National centre of telemedicine

University Hospital of Tromsø

Telemedisinsk avdeling RiTø

An economic evaluation of telemedicine in north-west Russia

Elena Dzedzelava
Arkhangelsk, Russia
Trine S Bergmo
National Centre of Telemedicine,
University Hospital of Tromsø, Norway

01.03.00

Table of contents

Summary

An economic analysis of a telemedicine service in Arkhangelsk was carried out. The telemedicine service is a still image network, and they use specially equipped studios, trained personnel, suitable software and communication lines for transmission of still images from the local sites to the central TM-studio at the RHA. The transmitted images might be x-rays, ECG print-outs, images of skin lesions. Specialists at the RHA make diagnoses based on still images and additional written information, work out treatment plans and, if necessary recommend more diagnostic tests. A physician at the local hospital is then able to provide qualified medical care with assistance from a senior specialist in Arkhangelsk. The costs of using still images in providing health care services to patients in local hospitals in the region were compared to the costs of alternative methods of treatment. The total annual workload in 1997, 1998 and the first nine months of 1999 was 31, 45 and 45, respectively. Most of these patients (60 to 71%), approximately half of them from Kotlas, would have travelled by train with a guardian if telemedicine had not been available. The telemedicine service was cost-effective in Kotlas but not in Velsk, Onega, Nyandoma, Koryazhma and Severodvinsk. The savings in Kotlas, however, covered losses in these other regions. Too low workload, the absence of air transfer as an alternative, the lack of information to doctors about telemedicine opportunities and the absence of preliminary economic calculations might explain these results.

Introduction

Telemedicine in north-west Russia is a joint project between the National centre of telemedicine at the University Hospital of Tromsø and the Regional Hospital of Arkhangelsk (RHA). The telemedicine project was established in 1994, with the RHA delivering specialist care to patients in local hospitals using telemedicine. This service has partly been financed by the National Centre of Telemedicine and the Health Department of the Arkhangelsk Regional Administration. The project has also received considerable financial support from the Norwegian Ministry of Foreign Affairs, the Barents Euro-Arctic Region and the Inter-Reg Barents Programme.

One of the main tasks of the project 'Telemedicine in North West Russia' was to use telemedicine in providing health care services from the RHA to patients in local hospitals in the region. By using specially equipped studios, trained personnel, suitable software and communication lines, the ambition was to offer a twenty-four-hour still image transmission service.

In this report the objective is to describe and analyse the costs and benefits of introducing this telemedicine service. The analysis was carried out as a cost comparison study in which the cost of telemedicine was compared to the cost of traditional methods of providing health care services to the population in the region.

The Arkhangelsk region

The Arkhangelsk region is located in the north-western part of European Russia and covers an area larger than France, almost 600 000 sq. km. The population, only 1,5 million, is mainly concentrated in the cities of Arkhangelsk, Severodvinsk and Novodvinsk. The rural population comes to 26% of the total, or about 390 000. The long distances between cities and villages - as in other northern regions - mean that communication is poor. During the long winter, transportation is especially difficult. Many settlements have year-round transportation by air only. Distance is a problem in providing satisfactory heath services to the population.

The health care system consists of three levels. The first level includes primary health care centres and rural hospitals, which provide health care services to chronic invalids, social and aged patients. Most primary health care centres have poorly skilled health care personnel and high labour fluidity. In most cases the local level does not offer patients specialised medical care. The second level is where patients receive intensive treatment and specialised care in district hospitals. This level is very important in the networking between the first and third levels of the health care system. Third level provides highly specialised medical care. Health care institutions at this level consist of a network of specialised hospitals organised under the Health Department of the Arkhangelsk Regional Administration. The network includes the Regional Hospital of Arkhangelsk (RHA), the Regional Children's Hospital, two mental hospitals, and a number of dispensaries, skin-venereal, cancer, TB, alcohol and drug abuse prophylactic centres.

The Health Insurance Fund (HIF) and public budgets are the main financial sources for the public health services. HIF is funded by prepaid monthly insurance contributions made by businesses, institutions and other legal entities in the region (2,5% of the monthly salary of all employees are paid as a premium to the HIF). The HIF covers both in- and outpatient costs at the hospitals (including drugs) and all health care personnel costs. Travel to hospitals and

health care clinics is paid for by the patients, regardless of the distance. As a consequence, people in rural areas have to bear high travel expenses if they need to see a specialist at the RHA.

Challenges for the Russian health services

The economic crisis in Russia started in the middle of August 1998, and affected health care services as well as the rest of the Russian economy. Out-of-control inflation created a massive increase in health care costs without any increased transfer of funds to cover these costs. As a consequence of tight budgets there has been no investment in modernisation of the rural health institutions**,** so they remain poorly equipped. Evidently, the quality of health care for remote populations has been poor. The Arkhangelsk region is also facing health care challenges due to the ecological problems caused by i) pollution from the pulp, paper and timber industries in Arkhangelsk, Novodvinsk and Koryazhma, and ii) the centre of nuclear submarine industry in Severodvinsk and the cosmodrome "Plesetsk". As a result, the rates of cancer, skin diseases, asthma and TB are the highest in the Russian Federation.

Still, public health care authorities in the region provide high quality health care given the great distances, sparse population, considerable number of remote settlements and the lack of means of communication and transportation. All these challenges including the marginal economic situation, make telemedicine applications possible means of improvement. In this perspective, the implementation of telemedicine is considered important with particular reference to quality, safety and cost-effectiveness.

The telemedicine network in Arkhangelsk

Teleconsultations in the Arkhangelsk region have been used for a variety of medical purposes. The demography of the Arkhangelsk region, with its scattered population creates many challenges in emergency situations at the remote sites. Many of the local communities do not have roads or railways linking them to the outside world. Air transport is used all year round, while sea and river transport is a possible option only during summer and autumn. This situation required a special emergency centre in order to co-ordinate the need for emergency transfers of patients and health care personnel. The Regional Emergency Centre (REC), which is a department of the Regional Hospital of Arkhangelsk (RHA), was established to fulfil this need.

A telemedicine workstation was set up at the Regional Emergency Centre in 1995. Telemedicine consultations between the RHA and local hospitals began with Kotlas in 1996, then five other sites followed (tab1).

