation was chosen as the only consultation result for the specific patient when there were several medical specialities involved in the case. In the technical section, details were recorded for the time spent, image transmission method, the software used, the volume of data transmitted and its quality. All recorded data was subjected to annual summarizing and analysing.

RESULTS

This analysis includes data from 1996 to 2004. This data was extracted from the electronic documents used as a medium for telemedical requests and reports during this period. Documents archived using the telemedical software were browsed and statistics were collected on aspects such as the gender of the patients and the medical speciality involved in the consultation. The statistics came from the two principal telemedical facilities in the region: the

Regional Hospital and the Children's Regional Hospital in Arkhangelsk. These two facilities were designated to collect all types of statistics on telemedical activity; in terms of the hierarchical health care structure, these facilities were responsible for the entire telemedical process in the region and received all the telemedical requests from the district hospitals. During the data collection no exceptions were made, so the statistical data used in this article covers all the telemedical consultations conducted during these eight years.

The use of telemedicine in Arkhangelsk regional health care started from scratch, since in the early 1990s regional telemedicine networks had not been implemented in the Russian Federation at all. Telemedicine solutions were literally introduced on the first day, and their benefits soon became clear.

The development of the network over time

The first stations were deployed in 1996 in 2 of the region's southernmost rural areas with populations of 110,000 and 70,000. These were selected because of their remote locations of 700 km and 600 km from Arkhangelsk, respectively. In 2001, 13 stations in the rural areas were linked to 2 principal receivers in the Arkhangelsk city. Of these 13, 3 stations were located at hospitals in towns with a population of between 45,000 and 200,000, and 6 stations were located at central district hospitals with up to 200 beds and multidisciplinary outpatient clinic services. The stations also covered the need for teleconsultations for the population in the neighbouring districts. Four stations were at primary health care sites, each with 2 or 3 employees.

The stations are still staffed by the same people who have been involved from the start.

These are medical specialists in various disciplines who are interested and skilled in the use of information and communication technology.

Data entry and collection formed an important part of the day-to-day telemedicine routines. The type and extent of the information – what was to be transmitted and in which cases – was not planned in advance. Health workers in Arkhangelsk had no “user guide” for such data entry before the start up of the project. This was discussed at joint meetings with all those responsible for telemedicine in the region early on during the project period, and at that stage considerable progress had already been made in the development of the documentation to be recorded.

Communication between the sender and recipient

Telemedical technologies allow us to conduct more detailed consultations for both inpatients and outpatients. This means that in addition to verbal communication by telephone, we can demonstrate and discuss images produced with the help of X-rays, fibrogastroscopy, ultrasound or ECG, as well as images captured during the examination of wounds and surgical incisions, and evaluations of cross-sections blood smears (6).

Most of the consultants are doctors from RiA and the children’s hospital. They are contacted in cases when the competence in the district is inadequate to meet specific needs and when a second opinion can be provided via data communication with the same quality as if the patient was present in person, for example in dermatological cases, or when data communication can replace dispatch of samples, for instance within pathology. Such

a consultation is a multidisciplinary discussion among several specialists concerning a patient, and is a modern variant of the traditional advisory council. The final decision is made by the doctor responsible for the patient in the district. Regardless of which specialists discuss the cases in Arkhangelsk and their rank, their functions during the consultation are purely to provide advice and guidance (7), and they do not bear any responsibility for compliance with their advice.

By 31 December 2004, a total of 1,092 consultations had been performed. In the 1996–1997 period, 56 consultations were performed. The annual number of teleconsultations increased steadily and reach 245 by 2004.

Patients/cases

Right from the start, users and health staff looked upon telemedical solutions as a tool for solving extremely important health problems. An analysis of the first 3-year period, from 1996 to 1999, showed that:

- 51% of teleconsultations were related to acute cases with a need for immediate assistance,
- correction of treatment was recommended in 70% of cases,
- in 97% of cases, the specialists’ recommendations were enough to enable doctors to continue the patient’s treatment locally, and
- only 3% of teleconsultations resulted in travel by specialists to rural areas.

The analysis conducted in 2000 concluded that telemedicine consultations rationalized acute help and saved on travel expenses (8).

