Analysing the Use of a Telestroke Service

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***Abstract*—Telestroke can facilitate remote cerebrovascular specialty consults from virtually any location within minutes of attempted contact, adding greater expertise to the care provided to any individual patient. In 2010, a Telestroke service was established between the three hospitals that constitute the Nordland Hospital in Northern Norway. The Telestroke service connected the neurological department at the central hospital with two small, local hospitals. The aim of our study was to implement a Telestroke service and explore if the benefits reported internationally could be achieved in the North Norwegian healthcare context. The study presented herein was based on Telestroke log data, field observations, semi-structured interviews and focus group discussions with the health personnel involved. After more than two years of operation, Telestroke consultations were described as successful. However, the frequency of use was much lower than the estimate before implementation, and the Telestroke service was terminated with the project conclusion. In this article, we ask why the service was terminated, and focus on the significance of the local context when establishing telemedicine services.**

Keywords- Telestroke; video-teleconferencing; consultation; cerebral stroke; local hospitals; local context

I. INTRODUCTION

The volcano ash incident in Iceland in April 2010, gave a reminder of how vulnerable the health services are in Norway without air transport. In May 2010, Northern Norway Regional Health Authority, decided to establish a telemedicine service for diagnosis and treatment of cerebral stroke patients in the Nordland Hospital (NLSH). A Telestroke service was implemented by connecting the two local hospitals, NLSH Vesterålen and NLSH Lofoten, to the Neurology department at the central hospital NLSH Bodø [1]. A pre-study estimate, based on the average frequency of stroke incidents in Norway and the number of inhabitants in the actual area, indicated that the two local hospitals receive an average of two patients with stroke symptoms every week; NLSH Vesterålen (1.25) and NLSH Lofoten (1.6). As the numbers are small, a fully specialized stroke unit with stroke specialists physically present day and night, seven days a week, is expensive and difficult to staff. Therefore, a "VAKe" [2, 3] compatible video-teleconferencing system (VTC) was installed in June 2010. After reaching an agreement on common procedures, revising and on-site training of local health personnel, the Telestroke service was operational from September 2010. It was utilized immediately at one of the local hospitals. At the second local hospital the usage was postponed until a specialized stroke unit was established, including the employment of a specialized stroke nurse and the furnishings of dedicated stroke rooms at the second local hospital.

Telestroke implies that the stroke specialist at the central hospital examines the patient in cooperation with the physicians and nurses at the local hospital, through VTC systems. Radiology images are transmitted using the RIS/PACS systems [4]. The recommended procedure was to make the Telestroke unit ready for transmission and call the central stroke specialist when a patient with stroke symptoms arrived, or was notify to arrive at the local hospitals. The on duty stroke specialist at the central hospital headed to a room dedicated to the Telestroke system.

For more than two years, the Telestroke service was used with success for a few patients with stroke symptoms in Northern Norway. However, the numbers were much lower than the estimate prior to the implementation of the system, and the Telestroke service was terminated with the project conclusion. In this paper, we discuss why the system is no longer in use, and focus on the significance of the local context when establishing Telestroke services.

II. BACKGROUND

Cerebral stroke is the third most frequent cause of death in Norway, and the most common cause of severe disability in adults. The annual incidence is about three per thousand inhabitants, where 85-90% is due to ischemic stroke. The

average treatment cost of one stroke incident is approx. NOK 600,000, adding up to a total annual cost of NOK 7.8 billion. Timely treatment and rehabilitation can reduce disability after stroke, improve quality of life and reduce costs [5, 6]. Hospitalization in a specialized stroke unit leads to a 10 % absolute reduction in mortality in the acute phase [5]. The prognosis for patients with ischemic stroke is further improved by thrombolytic treatment in the acute phase. The main challenge for optimal cerebral stoke treatment is the narrow time window. Thrombolytic treatment should be given as soon as possible, and not later than 4.5 hours after the first symptoms. The national registry of thrombolytic treatment [7] indicates that only 10 % of all stroke patients in Norway received such treatment, whereas 20 % is the recommended frequency by the Norwegian Health Ministry [6]. According to the register, the two local hospitals, in average, used thrombolytic treatment for one patient each during the four month periods reported in 2010 and 2011.

For stroke patients, it is crucial to decide on the cerebral stroke diagnosis and indication for thrombolytic therapy as soon as possible, and no later than 4.5 hours after the first symptoms. Telestroke networks are successful in Europe and the USA [8, 9]. In the Nordic Countries, a Telestroke network between the University Hospital in Helsinki and five local hospitals demonstrates increased frequency of thrombolytic treatment [10].