Table l. Six local telemedicine sites participate in the still image network

District	**Population**	**Distance from RHA**	**Established**
Kotlas	110 000	650 km	03.96.
Velsk	70 000	500 km	01.97.
Koryazhma	40 000	700 km	02.98.
Nyandoma	40 000	400 km	05.98.
Severodvinsk	245 000	50 km	05.98.
Onega	45 000	400 km	12.98.

The local hospitals were selected for the telemedicine network based on both their financial status and the human resources available, as well as the size of the local population and the presence and frequency of specific diseases which could benefit from teleconsultations. It was expected that this network, would not only increase the volume of teleconsultations, but also provide more knowledge about the effects of telemedicine in general, as well as improved quality and efficiency.

The telemedicine service is a still image network. The use of specially equipped studios, trained personnel, suitable software and communication lines makes daily transmission of still images from the local sites to the central TM-studio at the RHA possible. The transmitted images might be x-rays, ECG print-outs, images of skin lesions, etc. Specialists at the RHA make diagnoses based on still images and additional written information, work out treatment plans and, if necessary recommend more diagnostic tests. A physician at the local hospital is then able to provide qualified medical care in the shortest possible time with assistance from a senior specialist in Arkhangelsk.

Table 2. Number of TM consultations from regional hospital (Jan 1996 - Oct 1999)

Hospital	**1996**	**1997**	**1998**	**1999**	**Total**
Kotlas	12	49	20	23	104
Velsk		10	7	6	23
Koryazhma			11	5	16
Severodvinsk			3	1	4
Nyandoma			8	13	21
Onega			3	9	12
Total	12	59	52	57	180

180 teleconsultations had been carried out in the region by October 1999 (table 2). The number of patients involved was 130 which indicates that some patients have generated more than one teleconsultation.

The telemedicine activities are based on simple, low-cost technology; a PC, camera and the VIDA-system. The VIDeo image acquisition and Analysing system VIDA, is a Windows PC-based system for collection, storage and transmission of still images using the telecommunications network. The software is built up around the consultation concept, with each case consisting of a number of images and textual patient information. The VIDA system makes it possible to capture, add text to and send still images from one site to another using modem links. VIDA was originally developed by Telenor R&D in Tromsø and is now a freeware application (http://www.telenor.no/fou/english/freeware/vida/).

Alternative methods of providing health care services

Telemedicine services have so far been a supplement to the traditional methods of health care provision in the Arkhangelsk region. It is still important to focus on the traditional methods, both to improve routines and to establish whether telemedicine is a suitable supplement to the health care provision or not.

1. Patient travel to specialist on referral from local doctors

Patients in remote areas often have to spend a lot of time and money travelling to Arhangelsk for health care. Most of the patients travel by train. Today practically all travel expenses are

paid by patients. Patients travel to the RHA for examination on referral from a local physician. Children and patients in need of assistance are accompanied by health care personnel or a guardian, but usually patients travel alone. Using telemedicine, some of patients might avoid a journey, saving both time and money.

2. *Specialists travel to see the patients.*
The Regional Emergency Centre (REC) organises emergency services in the region. The REC decides whether patients need emergency transfer to the RHA or not. In cases where there is no real danger to the patient's health, consulting specialists travel by car, train or plane, depending on the seriousness of the case (table 3). The REC also co-ordinates journeys to local clinics. Travel costs are not a critical aspect and are therefore considered relatively moderate for regular transport, with the exception of leasing air transport, which is expensive. A more critical aspect are the considerable losses of specialist resources at the central hospital where patients also need specialist care. For the RHA, this means losing specialist resourses in a variety of medical fields; traumatic surgeons, neuro-surgeons, anaesthetists, haematologists, etc.

Table 3. Specialist travel to outlying districts 1996-98.

means of transportation	1996		1997		1998	
	number of calls	%	number of calls	%	number of calls	%
by air ambulance	349	39,1	338	39,7	329	39,1
by plane	271	30,4	256	30,1	234	27,8
by train	68	7,6	54	6,3	73	8,7
by car	204	22,9	203	23,9	205	24,4
Total	892	100,0	851	100,0	841	100,0

The scattered population and long distances between cities and villages in the Arkhangelsk region also mean that communication is poor. Many settlements have year-round transportation only by air. The Regional Emergency Centre organises air ambulances for transferring emergency patients and/or specialists; this is often the only practical option. In 1997 there were 338 flights and 329 in 1998. Some of these emergency transfers have now been replaced by teleconsultation (table 4).

Table 4. The share of teleconsultation compared to the total workload at REC in 1996-98.

	1996		1997		1998	
Number of calls	892	98,6 %	851	93,5 %	841	94,2 %
Number of teleconsultations	12	1,4%	59	6,5 %	52	5,8 %
Total	892	100 %	910	100 %	893	100 %

Method

A cost-effectiveness analysis[1] was used to evaluate the telemedicine service in this study. Assuming that telemedicine does not affect the patients' health outcome per se, but is merely a method of examining patients located at a remote site, an assumption of a constant health outcome was made. This implies that the transmitted images were assumed to be of sufficient quality to enable the medical specialists to recommend treatment based on such information and that this choice did not result in patients receiving poorer health care services. Evaluating various alternative ways of providing the services with similar health outcome is referred to as cost-minimisation analyses or just cost analyses.

For the present analysis a societal perspective[1,2] was adopted, as this takes into consideration both costs and benefits for all participants in the telemedicine programme; regional and local health institutions, the Health Insurance Fund, and patients.

Another important aspect to consider when evaluating new health care programmes is to determine break-even or threshold values, i.e. the annual workload required in order to make such an investment cost-effective. This is essential for planning purposes and for identifying new locations where the introduction of such health care services would be economically beneficial. In the economic literature this type of analysis is sometimes referred to as operation-without-loss analysis,[2,3] CVP (cost-volume-profit) analysis or operational analysis.[4] Operational analysis is often used to identify the operation-without-loss point or the critical point, that is, when costs and benefits break even, and there are neither gains nor losses. Recent publications recommend this method for planning activities in health care institutions.[6] Operational analyses bring together marketing research, cost-flow assumptions, financial analysis and volume planning.