Almost 9 out of 10 patients involved in teleconsultation between 1996 and 2004, or 86%, could continue their treatment locally. Of all

transfers to the regional level decided on during teleconsultations, about half related to very serious conditions, where the patient needed to be transferred very quickly.

The age of patients involved in telemedicine consultations ranged from 1 day to 85 years. The distribution between genders is even, 50.5% and 49.5%, respectively. During the period 1996–1999, men represented the greatest proportion in the age group between 20 and 55. This may be due in part to the fact that many consultations concerned injuries in men (9).

Children aged from 0 to 15 accounted for a significant proportion of all the consultations, an average of 18.3% during the whole period. In 1999, a separate central telemedical site was established at the regional children's hospital in Arkhangelsk. Since then, it has been possible to arrange consultations for children more quickly and directly without involving the

RiA as an intermediary. It became easier for the paediatric specialists to offer telemedicine assistance when they could use the studio at their own hospital. Direct communication between the paediatric departments of the district hospitals and the regional children's hospital reduced the communication time. The proportion of consultations for children rose to 33% in 2000 compared with 8% in 1996. For a number of children from rural areas who were admitted to the regional children's hospital, consultations took place with Russia's leading cardiac surgery centre in Moscow as part of the nationwide telemedicine program.

For the first year, acute cases accounted for the majority of teleconsultations in the region (10) (see Fig. 1).

The first-ever patient involved in telemedical consultation had bone fractures and sarcoma of the ribs, and several consultations were held with up to 9 specialists

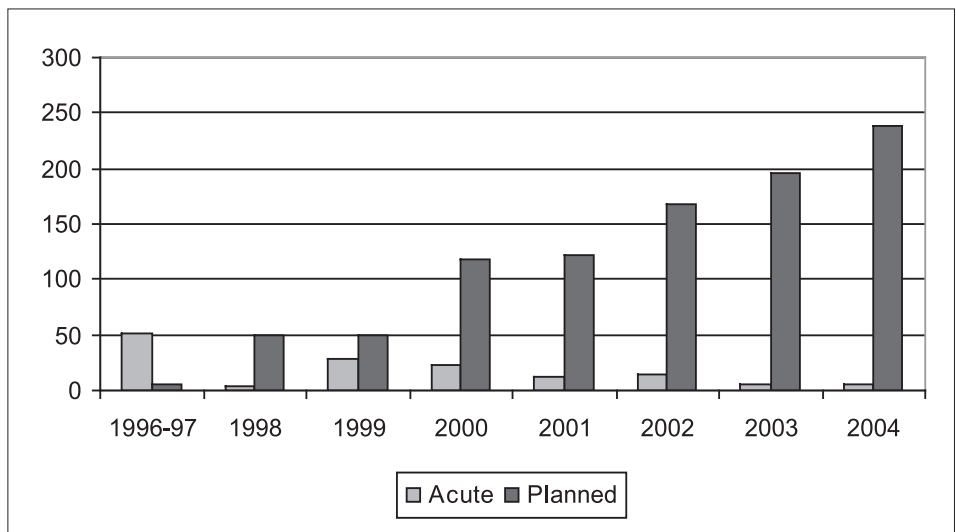


Figure 1. Teleconsultations within Arkhangelsk region in 1996–2004. Distribution of acute and planned consultations.

in Arkhangelsk. The second patient had a life-threatening thoracic haemorrhage caused by an injury. The X-ray images transmitted showed that emergency surgery was needed, and the thoracic surgeon was sent to the local hospital immediately (11). The transfer of still images has helped to save lives on several occasions.

Since 2000, the number of consultations for acute cases has declined, while the proportion of planned telemedicine consultations has increased.

The objectives of the consultations

The objectives of the consultations were:

- In the case of a difficult diagnosis or the atypical progression of an illness, when the competence of a more experienced colleague is needed: the correction of the suspected diagnosis and recommendation of additional examination methods.

- In crises, when every second counts: a medication strategy and discussion of surgical interventions.

- During discussions concerning patient transfer to regional health care institutions: the need for and date of face-to-face consultations at regional centres.