For cardiac stroke patient, pre-hospital stroke treatment in ambulances is the established procedure in Norway. In Germany, pre-hospital treatment in ambulances has also been tried for cerebral stroke patients [11]. The German study reports that pre-hospital cerebral stroke treatment in specialized ambulances equipped with a Computed Tomography (CT), point-of-care laboratory, and telemedicine connection reduced the median time from alarm to therapy decision substantially [11]. Implementation of CT-ambulances and pre-hospital treatment of cerebral stroke is discussed in Norway, and particular in Northern Norway were dispersed settlement and long travel distances to the nearest hospital is part of everyday life. An internal assessment from the University Hospital of North Norway concludes that the implementation of specialized stroke ambulances with existing mobile CT-equipment will not improve the emergency care for cerebral stroke patient in the northern region. On the contrary, the assessment recommends strengthening the procedures with in-hospital treatment of cerebral stroke patients in this region.

Telestroke can be used to guide and support the local physician remotely [12-16]. According to Audebert, 2006 and Audebert and Schwamm, 2009 [12, 13], the organization of Telestroke networks requires:

- Specialized stroke units in all hospital;
- Comprehensive and continuous education and training of the entire staff in the units;
- Stroke specialists available 24/7 on VTC, combined with teleradiology;
- Centralized organization of patient transfers.

The establishment and use of Telestroke network is consistent with the Norwegian Health Ministry's national guidelines for treatment and rehabilitation of stroke [6]. Telestroke consultations may be useful to decide on the best treatment for the patient, whether it is a conservative treatment, thrombolytic treatment or a more advanced neurological or neurosurgical emergency treatment. Telestroke is also helpful to support quick triaging and transfer to the appropriate unit. Although the decision to give thrombolytic treatment is seen as the end-point of the Telestroke consultation, this is just the beginning of care for the patient [8]. Post-thrombolytic care requires intensive cardiovascular and neurological monitoring, neurosurgical backup, and decision whether to keep the patient or to "drip-and-ship". Tele-consultation may also be useful for follow-up after the acute phase [8].

In Norway, there is limited experience with Telestroke. Some hospitals use remote CT images in combination with phone advice to support acute stroke treatment at small, local hospitals. The single documented service in Norway is between Haukeland University Hospital and the local hospital in Voss, which reports an increase in thrombolytic treatment [17]. Internationally, there is substantial scientific evidence of the medical impacts of Telestroke [12, 13, 18-23]. Several studies of Telestroke solutions including video, versus solutions without video, show that VTC may [24, 25]:

- Reduce the number of wrong diagnoses:
  7.1 % vs. 17.6 %, $p < 0.05$;
- Reduce death rate:
  1.3 % vs. 6.8 %, $p < 0.05$;
- Reduce needs for nursing homes:
  2.6 % vs. 5.4 %, $p = 0.58$.

Telestroke networks, where the experienced stroke specialists performs an evaluation and examination of the patient through a VTC system, and considers the indication for initiation of thrombolytic treatment, is comparable with face-to-face consultations [16]. In our study, the aim was to implement and organize a Telestroke service, and then explore whether the same benefits reported internationally were possible to obtain in a North Norwegian context.

In spite of limited experience with Telestroke in Norway, the nation has long experience with telemedicine, and particular in Northern Norway [26-28]. Unfortunately, in Norway as well as internationally, there is also a long track record of telemedicine services terminating after the pilot project is over [29-30]. The failures do not, in the majority of cases, represent technological problems, but rather human and organizational factors. Numerous studies show that the past failures of technological innovations with respect to improving health outcomes have not necessarily been due to their clinical ineffectiveness, but rather to social, technological and cultural issues relating to their implementation and adoption [31-34].

Hence, the rationale for this paper is to follow the Telestroke service, by studying the social and cultural context of the Telestroke service. The context of the health services has already proven to be important factors to ensure a functional and sustainable telemedicine services in this region [40-41].

III. MATERIALS AND METHODS

A. Research settings

The research was conducted at the three hospitals that constitute NLSH, in Nordland County, Norway. NLSH serves a geographical area with 131,000 inhabitants, and consist of hospitals in the city of Bodø and the archipelagos of Vesterålen and Lofoten. While Bodø is located on the main land, the district of Vesterålen and Lofoten are made up of several islands, see Fig. 1. NLSH Bodø is the largest hospital in the county, and acts as the central hospital of NLSH [3]. The two local hospitals are situated in a geographical area known for its wild and beautiful nature, long distances, small communities, a culture based on earning a living from the sea and extreme rough weather conditions. The intense weather conditions, particularly during the winter, often make it difficult, or even impossible, to use air transport for severely ill patients. Other types of transport from the local hospitals to the central hospital take between five to ten hours.