One of the key issues when analysing telemedicine is the distinction between variable and fixed costs. This is due to telemedicine being relatively capital intensive and therefore the cost of developing telemedicine will be workload sensitive. The fixed costs are those which do not vary with the number of patients served, while the variable costs vary in proportion to number of patients. The cost-to-volume relation is presented using both tables and graphs, which both are simple and effective when illustrating the cost development and how the total costs depend on the annual workload.[5]

The cost calculation formula was derived from the equations:

$T = N_t \times V_t + C_t$
where:
T - total annual costs of the telemedicine service,
N_t - number of patients
V_t - variable costs
C_t - aggregate per annum fixed costs of the telemedicine service.

$A = N_a \times V_a + C_a$
where:
A - annual costs of the alternative method of treatment,
N_a - number of patients
V_a - variable costs
C_a - aggregate per annum fixed costs of the alternative method of treatment.

Then: $N_t \times V_t + C_t = N_a \times V_a + C_a$

And the break-even value (N) is then calculated as follows:

$$N = \frac{C_a - C_t}{V_t - V_a}$$

The above formula considers only one alternative. Since this study is evaluating five local sites, the following formula describes the calculations:

$$N_{tj} \times V_{tj} + C_{tj} = \sum_{i=1}^{5} k_{tj} (N_{ai} \times V_{ai}) + \sum_{i=1}^{5} C_{ai}$$

where:

a) «j» is used to indicate the local TM sites, where j = I, II…VI and

I - Kotlas,
II - Velsk,
III - Koryazhma,
IV - Severodvinsk,
V - Nyandoma,
VI - Onega.

b) «i» is used to identify the type of alternative service, were i = 1, 2..5 and

1. Patient travels to the RHA accompanied by medical personnel on referral from a local health clinic
2. Health care personnel travel to the district by air ambulance organised by the Regional Emergency Centre
3. Specialists from the RHA travel by train to the district to meet patients,
4. Specialists from the RHA travel by scheduled airplane,
5. Specialists from the RHA travel by car.

c) k_i = relation of the i-alternative to the total number of annual patient workload.

The following formula was used for calculation of telemedicine costs in the region:

$$\sum_{j=1}^{6} T_j = \sum_{j=1}^{6} C_{tj} + \sum_{j=1}^{6} N_{tj} x V_{tj}$$

For calculation of alternative service cost, the formula was

$$\sum_{j=1}^{6} Aj = \sum_{j=1}^{6} \left(\sum_{i=1}^{5} C_{ai}\right) + \sum_{j=1}^{6} \left(\sum_{i=1}^{5} N_{ai} x V_{ai}\right)$$

Data

The information used in this study was gathered using the following sources:

1. The Regional Emergency Centre and the RCH's expense budgets, annual financial statements and staff schedules,

2. Health care personnel pay scales,
3. Budget planning standards used in the public health care sector,
4. Teleconsultation research charts,
5. Annual accounts for 1997-98 from the Regional Emergency Centre, regional TM centre and local TM sites,
6. The Regional Emergency Centre and regional TM centres' registration forms for 1997-98
7. Railroad passenger fares.

Annual statistical and financial reports cannot give the complete, reliable information necessary for valid cost estimates. In order to acquire additional information about the costs of telemedicine, a research chart or questionnaire was worked out (see appendix 2). The forms were filled in for every teleconsultation carried out, and this provided information about (1) consultation type, (2) number of in- and outpatient consultations, (3) time used on preparation of and carrying out teleconsultations, (4) what alternative would have been provided, (5) in-patient treatment costs and cost of in-patient stay; (6) costs of paraclinical examination (cost of additional examinations, such as X-rays, ECG print-outs, images of skin lesions, etc.) required for remote consultations, and (7) transmission line costs.

Teleconsultation

Fixed costs

All TM sites have the following equipment; personal computers of various configurations, video-cameras (Panasonic SVNS or Sony), computer plates "Screen Machine II" and VIDA computer software. Information from the local sites was transmitted using e-mail at 28,8 – 33,6 kbit/s. For transmission of medical reports back to the local hospital, ordinary telephones were used.

For the present analysis an eight-year lifetime was assumed for the equipment. The discount rate was set to zero, and the annual maintenance cost was assumed to be 4 percent of the purchasing price (these assumptions are based on recommendations made by the Russian authorities i.e. regulations assumed for planning purposes within the health care system).
.
Different commissioning time were taken into account for the equipment when calculating the costs. The purchasing price of the equipment bought abroad was estimated at the rouble-dollar (or NKr) exchange rate on the date of delivery (see Table 1, page 3).

The costs falling to the TM centre at the RHA were included in the total fixed telemedicine costs and these costs were distributed in proportion to the number of patients involved from each district. The same approach was used to estimate the additional costs falling to the TM centre at the RHA of using health care personnel, communication lines and maintenance costs.

Variable costs

The annual variable costs included hourly wages (including social costs) for medical personnel and a technician at the central hospital and for physicians at the local TM site. Call costs for modem line transmission and long distance telephone calls were also included in the variable costs, in addition to costs related to the particular teleconsultation (x-ray films, developing costs, ECG-paper, etc).

The cost per patient depends on the number of teleconsultations per patient. The more teleconsultation per patient the higher cost per patient. For example, in 1997 there was an average of 2.3 teleconsultations per patient in Kotlas (49 consultations for 21 patients), whereas only one per patient in Velsk (ten consultations for ten patients). Thus, the average variable costs per patient in Kotlas were much higher than in Velsk.

The difference in cost between certain types of still images depends on the costs of the requisite materials and the number of working hours nurses and lab assistants spent on the preparation and transmission of the still images.

Alternative methods of treatment

The costs included in the alternative methods were also divided into fixed and variable costs, because some of the costs related to each alternative were to be considered fixed, like down-time rent for the air ambulance, and some personnel and maintenance costs which run independent of the number of patient transfers.

The Regional Emergency Centre (REC) leases aircraft from Arkhangelsk Airlines and pays rent in the air time and down-time rent, the latter at a reduced price. With the present practice of concluding contracts with Arkhangelsk Airlines, these costs fall to the Regional Emergency Centre regardless of the use of telemedicine. Calculation of demurrage expenses was made in proportion to the number of flights.

The variable costs included the current market prices for travel (train and airline fares, price of fuel), hourly wages of health care personnel, standard travel allowance, and the cost of drugs and other medical supplies needed for treatment during the journey.