- When there is a need for clarification of the treatment strategy, especially for patients who have undergone surgery or have been treated at specialized centres and are continuing the treatment locally, or when other consultation methods are unavailable, for example for patients in outlying districts: clinical evaluation of treatment performed and discussion about further treatment; rehabilitation measures; prevention of complications and secondary conditions; discussion on prognosis and follow-up.

In 38% of all cases between 1996 and 2004, additional examinations were recommended. Changes in the diagnosis with subsequent corrections in treatment were recorded in 18% of cases. In 14%, transfer to specialized departments or institutions was recommended, and in 4%, surgery was recommended. Almost 1% of the consultations resulted in air ambulance flights, in which a specialist team had to travel to the local hospital and perform surgery or support local surgeons on site. One per cent of the consultations resulted in local doctors rejecting the proposals for surgery made by specialists.

Transmitted medical information

The development of email services in the region at the end of the 1990s and the introduction of the software DORIS (12) facilitated the technical exchange of information between health care institutions. In 1996–2004, around 4,700 images were transmitted. Of these, 45% comprised X-ray pictures. Images of optical microscopy examination accounted for 30%: histological sections and material for cytological examination using both exfoliative and aspiration methods. In third place, with 10%, were images of the patients' skin and mucosa in the case of dermatological conditions, wounds and injuries, characteristic images of skin colour, facial expression, and so on. ECGs accounted for 7%. Documentation represented 4%, and another 4% comprised tests or other types of examination such as endoscopy, EEG and ultrasound (see Table I). With still-image transfer it is not technically possible to transmit patients' movements and manner of speech, auscultation data or surgical procedures.

Required specialists and specialties

The number of specialties requested varied between 18 and 26 per year (see Table II).

Every year, teleconsultations involved neurosurgeons (4 times in 1996–97, 31 times in 2004), orthopaedic surgeons (2 in 1996–97, 25 in 2004), traumatologists (6 in 1996–97, 19 in 2004), anaesthesiologists (26 in 1996–97, 3 in 2004), thoracic surgeons (22 in 1996–97, 28 in 2004), radiologists (7 in 1996–97, 30 in 2004),

gynaecologists (7 in 1996–97, 3 in 2004) and specialists in infectious diseases and resuscitation. The need for other specialists varied from a single consultation (for example, with specialists in burns) to many consultations. The requested experts were most often specialists in injuries and orthopaedics (18%), pathology/cytology (15.5%), pulmonology (15%), various surgical disciplines (11%) and cardiology (9%). (See Table III).

Table I. Teleconsultations within Arkhangelsk region in 1996–2004: number of images transferred from districts to Arkhangelsk.

Picture types	1997 n(%)	1998 n(%)	1999 n(%)	2000 n(%)	2001 n(%)	2002 n(%)	2003 n(%)	2004 n(%)	Total n(%)
X ray	110 (40)	127 (51)	183 (50)	395 (55)	195 (41)	316 (50)	281 (34)	433 (38)	2040 (45)
Cytology/cross-section	4 (1)	24 (10)	55 (15)	125 (17)	187 (39)	127 (20)	381 (47)	516 (45)	1419 (30)
Skin	37 (14)	68 (28)	67 (18)	92 (13)	16 (3)	88 (14)	41 (5)	74 (7)	483 (10)
ECG	31 (12)	11 (4)	15 (4)	72 (10)	45 (9)	59 (9)	59 (7)	53 (5)	345 (7)
Ass. tests	86 (32)	12 (5)	28 (8)	16 (2)	10 (2)	20 (4)	12 (1)	17 (2)	201 (4)
Documents	4 (1)	5 (2)	18 (5)	22 (3)	30 (6)	19 (3)	53 (6)	34 (3)	185 (4)
Total	272 (100)	247 (100)	366 (100)	722 (100)	483 (100)	629 (100)	827 (100)	1127 (100)	4673 (100)

Table II. Teleconsultations within Arkhangelsk region in 1996–2004: number of specialists/participants and specialties per consultation made from regional hospitals.

Specialists from regional hospitals	1996–97	1998	1999	2000	2001	2002	2003	2004	Total
Total	124	81	113	167	178	213	262	319	1457
Number of specialists	2,2	1,5	1,4	1,2	1,3	1,2	1,3	1,3	1,3
Number of specialties	18	19	26	26	24	25	21	22	32

Table III. Teleconsultations within Arkhangelsk region in 1996–2004: the most requested specialties from regional hospitals: "Eight on the top."