NLSH Lofoten is placed on the island Vestvågøy, Gravdal (see Fig. 1), which is located in the middle of the Lofoten Islands. The hospital serves approximately 24,000 inhabitants, has a surgical and medical emergency unit, and a maternity ward. NLSH Vesterålen is placed in the community of Stokmarknes (see Fig. 1), covers a geographical area with approximately 30,000 inhabitants. The hospital has a surgical and medical emergency unit and a maternity ward.

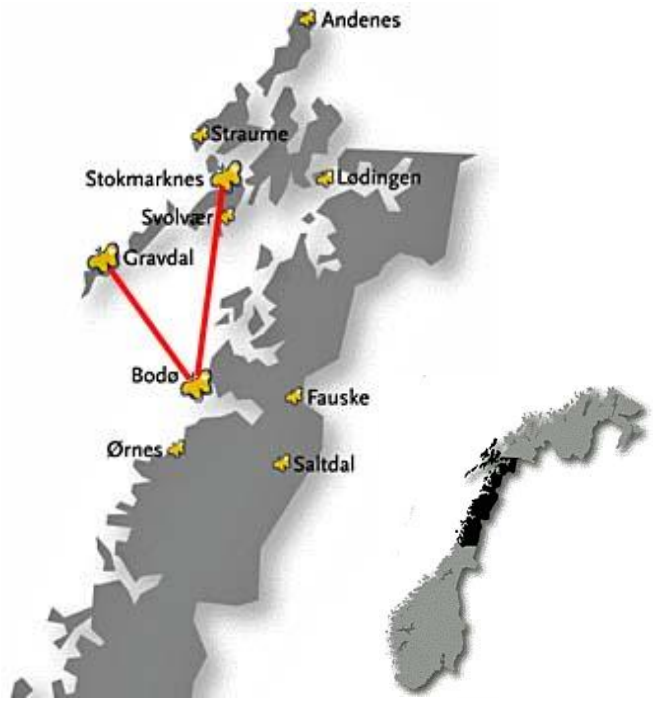

Figure 1. Nordland County, Norway.

In our study the Telestroke service was implemented simultaneously at all three hospitals, and was operative from September 2010. To ensure user confidentiality we will from now on use local hospital A and local hospital B.

At local hospital A, the Telestroke equipment was placed at the intensive care unit (ICU), while the mobile patient centered unit was placed in a small room connected to the emergency room at local hospital B.

To make sure that the technology was operational and worked flawlessly, to maintain the users' expertise and to educate new users, the implementers, Norwegian Centre for Telemedicine (NST), who implemented the service, recommended that each hospital tested the Telestroke solution regularly, and preferably once a week. The local staff agreed to use the system in the initial phase in accordance with these recommendations.

When a potential cerebral stroke patient arrived at one of the two local hospitals, a junior physician could be the first attending. At both hospitals, the procedure was to conduct a CT examination and collect the necessary blood samples as soon as possible. As already mention, the equipment was set up in the intensive care unit at local hospital A. At this hospital the Telestroke system was connected and made ready for a potential session by a nurse, while the patient had the CT examination. At hospital A the Telestroke service was only prepared upon request from a senior physician. This setting was different from local hospital B. Where the system was located next to the emergency unit and part of the nursing procedure was to move the system into position, connected it, and made it ready for use as soon the hospital was notified about an incoming stroke patient.

B. Materials

To implement a Telestroke service VTC equipment must be installed, at least one on each site. In this project, we decided to supply each of the hospitals with the same type of equipment, which reduces possible sources of error and eases user-support. Only minor local adjustments were made due to room configuration. The VTC equipment consisted of a Tandberg Quick set C60 and a Sony full HD (1080p) television, mounted on a mobile rack (see Fig. 2). The Tandberg Quick set C60 has the possibility to connect with medical equipment such as electrocardiography (ECG) together with two full HD (1080p) cameras. The system was also made ready for multipart conferences for communication between more than two locations. The total cost of each unit ready for use was approximately NOK 200,000.

At the central site, the Telestroke system was installed in a dedicated Telestroke studio. The studio had a computer equipped with two 24 inch displays; one display is devoted to the electronic patient record, and one to the CT images. At the two local hospitals, the VTC equipment (see Fig. 2) was mounted on mobile racks, enabling the equipment to be used in different settings such as treatment, education and meetings. The three Telestroke units were connected through the Norwegian Health Net (NHN) [35], which is a dedicated, secured network for health information, see Fig. 3, and were set up to use minimum 2Mbit for this communication.