According to the reports, in 1997-98 the flying time for the air ambulance was on average two and a half hours. As a rule there were two physicians and a theatre nurse in the medical crew. The crew was transported to the airport and back to the hospital by motor transport belonging to the REC. Thus, the variable costs included the hourly wages of the medical staff, drugs and other medical supplies for one emergency flight, the driver’s hourly wage, car rental and fuel expenses.

Results

Details of the annual fixed costs and the variable costs for the telemedicine service and alternative methods of treatment are given in Tables 1-7 in Appendix 1. The annual workload for the alternatives analysed, based on the data obtained from the teleconsultation registration form, are shown in Table 5.

Table 5. Number of patients/teleconsultations and number of alternative services

Local TM site	Year	Total number of patients/ telecon-sultations (Nt)	Patient travel by train with a guardian (Na1)		Air ambulance (Na2)		Specialist travel by train (Na3)		Specialist travel by air (Na4)		Specialist travel by car (Na5)	
			n	k1 %	n	k2 %	n	k3 %	n	k4 %	n	k5 %
Kotlas	1997	21/49	15	71	3	14	1	5	2	10	0	0
	1998	18/49	6	33	4	22	7	39	1	6	0	0
	1999*	18/23	12	67	3	17	0	0	3	17	0	0
Velsk	1997	10/10	7	70	0	0	0	0	0	0	3	30
	1998	6/10	4	67	0	0	2	33	0	0	0	0
	1999*	5/5	4	80	1	20	0	0	0	0	0	0
Koryazhma	1998	11/11	11	100	0	0	0	0	0	0	0	0
	1999*	6/7	6	1	0	0	0	0	0	0	0	0
Severodvinsk	1998	3/3	0	0	0	0	0	0	0	0	3	100
	1999*	1/1	0	0	0	0	0	0	0	0	1	100
Nyandoma	1998	4/8	4	100	0	0	0	0	0	0	0	0
	1999*	6/12	5	83	0	0	1	17	0	0	0	0
Onega	1998	3/3	2	67	0	0	1	33	0	0	0	0
	1999*	9/9	4	44	2	22	3	33	0	0	0	0
Total	1997	**31/59**	15	71	3	14	1	5	2	10	0	0
	1998	**45/52**	27	60	4	9	10	22	1	2	3	7
	1999*	**45/57**	31	69	6	13	4	9	3	7	1	2

* Data for the first nine months of 1999.

The total annual workload in 1997, 1998 and the first nine months of 1999 was 31, 45 and 45, respectively. Most of these patients (60 to 71%), approximately half of them from Kotlas, would have travelled by train with a guardian if telemedicine had not been available (see Table 5).

The difference between the annual costs of telemedicine and the costs of the alternative methods of treatment are shown in Table 6. The annual costs of telemedicine amounted to 54 745 roubles assuming an 8-year equipment lifetime in 1997. For the sensitivity analysis, a 6-year lifetime and 5% social discount rate were used. The annual costs then amounted to 57 398 roubles (Table 6). The number of patients served was rather small - 31 per year (Table 5). The local TM site in Kotlas had the greatest financial savings. The annual workload there made up 68% of the total workload (21 patients out of 31). The introduction of telemedicine turned out to be cost-effective even with one patient, because in approximately 20 % of cases, telemedicine replaced the most expensive alternative - air ambulance flights. The telemedicine service in Velsk was not cost-effective due to insufficient workload (10 patients per year).

Further calculation, however, showed that 21 patients per year would have made telemedicine cost-effective in this district as well (Table 7).

Table 6. Financial results, 1997-1999.

Region	Year	Annual costs of telemedicine assuming an equipment lifetime of		Annual cost of alternatives in total	Financial savings assuming an equipment lifetime of	
		8 years	6 years and a 5% discount rate		8 years	6 years and a 5% discount rate
Kotlas	1997	36867	39109	91651	54784	52542
	1998	23236	25116	100261	77025	75145
	1999*	20870	21664	81319	60449	59655
Velsk	1997	17878	18289	9463	-8415	-8826
	1998	9177	12258	7335	-1842	-4923
	1999*	9649	10724	24651	15002	13927
Koryazhma	1998	14693	17019	9240	-5453	-7779
	1999*	10676	11822	5640	-5036	-6182
Severodvinsk	1998	7671	9014	2613	-5058	-6401
	1999 *	8161	9364	1810	-6351	-7554
Nyandoma	1998	6857	9950	2608	-4249	-7342
	1999 *	11370	12424	7074	-4296	-5350
Onega	1998	4690	6179	2191	-2499	-3988
	1999*	13333	19510	50637	37304	31127
Total	**1997**	**54745**	**57398**	**101114**	**46369**	**43716**
	1998	**66324**	**79536**	**124248**	**58014**	**44712**
	1999*	**74059**	**85508**	**170864**	**96805**	**85356**
in US $ by average 1997 exchange rate (5.78 rouble per 1 US $)	1997	9471	9930	17494	8022	7563
	1998	11472	13758	21492	10019	7734
	1999*	9573	11561	29607	20034	18047

* Data for the first nine months of 1999.

The total annual costs of the telemedicine service in 1998 amounted to 66 324 roubles, assuming an 8-year equipment lifetime. The costs of the alternatives were 24 248 roubles in total, making the financial savings 58 014 roubles (Table 6). Using a shorter equipment lifetime, the financial savings were 44 712 roubles. Kotlas was the only district where telemedicine was cost-effective. In Velsk, Nyandoma, Koryazhma and Severodvinsk telemedicine was more expensive than the alternative methods of treatment both in 1997 and in 1998. The savings in Kotlas, however, covered the losses in these other regions.

The total annual costs of telemedicine in the first nine months of 1999 amounted to 74 059 roubles with an 8-year equipment lifetime. The alternative costs of transportation with the given annual workload would have been 170 864 roubles without telemedicine.

The telemedicine service was cost-effective also for the first nine months of 1999. Financial savings due to telemedicine amounted in total to 96 805 roubles. Patients who were treated via

the telemedicine service would otherwise have travelled to the RHA in an air ambulance, the and air ambulance is an expensive alternative. Telemedicine produced financial savings in Kotlas, Velsk and Onega in 1999. At the other TM sites, the annual workload was to small to make telemedicine cost-effective. The total savings in Kotlas, Velsk and Onega however paid for losses at these sites.