Specialties	1996–97	1998	1999	2000	2001	2002	2003	2004	Total
Total	124 (100)	81 (100)	113 (100)	167 (100)	178 (100)	213 (100)	262 (100)	319 (100)	1457 (100)
Cytologist	0	1 (1)	3 (3)	13 (8)	20 (11)	23 (11)	64 (24,5)	70 (22)	194 (13)
Thoracic surgeon	22 (18)	11 (14)	7 (6)	23 (4)	20 (11)	23 (11)	25 (10)	28 (9)	159 (11)
Cardiologist	0	2 (2,5)	7 (6)	14 (8,5)	15 (8)	24 (11)	19 (7)	33 (10)	114 (8)
Neuro-surgeon	4 (3)	2 (2,5)	5 (4)	7 (4)	20 (11)	15 (7)	25 (10)	31 (10)	109 (7,5)
Specialist in injuries	6 (5)	4 (5)	9 (8)	13 (8)	17 (10)	23 (11)	18 (7)	19 (6)	109 (7,5)
Radiologist	7 (6)	13 (16)	2 (2)	10 (6)	4 (2)	11 (5)	14 (5)	30 (9)	91 (6)
Orthopaedic surgeon	2 (2)	2 (2,5)	11 (9,5)	14 (8,5)	3 (2)	13 (6)	4 (1,5)	25 (8)	74 (5)
Intensivist	26 (21)	2 (2,5)	9 (8)	9 (5)	11 (6)	4 (2)	4 (1,5)	3 (1)	68 (5)

A total of 32 specialities were involved on the receiving side: 7 different disciplines in surgery, 10 in internal medicine, and the rest with leading-edge competence in psychiatry, radiology, cancer, tuberculosis and medical genetics. In total, there were 13 medical fields in which teleconsultations took place (see Table IV).

Over the time, the proportion of planned teleconsultations increased: from 9% in the start-up phase to 97.5% in 2004 (as shown in Fig. 1). During the period 1996–2004, an average of 15% of the consultations took place in connection with acute situations, while 85% were planned.

In the first two years, 1996–1997, the average number of doctors per consultation was 2.2. During the entire period, there were 1,457 requests for specialists, that is, an average of 1.3 per consultation (see Table II). The number

of specialties increased from 18 in 1996 to 26 in 2000. As well, new health disciplines have become the subject of teleconsultations, such as medical genetics, psychiatry and urology.

DISCUSSION

The result of the project described is an established and functioning region-wide telemedical network created from scratch in terms of communications and methodology. This experiment of transferring foreign knowledge and experience and developing them in north-West Russia appears to have been successful. The statistics show that even after the project was finished in May 2001, the network has continued to grow and gather its own experience and momentum; it is, in our opinion, the greatest achievement of collaborators from

Table IV. Teleconsultations within Arkhangelsk region in 1996–2004: medical fields which made majority in teleconsultations number.

Medical fields	1996– 1997	1998	1999	2000	2001	2002	2003	2004	Total
Number of consultations	56 (100)	53 (100)	79 (100)	141 (100)	135 (100)	182 (100)	201 (100)	245 (100)	1092 (100)
Injury/ orthopaedy	7 (13)	8 (16)	22 (27)	32 (24)	14 (10)	22 (12)	38 (19)	51 (21)	194 (18)
Cytology/ histology	2 (4)	9 (17)	7 (9)	20 (14)	29 (22)	18 (10)	44 (22)	41 (17)	170 (15,5)
Pulmonology	4 (7)	6 (11)	2 (3)	17 (12)	25 (19)	21 (11)	45 (23)	47 (19)	167 (15)
Surgery	5 (9)	4 (8)	7 (9)	16 (11)	15 (11)	26 (14)	10 (5)	37 (15)	120 (11)
Cardiology	0	5 (9)	2 (3)	13 (9)	11 (8)	11 (6)	20 (10)	33 (13,5)	95 (9)
Pediatry	3 (5)	1 (2)	3 (4)	9 (6)	3 (2)	49 (27)	3 (1)	2 (1)	73 (7)
Hematology/ nephrology	3 (5)	1 (2)	8 (10)	5 (4)	7 (5)	12 (7)	24 (12)	13 (5)	73 (7)
Dermatology	3 (5)	8 (15)	7 (9)	0	5 (4)	7 (4)	5 (2,5)	8 (3)	43 (4)
Gynaecology/ Obstetrics	20 (36)	1 (2)	2 (3)	1 (1)	10 (8)	2 (1)	3 (1)	1 (0,5)	40 (3,5)
Endocrinology	0	6 (11)	9 (11)	6 (4)	3 (2)	2 (1)	4 (2)	7 (3)	37 (3)
Intensive	9 (16)	2 (4)	9 (11)	3 (2)	4 (3)	5 (3)	2 (1)	0	34 (3)
Neurology	0	0	0	17 (12)	6 (4)	5 (3)	3 (1,5)	3 (1)	34 (3)
Infectious	0	2 (3)	1 (1)	2 (1)	3 (2)	2 (1)	0	2 (1)	12 (1)