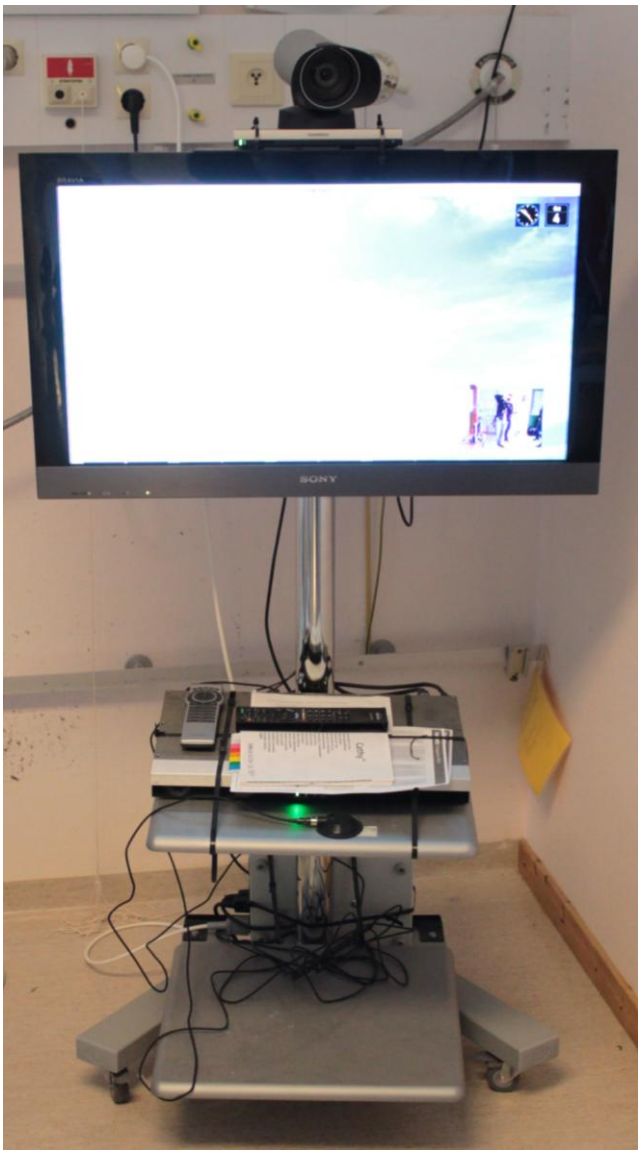

Figure 2. Telestroke equipment.

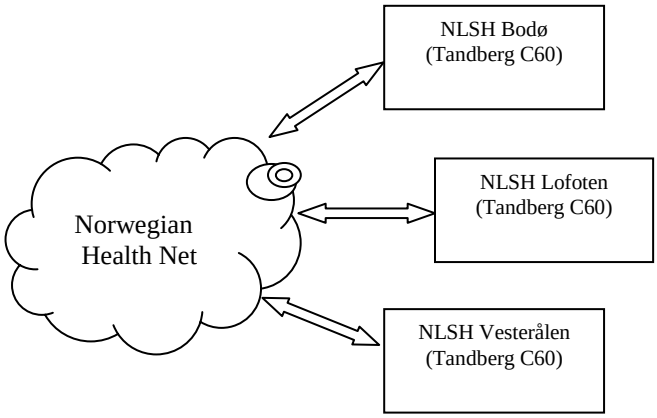

Figure 3. NLSH Telestroke service.

C. Methods

A qualitative, multi-method research approach has been used. Our interdisciplinary analytical approach is inspired by Science Technology Studies (STS) and Actor Network Theory (ANT) [36, 37]. We have followed the technology in use, with a particular focus on how Telestroke is used or not used in the local context. This approach is suitable to avoid both technical and social determinism [38]. Quantitative methods with control-groups were considered, but found non-ethical. It was also considered to include two similar hospitals as control-groups. This was however difficult within the empirical context of Northern Norway, and the framework of our study. The same counts for cost evaluation. As we will show, the numbers in the study are small, and not sufficient for cost analyses. The methods used were:

- Analysis of log data
- Field visits including observations and 15 semi-structured interviews with involved health personnel
- Focus group discussions

Our multi-method approach did not only capture research data, it was also helpful to ensure that the Telestroke system worked according to the plan. It revealed needs for follow-up actions like additional training and revision of procedures.