Break-even values, i.e. annual workloads that would have made telemedicine cost-effective, are presented in Table 7. These values depend on the cost of alternative transportation. If air ambulance had been used as an alternative for the patients, telemedicine would have been cost-effective with only one patient (as for Kotlas in 1997 and 1998, and for Kotlas, Velsk and Onega in 1999). Whether telemedicine is cost-effective or not is very sensitive to both the cost of the alternative transportation and the annual workload. For example, the telemedicine service in Velsk would have been cost-effective with 22 patients per year in 1997. The actual workload was 10 patients. In 1998, however, the break-even level was at 10 patient per year while the actual workload was 6. These calculations show that the annual workload required for telemedicine to become cost-effective is in general very low and depend on the alternative treatment. In 1998 the break-even level for the different TM sites ranged from 8 – 19 patients on a yearly basis (Table 7).

Table 7. Break-even values

Region	1997		1998		1999 (9 months)	
	8-year	6-year and a 5 % discount rate	8-year	6-year and a 5 % discount rate	8-year	6-year and 5 % discount rate
Kotlas N_1	1	1	1	1	1	1
Velsk N_2	22	24	10	16	1	1
Koryazhma N_3			19	22	14	15
Severodvinsk N_4			18	22	18	20
Nyandoma N_5			14	16	11	16
Onega N_6			8	11	1	1

Figures 1 and 2 show the cost curves for TM and the curves for the total costs of not having used telemedicine, i.e. the alternative methods of treatment evaluated, labelled travel, in Kotlas and Velsk in 1998. The horizontal axes show the annual workload, the vertical axes the costs in roubles. The solid lines show the costs of telemedicine, the dotted lines the total cost of alternative transportation. The crossing point marks break-even values or the annual workload required to make the two options equally expensive.

Using Kotlas as an example, Figure 1 shows that the cost of patient travel increases more rapidly than the cost of telemedicine. This is due to higher variable costs, here costly transportation. The absence of a break-even point in Figure 1 illustrates that the telemedicine service is cost-effective for any annual workload.

Figure 1 Total costs for Kotlas in 1998

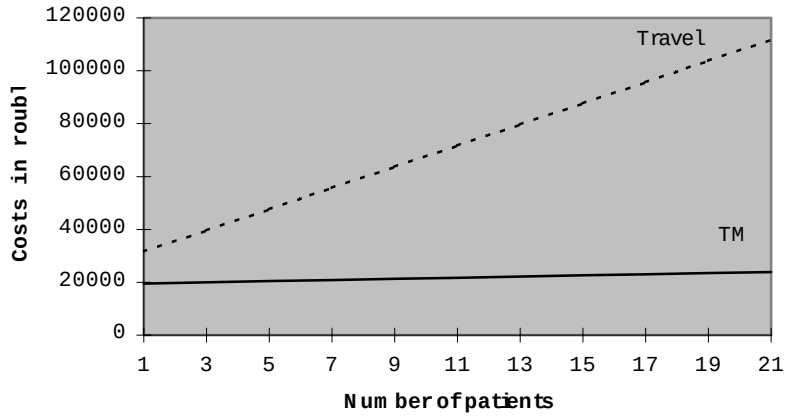
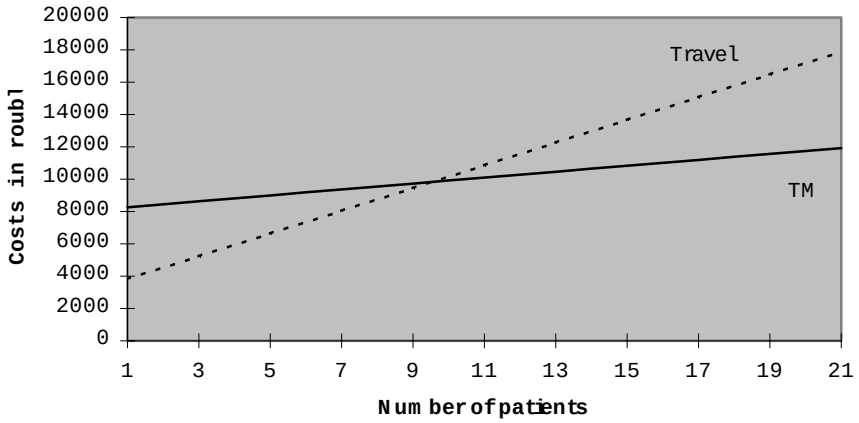


Figure 2 Total costs for Velsk in 1998



In Figure 2, Velsk is used as an example to illustrate that whether telemedicine is cost-effective or not, depends on the relationship between the costs of the alternatives under consideration and the annual workload. The figure shows that below 10 patients a year, travel cost less than telemedicine, and above 10 patients telemedicine becomes cost-effective. During this period only 6 patients were treated using telemedicine in Velsk.

Discussion

In assessing whether telemedicine is a cost-effective method of examining and treating patients at a local health centre or not depends on several interdependent factors. The most important one is the annual workload, but also equipment prices, the costs of the alternative methods, geographical distance, and assumptions about the cost structure will influence the result.

Methodological issues

Several simplifying assumptions were made in this economic evaluation. All cost figures are to some extent the product of the assumption made in their calculation. Therefore, they must

be interpreted in the light of local circumstances. What is cost-effective in one location might not necessarily be cost-effective in another. The key issue is hoe to take into consideration certain economic aspects that might aid decision making when determining resource allocation within the health sector.

For calculation of depreciation expenses, the equipment was assumed to have an 8-year lifetime, which is less than that officially set for public institutions (10 years) and more acceptable. 4-6 years lifetime for the hardware and clinical equipment is reasonable. For sensitivity analysis, it was assumed to be 6 years. With the constant advance of medical technologies and, as a consequence, their rapid obsolescence, such an annual depreciation index would be an absolutely unreal assumption. For example, a similar index of 6 years, was used for cost calculations at the University Hospital of Tromsø, Norway.[7]

The annual maintenance cost of 4 percent of book value, though questionable, was assumed in accordance with the existing regulations for expense budget planning in the public health service. In foreign practice, 5-15 percent maintenance cost is used[6].