both sides of the border. The discussion below is based not only on Norwegian experience but also on elaborations made by Russians themselves.

The work in the network

Empirical results show that in practice, in order to put teleconsultations into routine operation, a PC, a digital camera and communications equipment are adequate. It is important that all participants in the network use the same software and share the same methodological approach and electronic templates to ensure the coherence and consistency necessary for providing useful and high quality medical information.

The deployment of the central telemedical station at REC has helped to improve communication between health staff in the rural areas and regional health care institutions. In many cases, the need to use an air ambulance with specialists from RiA and/or other regional health care institutions was questioned. Although general hospitals in outlying districts have the medical expertise to treat most of the cases, telemedicine will help to strengthen the regional health care service by providing instant access to colleagues specializing in the management of complex or unusual cases (6). This means that the local population has better access to specialized medical help, which is important in sparsely populated districts. (13)

The work principles in the network have not changed significantly since the establishment phase. The list of specialists shows involvement and responsiveness on the consulting side (as shown in Table 3). During teleconsultations, considerable specialist support was provided to the doctor responsible for the patient, who was then able to offer highly qualified medical assistance.

Communication between the sender and recipient

The use of telemedicine solutions in the medical process helps to speed up the delivery of medical help and increase its quality substantially at all levels. The analysis of the consultations corresponds to the results obtained from the summary of the practical use of telemedicine in other regions of Russia (14):

(1) Consultations between doctors and specialists are useful in diagnosis as well as for decisions about and control of treatment. Sometimes district doctors have problems in interpreting the results of examinations undertaken using modern equipment. They then need advice from one or more specialists with leading-edge competence. In addition, strategies for treatment and intervention can be discussed.

(2) Preparation of team for call-out to rural areas. Advance information about patients makes it easier to gather the right specialists and equipment to provide the most highly qualified and specialized medical help possible for patients who, for health reasons, cannot be moved to regional health care institutions.

(3) Monitoring of patients after treatment in regional health care institutions.

Teleconsultations meet many different needs: verification of diagnosis; advice about treatment; quality assurance and competence development at district hospitals; easier access to specialists with the greatest expertise in the health disciplines in question (15). The principal indications for teleconsultations in Arkhangelsk correspond to those in other regions (16).

As well as the medical aspects, organizational issues were also discussed: the need for admission and selection of the most suitable

alternative for the hospital and transport. Some proposals from district doctors were rejected after in-depth evaluation by leading specialists who recommended that conservative treatment could replace surgery, or who felt that the patient's condition or illness was so serious that the operation could not be recommended at all. This confirms that consultations are not only a tool for diagnosis and treatment of patients but they can also enable the transfer of competence and the development of knowledge as well as help professionals overcome isolation (17). The use of appropriate diagnostic methods strengthens the value of teleconsultation; after about a third of teleconsultations, additional examinations were recommended. Both the rejection and confirmation of suspected diagnoses, especially serious ones such as cancer or tuberculosis, result in optimal treatment through the correct selection of the treatment location and method. In addition, patients' uncertainty can be reduced, so that their satisfaction is increased. nOne example of this is teleconsultations on foot wounds in patients with diabetes. In rural areas without diabetes specialists, such patients were often on the brink of undergoing surgery. Teleconsultations with regional diabetes specialists, based on photographs of the foot and case summaries, led to correction of the insulin dose and helped to prevent amputation of toes or feet.