1) Analyzing Telestroke log data: Exploring and analysing log data is an adequate approach to gather a broad and general understanding of the Telestroke service. The log data indicates the year, date, time, length and frequency of the video and sound communication between the hospitals. Therefore, the study of log data is sufficient to explore the frequency and the length of the connections between the hospitals. It reveals use, as well as lack of activity or absence of Telestroke collaboration. In addition, to visualize the actual Telestroke activity, the study of log data is also a useful approach to map the number and the length of the training sessions, if and how often the hospitals are testing the equipment, if the system is used for other purposes, and the differences in use between the two local hospitals.

2) Field visit and semi-structured interviews: About a year after implementation, autumn 2011, we visited the three hospitals. During the field visits we spent time at the hospitals and in the different local communities. In addition to observations, the data includes informal conversations with health personnel and local inhabitants. Field observations were particularly useful to get an in depth understanding of the stroke treatment at the three hospitals, and to contextualize the Telestroke service in three different hospitals settings. It was also helpful to get an understanding of the visited area and the population.

Semi-structured interviews with the involved health personnel are a constructive approach for gathering the users' satisfaction and experiences with the Telestroke system. During the interviews health personnel reported on specific cases where Telestroke has been used or not used. For instance, why VTC was used or not, the age of the patient, time from onset of symptoms to hospitalization, if

the patient receive thrombolytic treatment or not, etc. The method is also sufficient for gathering information about health personnel experience with the technology and the online collaboration. In addition, semi-structured interviews can reveal potential differences between users, for instance between the remote neurological experts and the onsite local hospital staff. It may also detect technological obstacles or organization challenges with the Telestroke service.

We perfomed a total of fifteen interviews, six were done at the central hospital and nine at the local hospitals. The health personnel have been interviewed at their workplace; in their office, a meeting room, the nurses break room, in the corner of a hospital lounge, or in an empty patient room. Most interviews have been done individually face-to-face, two interviews were in groups, with two and four participants, and one by phone. The interviews were conducted in Norwegian, recorded and transcribed. The quotations used in this paper were translated into English. Throughout the study, we also had e-mail and phone correspondence with selected health personnel.

3) Focus group discussions: Focus group discussions with participants from all three hospitals was an adequate approach to get in contact with the everyday practice of cerebral stroke treatment. Similarities, differences and the dynamic character of the local practices are often revealed in group discussions [39]. Focus group discussions between health personnel from different institutions were also suitable to expose contextual and organizational aspect of the Telestroke service.

4) Ethical considerations: The study has been approved by the North Norwegian Regional Medical Ethics committee (REK). We have not studied patients.

IV. RESULTS

The Telestroke service in Northern Norway was in operation from September 2010 until April 2013. It was only used at one of the two local hospitals, and just for a total of four patients with acute cerebral stroke symptoms. After more than two years of service, the frequency of Telestroke conferences was considerably lower than expected. Telestroke was never integrated in daily practice at the hospital and the service was terminated by the end of our study.

Despite low frequency and lack of use, it is worth noting that the few conferences that were carried out were reported as successful, constructive and valuable. The conference quality was characterized as excellent. The video quality was good enough to detect pupil contraction and eye movements like nystagmus (a rapid, involuntary, oscillatory motion of the eyeball).

During the implementation of Telestroke, the project team strongly recommended to use Telestroke for all patients with acute cerebral stroke symptoms. Neither of the local hospitals followed this advice, but developed local, specific and confined Telestroke procedures. Even if the hospitals procedures varied, both hospitals limited the use of Telestroke for thrombolytic treatment.

The local staff at the hospital that used Telestroke (hospital B) was, in general, more committed to adopt the new service than the involved staff at local hospital A. However, as demonstrated in the four quotes below, physicians from all three hospitals mentioned the potential for using the VTC for additional clinical consultations. This could be other neurological disease, but also entirely different acute or none acute conditions with uncertain diagnoses and treatment.

Informant 1, local hospital:

"Yes, especially in neurology where the examination is particularly important. You know, it is subjective what you see, and how to interpret what you see. If you could get assistance from a neurologist under the examination… very useful!"

Informant 2, local hospital:

"I would like, say a telestudio that can be used for multiply purposes, for instance for interdisciplinary discussion about a cancer patient. I am thinking about the establishment of teams. ….That would have been excellent. I would like an examination and conversation room, where you can talk with the patient and demonstrated in a telestudio."