In other countries economic evaluations of public health projects the discount rate is universally used for calculation of depreciation expenses. The bank interest on foreign credit is on average from three to seven percent. In practice, a 5 percent discount rate is used for sensitivity analysis of public health projects. In Russia the bank interest on credit amounts to fifty-five percent.

As the telemedicine project was a Norwegian investment its economic evaluation should meet international demands. Thus, for sensitivity analysis assumptions of a 5 percent discount rate and 6 years equipment lifetime were made.

The introduction of TM sites in the region was carried out under rather complicated economic conditions. As is generally known, a sharp increase in the inflation rate started in Russia in the middle of August 1998. Considerable changes in the economic life of the country caused by inflation were not accompanied, however, by increased budget assignments for public health care. In spite of the inflation rate, medical staff wages, travel allowances, the operating budgets for Regional Emergency Centre and medicine remained the same. Revaluation of capital funds was not carried out either. This, however, did not affect the results in this evaluation because railroad rates, air ambulance rental rates or personnel salaries did not increase in this period

Health outcomes

Lack of effectiveness data is one of the main problems when evaluating telemedicine[8]. Will telemedicine bring any benefits to patients' health, any increase in utility due to changes in the process of care, or is it just a method of providing the same service in a different manner? This study is based on the assumption that the only measure of outcome is image quality and that the image is of sufficient quality for the specialist at the RHA to recommend treatment.

A telemedicine network, in which diagnosis and treatment are based on still images and textual information might not provide the same quality of care as a referral to specialists at the RHA. The use of still images might affect the patients health per se in a negative manner. This

is an important issue to consider in future studies of using telemedicine networks, and would require a cost-effectiveness study.

Benefits like a more timely diagnosis and treatment may influence the patient recovery process and thus the patient's health outcome. Patients who avoid travel save both time and money. This effect, however, has not been documented in this study.

Financing of public health care in the region

Considering the results of telemedicine, the impact of this technology on the formation and movements of financial flows should not be overlooked. In this section it is necessary to give some information about financing of the medical institutions implementing telemedicine.

According to the present study, the major financial savings were due to reduction of the transfer expenses borne by the regional budget. The local telemedicine sites are operated at the expense of the regional budget. According to the study's estimate the regional budgets' share was 70% of the total costs in 1997 and 65% in 1998. The HIF`s and municipal budget share was insignificant, 6-7% of the total costs.

There is a significant difference between treatment costs per patient in regional and district hospitals. For example, in the Regional Hospital the cost of a course of treatment amounts to 1686 roubles, while in a district hospital the average treatment cost is only 868 roubles. The length of patient stay is also different, in the Regional Hospital it is on average 20 days, in district hospitals about two weeks. Thus, using remote consultations, the HIFs' expenditure on in-patient treatment can be reduced by half by means of shortening the treatment terms.

In the region, the telemedicine service gives substantial economic effects in the reduction of budgetary transfer expenses, in saving patients time and money, and in rational use of the HIFs' resources. The total economy due to the difference between the tariffs was 24 879 roubles in 1997, in 1998 17 289 roubles, and in 1999 19 200 roubles. Considering that in 1998 the number of patients in the Regional Hospital and, consequently its financing from insurance sources, were not reduced, we may conclude that telemedicine has a favorable influence on the effectiveness of hospitals having TM studios.

Other hospital costs per patient are also cheaper for the municipal budgets than for the regional budget in Arkhangelsk hospitals. In 1997, the total savings due to these differences were 18 782 roubles, and in 1998 5 797 roubles.

Positive results were was achieved in terms of use of beds at the Regional Hospital. In three years, the number of in-patients served was not reduced, and accordingly the volume of financing from HIF was not reduced. Thus, we can conclude that telemedicine had a positive influence on the efficiency of the work of in-patient hospitals equipped with telemedical communication facilities.

However, effective functioning of the telemedicine centre mayhave the effect of lowering the number of hospital beds at the RHA and, as a consequence, cutting its financing. This issue should be approached with particular caution, as the reduction of beds may involve reductions in the staff, which is far more skilled than the staff of district and local health care centres.

Before making decisions concerning the restructuring of hospital resources and a possible staff reduction, the following issues should be properly analysed:

1. The influence of expected telemedicine service volumes on the structure of hospitalized patient,
2. Possible hospitalization waiting time,
3. Utilization of beds in the Regional Hospital and district health centres,
4. The professional training standards of local specialists,
5. The possibility of professional control and correction of diagnosis and treatment in district hospitals,
6. Lowering of the number of hospitalized patients and potential cuts in financing,
7. Expected volume and structure of the reduction of beds and respective staff reduction.

One of the favourable factors of the introduction of telemedicine is the possibility of selection of patients needing specialized care in the regional hospitals with high costs of treatment and hospital stay.

The following case illustrates the potential of telemedicine in saving patients` lives, at the same time avoiding considerable transfer costs.

In 1997, a nineteen-year-old woman was admitted to Kotlas town hospital instead of the RHA due to bad weather. She was diagnosed: twenty-five-week pregnancy, histosis, nephritis, pyogenic haematoma of the thigh muscle, septic pneumonia, infantile cerebral palsy, respiratory insufficiency (stage 2-3), secondary myocarditis. Usually such extraordinary cases are under the care of the Regional Hospital specialists, but as transportation of the patient was impossible, the case would have required several emergency transfers of the medical crew. Because of the very complicated diagnosis, the treatment lasted 64 days; the patient was under the care of the town hospital specialists and the senior specialists from the Regional Hospital - therapists, resuscitators, thoracic surgeons. During the treatment, 21 remote consultations were carried out and 114 still images were transmitted - 84 radiographs, 15 clinical analyses, 15 functional examinations of various kinds. Having avoided emergency transfer, the economic result amounted to 38 500 roubles.

Indices of the calculated optimal workload of the centres do not allow us to estimate planned indices for local studios due to great differences in means of transportation, namely the high cost of air ambulances and relatively low cost of other means of transport. We should take into consideration that in districts with little use of the air ambulance the workload has to be high (Nyandoma, Severodvinsk, Koryazhma). On the other hand, it would be wrong not to pay attention to the low workload of studios in Velsk, Kotlas and Onega where the results of telemedicine use are positive. The potential of all studios are not limited to 3-11 consultations a year.