Patients/cases

Teleconsultations were used in connection with a very wide variety of diseases and conditions (as shown in Table IV). Complex diseases in the same patient sometimes make it difficult to provide a clear distribution. In such cases, the requester prioritizes the diseases according to the primary requirement.

The medical technology available locally also influences the range of telemedicine consultations that can be conducted. For example, before the introduction of telemedicine, pathological samples from Narjan-Mar were sent by passenger aircraft. As early as 2000, when the telemedicine station there obtained advanced medical equipment which enabled transmission of microscopy images, cytology and histology accounted for 32% of the consultations, and the diagnostic process in the case of cancer and other serious diseases became easier and faster. The procurement of computer tomography in Korjazma has also resulted in more local examinations of the brain diseases and therefore more consultations with neurosurgery specialists.

During the first two years when telemedicine was new, interesting and relatively untested, several consultants attended the same consultation. In the same period, there were also a high proportion of emergency consultations when up to 9 specialists at the same time were required to respond to the case.

During the period 1996–2004, the structure of the consultations changed. The ratio of acute to planned consultations in the start-up phase, 91% to 9%, respectively, changed to the opposite in 2004, with 2.5% to 97.5%, respectively (as shown in Fig. 1). The need for specialities increased (as shown in Table II). The number of planned teleconsultations grew steadily – that is, telemedicine was used to an increasing extent for “traditional” purposes such as radiology and dermatology.

Telemedicine has been used to solve a wide variety of medical problems, as shown by the overview of specialties requested. Other areas of health were introduced (as shown in Table 4). To some extent this reflects changes in local needs with respect to the medical disciplines.

Transmitted medical information

The number of images transmitted exceeds the number of patients involved in consultations, because complex image packages are sent to illustrate a patient or a case, when X-ray images, dermatological images, ECGs and so on may be transmitted together. This applies in particular to the cases with complex problem formulations/diagnoses. The breakdown of the images reflects the prevailing profile of the consultations (pulmonology, cytology, injuries, surgery) and the range of illnesses. One can read about a similar distribution of images for still-image transfer in neighbouring countries such as Ukraine (18).

The fact that 45% of all images transmitted comprised X-ray pictures corresponds to the problems presented in the teleconsultations, where 44% were due to injuries, surgery, orthopaedics and tuberculosis or pulmonary diseases (as shown in Tables I and IV).

Radiographic examination is the most important diagnostic tool in such diseases. Images of sections and smears made up 30%, reflecting the fact that 15.5% of all the consultations concerned pathology. Similarly, 7% were ECGs, in line with the 9% of all the consultations which related to cardiology.

Telemedicine consultations are highly relevant in the areas of orthopaedics and injuries, especially in the large regions with an insufficiently developed transport network and the enormous distances between the local and specialized agencies as in the Arkhangelsk region. The patients' mobility is limited and they are treated at local hospitals. It is thus both difficult and unnecessary for these patients to travel to regional centres for follow-up. Most of these consultations

involved electronic transmission of X-ray images. In addition, orthopaedic surgeons and traumatologists showed interest in the use of telemedicine right from the start-up phase (17).

The limitations of still-image transfer were not regarded as an obstacle. Specialists were able to make the most of the patient information transmitted and discussed by telephone.

According to health statistics for the Arkhangelsk region (9,19) there may be indirect indications of the benefits of telemedicine in practice. For example, The hospital in Narjan-Mar serves a dispersed population of some 42,000 living in the Nenets territory, which covers 176,000 sq. km. (20). The nearest highly specialized competence institution is RiA, and the only means of transportation is a 2-hour flight on certain weekdays. In 1998, cancers discovered at a late stage accounted for 34% of all cancer cases in this region. In 2003, the proportion of cancers discovered at a late stage in this region fell to 25% of all cases. This may be the result of earlier diagnoses of cancer cases, in which the telemedicine station established in 2000 may have played an important role, since every third (32%) of all consultations from this station included cytology.