Informant 3, central hospital:

"I am very skeptical to telemedicine, so I might not be the right person to answer… No, what I would like to use it for is; if you look at YouTube on neurology, it is a lot of involuntary movements and odd symptoms, which is useful to visualize. That is what I would like to use it for. You know; strange movements by the arms, or eye movements that are different. It could be useful, but it is rare conditions."

Informant 4, central hospital:

"No, I think about different neurological conditions, which they (physician at local hospitals) are unsure about and need assistance to diagnose without putting the patient on a plane and fly him over here. I think about the patient. That's who I am concerned about. How to do stuff out there, without flying the patient over here to do the examinations? It must be useful for the patient, avoiding the strain and particularly for older sick people."

A. Hospital A

During the fall of 2011, at the time we did our field studies, a specialized stroke unit with a dedicated stroke nurse, a few beds reserved and adapted for cerebral stroke patients, was opened. Hospital A had one neurologist, five senior physicians, and several junior physicians. The neurologist was usually available during weekdays from 08:00-16:00, while the senior physicians also had second on-call duties, evenings and weekends.

The VTC equipment was mounted on a mobile rack to enable easy movement and use in different settings, though it was usually located in the intensive care unit. The new stroke unit, as well as the intensive care unit, was located on the third floor of the old hospital building. Narrow corridors, lifts and staircases made it impractical, if not impossible, to move the Telestroke equipment, for instance, to the emergency unit at the ground floor, where patients with cerebral stroke symptoms arrived. The laboratory and the CT

were also located at the ground floor. Due to room configuration, the Telestroke equipment could not be placed in the emergency unit. In order to use Telestroke, the patients had to be moved from the emergency unit or CT room at the ground floor, to the third floor and the intensive care unit. The placing of the equipment and the room outline in the old hospital building were described as impractical and time consuming for the use of Telestroke.

All the senior physicians were middle-aged men, who had been working at the hospital for several years. They had broad experience with treatment of cerebral stroke, and most weekdays' also access to local neurologist expertise. Patients with stroke symptoms were usually met by a junior physician in the emergency unit. In the cases where thrombolytic treatment was considered, the junior physicians' routine was to always consult a senior physician prior to initiating thrombolytic treatment or seeking remote cerebrovascular guidance. Remote assistance and using Telestroke were only considered in cases where the local team was uncertain about the best treatment for the patients.

When Telestroke was implemented, remote expertise from senior neurologists were available on weekdays, between 08:00-19:00. The Telestroke service was later expanded to include evening, nights and weekends. During this period, the Telestroke service could be staffed by a junior neurologist, while a senior neurologist was the second on call. Limited "opening hours", or access to a senior neurologist only weekdays and daytime, was a recurrent issue during the interviews. Due to these limitations most of the senior physicians were hesitant and doubtful about the benefits of the Telestroke service. In general, they emphasized that they had local access to equivalent stroke competence that Telestroke could offer from a distance.

At local hospital A, the use of Telestroke was limited to; the intensive care unit; thrombolytic treatment; senior physicians; nights and weekends. The Telestroke service was never used at the hospital.

B. Hospital B

While a specialized stroke unit was newly established at hospital A, such a unit had been in operation for several years at local hospital B. This hospital had trained stroke nurses, two rooms reserved and adjusted for cerebral stroke patients, and a rehabilitation unit for patients and relatives. The hospital had four senior physicians and several junior physicians, but no neurologist. Parts of the hospital buildings were modernized recently, although the major parts were old and not optimal for the work that was carried out. For instance, the emergency unit, which was the first stop for the patients, was located on the second floor. This was close to the stroke unit, still, on a different floor, and in a different part of the hospital than the CT and the laboratory.

Initially, the mobile Telestroke equipment was placed in a small room connected to the emergency unit. Part of the local stoke procedure was to connect the Telestroke system, and make it ready for all patients reported to arrive at the hospital with possible cerebral stroke symptoms. This was done by a nurse. The Telestroke equipment was later moved from the emergency room to a storage facility. The argument was not to occupy space in the emergency unit, as well as to enable alternative usage of the VTC equipment.

The stroke procedure at local hospital B was to use Telestroke to consult a neurologist at the central hospital in all cases where thrombolytic treatment was considered. Telestroke was used four times at the hospital. Prior to Telestroke, the hospitals procedure was to call the central hospital for thrombolytic assistance. Hence, Telestroke replaced the phone as a collaboration tool in cases of thrombolytic treatment. Telestroke, as a substitute for ordinary phone calls, was used on four out of five patients, where the one exception was referred to as a mistake. The hospital did not report delays in thrombolytic treatment when using Telestroke. On the contrary, and as the next quote illustrates, involved health personnel described Telestroke as superior to telephones.