For the receipt of material for teleconsultations there are two medically trained technicians on the Emergency Centres' staff, working in two shifts. In view of the average time for consultation, one hour, the annual workload should be at least 1500 consultations. Besides remote consultations, part of the working time of the technicians is spend on operating video conferences in the Regional Hospital, going on missions to the outlying districts, and methodological work connected with instruction and staff education. But, even with all these tasks, starting and closing time included, the yearly workload of 52 consultations is obviously insufficient.

Recommendation
The introduction of any modern medical technology strives for two main goals: improvement of health care and minimization of expenses. It is evident that telemedicine answers this purpose. Practically all studies in this field, both in Russia and abroad, speak of considerable savings. There are a lot of factors that make this technology economically beneficial for all participants in the project as well.

Regions with undeveloped transportation infrastructures, with insufficient numbers of beds in local hospitals, and with a minimum number of specialized departments should be viewed as sites for the location of telemedicine studios in the future. For example, in winter only air ambulances are used for emergency medical help to the inhabitants of the Mezensky, Leshukonsky, Primorsky and Pinezhsky districts. On average 20-70 flights are made annually to these districts. It should be mentioned, however, that telemedicine can not supplant the air ambulance totally as most calls are made in cases where surgery and anesthetization are necessary. The use of telemedicine will avoid unnecessary calls, will give more time for proper preparation of medical crews for flights, will help doctors to follow up patients after operations and choose patients for hospitalization in the regional centre. Moreover, regular consultations in complicated cases will result in increased proficiency among local medical staff.

Conclusion

The use of remote consultations makes medical advice from any specialist from the regional centre rapidly available to inhabitants of remote districts. The method involves transmission of still images by means of communication networks. Mostly remote consultations are used for radiographs, skin examinations, laboratory analyses, and functional examinations. It makes it possible to avoid using time on expensive patient transfers to Arkhangelsk and to reduce travel by specialists to outlying districts. One of the advantages of the new technology is effective use of equipment in local hospitals. Bettering the quality of diagnoses shortens treatment and, consequently, leads to efficient use of hospital beds within the framework of the programme.

In two years, the number of remote consultations was low and did not considerably influence the visiting service volume; 6.5% of total number of the calls in 1997 and 5.8% in 1998 (see Tables 1 and 2 in the Appendix). The situation of the local telemedicine sites in well-equipped highly specialized hospitals, with sufficiently skilled medical staff accounts for this.

The results of the work of TM sites in Nyandoma, Koryazhma and Severodvinsk were negative because of their low workload, the absence of air transfer as an alternative, lack of information to doctors about telemedicine opportunities, its economic in-efficiency and the absence of preliminary financial calculations.

Nevertheless, the findings of the study showed that the introduction of telemedicine was justified with minimum patient workloads. The sum saved on the budget amounted to 201 098 roubles or 38,076 US $ at 1997 prices by the average 1997 exchange rate (5.78 roubles per US $) due to the fact that TM consultations replaced expensive air transfers from Kotlas, Velsk and Onega. In the districts where other alternative services were used, TM consultation was

also cost-effective with comparatively small numbers of patients (15 to 20) and the real equipment lifetime of 6 years.

References

1. Drummond MF, Stoddard GL , Torrance GW. *Methods for the Economic Evaluation of Health Care Programs*. Oxford: Oxford University Press,1994.
2. McIntosh E, Cairns J. A framework for the evaluation of the telemedicine. Journal of Telemedicine and Telecare 1997;3: 132-9
3. Bakanov M.I. *Theory of economic analysis*. M: Finance and Statistics.1993:260-262;
4. Colin Drury . *Costing an introduction.* Chapman and Hall .1994:271- 290;
5. Áîêàð¸â A. *« Ñåìü íîò ìåíåäæìåíòà»*:Ýêñïåðò 1998:335-340
6. Äîëãàÿ Â.Ì. *Êîìåð÷åñêàÿ äåÿòåëüíîñòü â ó÷ðåæäåíèÿõ çäðàâîîõðàíåíèÿ* . M.1997:241-250
7. Bergmo TS *An economic analysis teleradiology versus a visiting radiologist service*. Journal of Telemedicine and Telecare 1996;2:136-42;
8. Lobley D. *The economics of telemedicine*. Journal of Telemedicine and Telecare 1997;3:117-25

APPENDIX A

Table 1. *Costs of the telemedicine service in 1997*

	Kotlas	Velsk	Total
Fixed costs Ctj:	**28,291**	**16,752**	**45,043**
Equipment depreciation costs	6,420	5,871	12,291
Maintenance costs	257	235	492
REC permanent employees' wages	15,269	7,521	22,790
Communication line annual rent	1,447	713	2,160
Operational costs	4,898	2,412	7,310
Variable costs Ntj x Vtj	**8,576**	**1,126**	**9,702**
1. Common for all types of teleconsultations:			
Hourly wages of consulting specialists in RHA (two employees)	867	177	1,044
Hourly wages of physician in the local hospital (one employee)	333	68	401
Modem line transmission charges	3,234	240	3,474
Long distance telephone charges	2,156	400	2,556
2. Individual teleconsultation costs:			
Supplies for radiological consultations and technician's annual wages	1,510	160	1,670
Supplies for histological consultations and lab assistant annual wages	80		80
Supplies for functional and laboratory consultations and annual nurse's wages	396	81	477
Annual variable costs Vtj	408	113	313
Total annual costs Tj	**36,867**	**17,878**	**54,745**