Health-economic analyses

Health-economic evaluation shows that the introduction of telemedicine in the region was useful. In many cases, teleconsultations replaced expensive air travel, especially in rural areas which only had air links with Arkhangelsk, and air ambulance flights. Studios in rural areas have been used for consultations not only for the local population but also for patients from other neigh-

bouring areas. This may indicate measures which saved travel for a much higher number of potential users. (21).

The same research shows that health services at regional health care institutions cost almost twice as much as at district and urban hospitals. In 1996–1997, the average length of stay at regional health care institutions was 19 days, compared with 15 days at district hospitals. Local treatment, when telemedicine services provide help and support for local health staff and patients, will thus enable substantial savings in the health budget.

The fact that, in many cases, teleconsultations replace travel for patients or doctors is very important, especially when patients cannot be transported because of the state of their health. Routine examination of patients with the help of telemedicine, such as the submission of tests, sections and X-ray images, also reduces the time needed for diagnosis. All this indicates that teleconsultations result in substantial savings for the health budget in the region (22).

Qualitative improvement of diagnostic processes and more effective use of the equipment in district hospitals lead to shorter hospital stays and rational use of hospital beds, which in turn reduces expenses (23). One example is the acquisition of a CT scanner in Korjzhma in 2000. By 2001, the number of neurosurgical consultations relating to brain injuries had quadrupled to 20 (11% of all teleconsultations in Korjzhma) from 5 (4%) in 1999. Specialists provide highly qualified help and advice early on in the progression of a brain disease, especially since there is no neurosurgeon employed at the city hospital in Korjzhma. North Norway offers examples of the rational

use of equipment supported by telemedicine in outlying areas, such as teledialysis in Alta and Hammerfest, which do not have specialist competence in nephrology (24).

Prospective activities

The regional telemedical network strengthened not only international but also interdisciplinary collaboration. The number of medical specialities involved in the consultations has been growing. By providing better access to information and its reusability, the network can continue to promote and develop a multidisciplinary approach to telemedical consulting for the patients' benefit. From the methodological perspective, the development of a multidisciplinary approach and widening of the range of telemedical services are the principal objectives for future network development.

From the technical side, the network will develop according to the resources, availability and accessibility of telecommunication services as well as the development of associated medical information systems such as Electronic Patient Records (EPR) and Clinical Information Systems (CIS). The transition from analogue dial-up to digital xDSL would be possible if enough financing could be found: it would create completely new possibilities for the amount of data and speed of its delivery, but it would also mean changing the routine that has been developed as well as introducing new telemedical services. The introduction of EPR, CIS and Radiology Information Systems will necessitate the integration of telemedical solutions with different information systems – a major challenge for the system which has been used as a stand-alone application for many years.

Conclusions

In 2001, the Ministry of Health in Russia and its coordinating council for telemedicine commented: "This investment has more than proved its value. The telemedicine network in the Arkhangelsk region is one of the most efficient telemedicine centres in Russia. It is noteworthy that they were all opened, not by order, but because life itself proved the need for and the benefits of telemedicine" (25). "Already, telemedicine is no fantasy, but a reality, and an everyday activity for many people." "Many local enthusiasts do not wait for external initiatives, but start actively introducing telemedicine activities as part of the practice at health care institutions. The experience from Arkhangelsk deserves our attention" (26).

It should be noted that this project was begun before the concrete parameters and development plans for successful telemedicine systems in the northern territories had been proposed (27). However, participants in the network empirically determined the necessary conditions for the successful functioning of the network.

The article is based on data recorded and collected over a long period. Despite the fact that the network launch was concluded on 31 December 1999, as planned, the work is continuing and the network is being extended throughout the region. It has therefore been both informative and interesting to follow the development of telemedicine and the health statistics in the Arkhangelsk region after the project ended. The source material was fairly detailed.

At the same time, it may be a shortcoming that data were collected from different sources. Despite this limitation, the benefits

of telemedicine in practice are clear. The telemedicine network in Arkhangelsk region is of interest from the perspective of health politics and medical disciplines because it applies telemedicine in practice on a fairly large scale. The fact that the network has shown sustainable development for many years after the project ended shows that telemedicine can and should be used in areas lacking a highly developed infrastructure. Simple solutions adapted to existing communication systems can save lives and improve health.

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