Informant 5, central hospital:

"I think it (Telestroke) was useful because I could talk directly to the patient, which made it easier to assess the aphasia, and also to consider other parameters. He had some additional symptoms, which actually made us decide not to give thrombolytic treatment."

Telestroke can be considered a success at local hospital B. To illustrate the diverse outcome and the clinical value of the service, we have included three cases of use.

- A patient arrived at the local hospital with a diagnosis of possible cerebral stroke. After using the Telestroke service, this diagnose was dismissed and changed. No thrombolytic treatment was given, and the patient was discharged from the local hospital two days later.
- A patient with a heart transplant arrived with cerebral stroke symptoms. After using the Telestroke service, the patient was diagnosed with a possible severe rejection of the transplant. The patient was transferred by air ambulance directly to a specialized hospital in Oslo. No thrombolytic treatment was given.
- A patient with a possible cerebral stroke diagnosis and history of cerebral stroke. The patient had successfully received thrombolytic treatment one and a half year earlier. After using the Telestroke service, the patient received thrombolytic treatment successfully.

However, despite clinical value and positive experience at local hospital B, the frequency of use was considerably lower than expected. From September 2010 - April 2013, the service was only used four times. Throughout the project period, health personnel from all three hospitals were concerned about how limited use could lead to ambiguity and hesitations on how to operate the Telestroke equipment, and how this could be a threat to the long term success of the Telestroke service. After approximately two and a half years of service, this concern became reality. The initial enthusiasm and optimism for Telestroke had faded, and the central hospital could no longer justify spending resources on training and education. Consequential, on one occasion when local hospital B tried to use the Telestroke service, a remote

stroke specialist was no longer available. The Telestroke service in Northern Norway was closed down soon after.

V. DISCUSSION

The three cases of remote stroke collaboration illustrate how a Telestroke service can be useful for diagnosis and treatment of patients with acute cerebral stroke symptoms in Northern Norway. At one of the local hospitals, Telestroke was used for all patients where thrombolytic treatment was considered, except for one. Telestroke became a replacement for phone consultations regarding thrombolytic treatment and was described as constructive, valuable and superior by central stroke specialists and local health personnel. This corresponds with international studies published by Handschu, R. et al. and Meyer, B.C. et al. [24, 25].

The interview data shows that health personnel, in general, were positive to the use of telecommunication services. Nonetheless, in spite of affirmative attitudes and positive feedback, the frequency of use was considerably lower than expected, and the Telestroke service in Northern Norway was only used at one of the local hospitals.

Limited or lack of use raises interesting questions. In the following, we will focus on the local context of the Telestroke service, and start by discussing how we can understand the limited use in Northern Norway. Few or none studies were found on the significance of the local context when implementing Telestroke. This is unfortunate since the context is known to be significant to other telemedicine services in the region, geographical, contextual and organizational environment have proven to be of significance when implementing telemedicine services in the Northern Norwegian region [40, 41].

A Telestroke service in Northern Norway might face challenges that are not reported internationally. Northern Norway, as most parts of Norway, has dispersed settlement, small communities, and relative small hospitals. The numbers of acute stroke incidences in each hospital are low. Long distances and extreme weather conditions, particularly during winter time, might add time to the patients hospital transportation. Clinicians in the region have high turnover, and technical support is not available 24/7.

Successful, but limited use of Telestroke questions the estimated number of potential stroke patients in the region. Was this estimate too high? Local hospital B reported approximately 40 patients with an acute cerebral stoke diagnosis during a 12 month period, from March 2011 to March 2012 (also reported in Nilsen and Solvoll, 2012 [42]). Since our data identified the number of stroke diagnosis, and not the total number of patients that arrived at the local hospital with acute cerebral stroke symptoms, it is difficult to determine whether the initial estimate was too high. On the other hand, interviews with local health personnel confirm a weekly average of one patient with stroke symptoms at the local hospitals. Given that Telestroke was used for almost all patients assessed for thrombolytic treatment at one of the hospitals, limited use might consequently address the low frequency of thrombolytic treatment at the hospital, rather than the actual number of stroke patients in the region.

The main ambition for initiating a Telestroke service in Northern Norway was to improve the stroke treatment and to increase the thrombolytic frequency in the region. This was probably also a key motivation for the Northern regional health authorities funding of this project (HST-1019-11) [43]. The Norwegian health ministry recommends thrombolytic treatment for at least 20 % of all stroke patients [6]. These guidelines specify that treatment must be given as soon as possible, and within 4.5 hours of the debut of the stroke symptoms [6]. However, the Norwegian Registry on thrombolytic treatment (2012) indicates a national average of 10 % [7], and even lower in Northern Norway.