Table 2. *Costs of the telemedicine in 1998*

	Severodvinsk	Nyandoma	Kotlas	Koryazhma	Velsk	Onega	Total
Fixed costs Ctj:	**7,135**	**6,040**	**19,331**	**13,060**	**8,080**	**4,194**	**57840**
Equipment depreciation	3,882	2,416	5,351	3,954	3,550	1,993	21,077
Maintenance cost	155	97	214	158	142	77	843
REC permanent employees' wages	2,051	2,279	8,660	5,697	2,735	1,367	22,790
Communication line annual rent	388	517	2,328	1,423	776	388	5,820
Operational costs	658	731	2,778	1,828	877	439	7,310
Annual variable costs Ntj x Vtj	**536**	**817**	**3,905**	**1,632**	**1,097**	**497**	**8,484**
1. Common for all types of teleconsultations:							
Hourly wages of consulting specialists in RHA (two employees)	53	141	354	247	124	53	972
Hourly wages of physician in the Local hospital (one employee)	24	56	138	97	48	21	384
Modem line transmission charges	54	144	1,320	497	168	82	2,247
Long distance telephone charges	54	240	880	532	280	137	2,123
2. Individual teleconsultation costs:							
Supplies for radiological consultations and technician's annual wages	351	92	1,017	277	444	92	2,273
Supplies for histological consultations and lab assistant annual wages	0	0	196	0	0	112	308
Supplies for functional and laboratory consultations and annual nurses' wages	0	144	0	0	33	0	177
Annual variable costs Vtj (per patient)	179	204	217	148	183	166	189
Total T	**7,671**	**6,857**	**23,236**	**14,693**	**9,177**	**4,690**	**66,324**

Table 3. *Costs of the telemedicine in 1999 (9 month)*

	Severodvinsk	Nyandoma	Kotlas	Koryazhma	Velsk	Onega	Total
Fixed costs Ctj:	**7,858**	**9,952**	**17,252**	**8,961**	**8,748**	**11,497**	**64,267**
Equipment depreciation	3,087	2,663	4,,400	2,928	2,723	5,367	21,168
Maintenance cost	123	107	176	117	109	215	847
REC permanent employees' wages	2,857	4,415	7,791	3,636	3,636	3,636	25,969
Communication line annual rent	1,188	1,836	3,240	1,512	1,512	1,512	10,800
Operational costs	603	931	1645	768	768	768	5,483
Annual variable costs Ntj x Vtj	**303**	**1,418**	**3,618**	**1,715**	**901**	**1,836**	**9,791**
1. **Common for all types of teleconsultations:**							
Hourly wages of consulting specialists in RHA (two employees)	9	90	172	52	38	68	429
Hourly wages of physician in the Local hospital (one employee)	19	230	442	134	96	173	1,094
Modem line transmission charges	13	18	34	410	7	264	747
Long distance telephone charges	12	360	810	399	160	251	1,992
2. Individual teleconsultation costs	250	720	2160	720	600	1080	5,530
Annual variable costs Vtj (per patient)	303	236	201	286	180	204	218
Total T	**8,161**	**11,370**	**20,870**	**10,676**	**9,649**	**13,333**	**74,059**

Table 4. *Travelling expenses borne by medical institutions for the patient coming on a refferal accompanied by medical personnel.*

Items of expenses	Year	Kotlas	Velsk	Nyandoma	Koryazhma	Onega
Patient's railroad fare	1997-1998	217	177	143	237	133
	1999 9 month	217	177	143	237	133
Travelling allowance for accompanying person	1997-1998	428	388	354	448	344
	1999 9 month	443	403	369	463	359
Accompanying person wages for the days of travel (with charges on payroll)	1997-1998	155	155	155	155	155
	1999 9 month	240	240	240	240	240
TOTAL in rubles	1997-1998	800	720	652	840	632
	1999 9 month	900	820	752	940	732

Table 5. *Emergency transfer costs by air ambulance (in roubles).*

Items of expenses	Kotlas		Velsk	Onega
	1997-1998	1999 9 month	1999 9 month	1999 9 month
Fixed costs (annual) *Ca3*:	**22278**	**17173**	**5921**	**11547**
Aircraft down time rent	21954	16873	5621	11247
REC staff wages (car drivers, administration), overhead costs	324	300	300	300160
Variable costs per one flight (total) *Va3*:	**15406**	**15516**	**15516**	**15516**
Time-in-the-air rent	15206	15206	15206	15206
Hourly wages of the medical personnel	140	190	190	190
Drugs	60	120	120	120

Table 6. *Consulting specialist travel cost by train or by air*

Items of expenses	Kotlas			Velsk, Onega, Nyandoma	
	1997-1998		1999 9 month	1997-1998	1999 9 month
	by train	by air	by air	by train	by train
Fixed costs (annual) Ca 3,4	3990	1338	3009	3121	2340
Variable costs (per one trip) Va 3,4:	**717**	**1212**	**1329**	**667**	**974**
Travelling allowance	450	1000	1000	400	544
Hourly wages of the medical staff	207	152	209	207	310
Drugs	60	60	120	60	120

Table 7. *Consulting specialist travel by car*

Items of expenses	Velsk	Severodvinsk	
	1997	1998	1999 9 month
Fixed annual costs, Ca5	1003	1125	1125
Variable costs per one trip, Va5:	1140	496	685
Fuel and travel allowence	500	207	250
Hourly wages of medical personnel	580	229	315
Drugs	60	60	120

APPENDIX B

Forma 1.

Arkangelsk State Medical Academy
Teleconsultation analysis chart

1. Central District (Town) Hospital _____
2.Patient`s name _____
3. Age _____ Case history number _____
4. Treatment at the place of residence :Central District Hospital ;Central Town Hospital ;district ;divisional ; rural hospital . (underline)
5. Teleconsultation type _____
6. Routine ,emergency consultation (underline)
7. In-patient, out-patient treatment (underline)
8. Consultation date _____ Time taken for preparation of and carrying out the consultation.
9. Time spent at the hospital (days)_____ , time before the consultation included_____
10. Health outcome after stay in the hospital : improvement ; worsening ; without change ;lethal ; (underline)
11. Actual cost of stay in hospital per day _____ , including Regional Medical Insurance Funds' expenses_____
12. Actual cost of paraclinical examination _____ , including personnel wages _____ , drugs _____
13. Diagnosis at the time of referral to the consultation _____
14. Diagnosis made at the consultation ._____
15. The degree of diagnosis accuracy : absolutely accurate , rather accurate , approximate . (underline)
16. Reasons for the referral to the consultation: insufficient medical qualification ; for want of the specialist; other causes . (underline)
17. Measures taken if teleconsultation is unavailable: call of the specialist (emergency, by air; delayed, by train), referral to out-patient consulting hospital , telephone consultation. (underline)
18. Transmission of the TMC report was at the expense of: Central Regional Hospital; Central District Hospital; Central Town Hospital (underline)
19. The report was transmitted by: telephone; E-mail. (underline) Minutes _____ Charge

Head of the Department Date
(signature)