We asked the local physicians if the thrombolytic frequency could be increased in line with the health authority recommendations. A senior physician, informant 2, at one of the local hospitals answered: *"It can be increased to a certain extent, but it's not… We can do something with our procedures internally, but what's more important, or as important, is to catch the public's awareness about cerebral stroke symptoms'. Similar to what has been done with cardiac stroke, where most people know how important it is to get there (to the hospital) quickly."*

Lack of stroke awareness in the population and late incoming patients were highlighted as the main reason for the low thrombolytic frequency at both local hospitals. A rather relaxed attitude towards health and illness might not only be common, but even essential to live in an area where health care services traditionally have not been easily accessible. The two local hospitals are located in a region built on a cultural heritage of earning a living from the sea, known for its remoteness, its closeness to nature and the inhabitants pride in making-do and getting-on. This is a place where it is common to "sleep on it", which means to wait until the morning and see if the situation improves. Contextual aspects like; cultural heritage, closeness to nature, long distances and extreme weather conditions are of significance for how fast stroke patient and their next of kin seek professional health care.

Telestroke was only used to verify thrombolytic treatment. Only a small amount of the stroke patients in the region arrived at the local hospitals within the time frame for thrombolytic treatment. Consequently, the local context was not only of significance for the thrombolytic frequency in the region, it was also crucial for the use of the Telestroke service. In fact, it seems like the strong link between thrombolytic treatment and Telestroke was fatal to the long term success of the Telestroke service in Northern Norway. The low frequency of thrombolytic treatment did not only affect the usage of Telestroke at the local hospitals, it also had consequences for the central hospitals' attitude towards Telestroke. After more than two years of service, the total number of Telestroke conferences was still only four. Due to low usage, the central hospital could not justify spending resources on education and training of new personnel, and the Telestroke service in Northern Norway was closed down by the end of our study.

Local hospital A was a bit larger than hospital B. The hospital had one neurologist and five senior physicians who had been working at the hospital for several years.

Consequently, these physicians knew the hospital, each other, the stroke procedures, the population, and the region well. In addition, most of them questioned the added value of the Telestroke service. That is why, lack of use at local hospital A can be interpreted as an expression for the senior physicians' confidence in their own expertise, and the quality of the stroke treatment at the hospital.

The hospitals' room configurations and the location of the equipment, the newly established stroke unit and clinical practice, were additional aspects that reflected the lack of use.

The air ambulance service in Northern Norway might also have influenced the use of Telestroke. A well-functioning air ambulance service was described as essential for the safety of the population in small rural communities in Northern Norway. Air Ambulances was not exclusive for cerebral stroke patient, it included all emergency patients. Some of the senior physicians were concerned that remote support from medical expertise, like Telestroke, could jeopardize rather than expand the ambulance service.

VI. Conclusions and Future Work

The aim of our study was to implement and organize a Telestroke service to explore if it was possible to obtain the same benefits reported internationally in a North Norwegian context. The results show that usage has been limited to one of the local hospitals, and only for patients where thrombolytic treatment was considered. In total, this was just four cases. However, for all four cases, involved personnel at the local, as well as the central hospital, reported beneficial results for the patient, successful online cooperation for involved personnel, and excellent video and sound quality. Despite positive feedback, the numbers are small, and we cannot demonstrate the same clinical benefits as reported internationally. Our main finding in Northern Norway is low frequency and lack of use.

Our study shows that a Telestroke service depends on a complex interplay of different contextual and local aspects. Lack of stroke awareness in the population, cultural heritage, local in-house procedures, the local hospitals current staff situation, the senior physicians' confidence, the air ambulance situation, and weather conditions, also influences the use of Telestroke.

When implementing and organizing the Telestroke service in Northern Norway, the recommendation was to use Telestroke for all patients with stroke symptoms. This recommendation is in line with international literature, but was not followed. The two local hospitals limited the use of Telestroke for patients considered for thrombolytic treatment. It needs to be questioned if this practice might have terminated the Telestroke service in Northern Norway.

The next step of our research is to compare the Telestroke service in Northern Norway with a similar service in Western Norway. In Western Norway, the local hospital use Telestroke for all patients arriving with cerebral stroke symptoms [17]. It will also be interesting to compare a dedicated service like Telestroke with more general telemedicine services, using similar equipment, in small local hospitals.

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