Cost-minimization analysis of a wide-area teleradiology network in a French region

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Abstract

Objective. The objective of our study was to perform a cost-minimization analysis of a wide-area teleradiology network.

Design. A prospective analysis of all transmissions over 1 year (data transmitted at the time of the remote consultation, and health outcomes of patients from medical record).

Intervention. The inter-hospital teleradiology network of the Aquitaine area (RIHRA) is a telemedicine system enabling the management of remote emergencies and elective radiology consultations.

Main outcome measure. A cost-minimization study enabled a comparison of care procedures following the use of the network with those which would have been implemented without the network. The outcome measures of effectiveness were the transfers, hospitalizations, and consultations avoided or added. Fixed and variable costs were estimated.

Results. Among the 664 transmissions included in the study, 562 (85%) were performed in emergency and 102 (15%) for elective (non-emergency) cases. In emergency, 48% of transfers were avoided. For elective teleconsultations, a transfer was avoided for 37% of the patients and hospitalization for 12%. An extra consultation occurred after remote consultation for 2% of the patients. Annual saving can be estimated at 102 779 EUR for the Aquitaine area.

Conclusions. This study underlines the efficiency of an inter-hospital teleradiology network. A qualitative evaluation of the impact of the use of the system should be carried out to improve technical and organizational operations.

Keywords: cost-minimization analysis, costs, evaluation studies, technology assessment, telemedicine, teleradiology

Effectiveness analysis of telemmedicine has been the subject of many evaluation studies since the end of the 1980s. However, it has been demonstrated that telemmedicine was more effective than usual care only in certain instances: teleradiology (and more especially teleneurosurgery), telespsychiatry, transmission of echocardiographic images, and the use of shared electronic medical records. In 2001, a systematic review performed by Roine et al. examined 13 studies on teleradiology [1]. Among these studies, seven were related to teleradiology systems in the area of the neurosurgical emergency. All of these demonstrated their effectiveness. Among the six studies concerning teleradiology systems for elective teleconsultations the conclusions were mixed. The most commonly used outcome measures were the reduction of unnecessary transfers. Economic evaluations, mainly conducted in English-speaking countries, are scarcer. They tend to show the efficiency of telemmedicine [2,3]. In France, economic evaluation of teleradiology has been the subject of a single publication [4] that showed 65% of patients’ transfers to neurosurgical units in Paris and the surrounding areas could be avoided through teleradiology; cost savings varied, depending on the utilization rates of the network.

In 1995, the French administrative area of Aquitaine established a teleradiology system called RIHRA (Réseau d’Image Inter-Hospitalier de la Région Aquitaine). This system was installed in 15 public hospitals in the administrative area of Aquitaine, which covers a 41 400 km² (7.6% of France’s total area) with 2 908 300 inhabitants (Figure 1). Each workstation comprises a computer dedicated to the teleradiology, and a software (TSI Sigmacom™) making it possible to digitize films or to recover the computed tomography data in a DICOM format. After a JPEG compression and encryption, images are sent from a workstation to another using a secure ISDN point-to-point protocol. Each hospital taking part in the network has a department of radiology, with a radiologist carrying out necessary imaging studies. If necessary, a second opinion is sent to the referents for each specialty (neurosurgery,
pediatrics, and so on), localized on a reference hospital. The 
RIRHA’s objectives are to facilitate health care decisions, 
ensuring optimal care for patients, from both diagnostic and 
therapeutic viewpoints. Two main applications are available: 
the management of remote emergency cases (neuro-
surgery, traumatology) and distance (tele)consultations (for 
chronic health problems). The emergency departments 
that belong to the network use this system to back up health care 
decisions relating to therapeutic intervention and potential 
transfer of a patient towards a reference hospital. The indi-
cations for transfer are dependent on the direct benefit for 
the patient (therapeutic project, complementary investiga-
tion). For non-emergency teleconsultations, the transfer of 
images makes it possible for practitioners to obtain advice 
from an experienced peer (referent) concerning diagnosis or 
therapy.

The goal of our paper is to present a cost-minimization 
analysis of the RIRHA.

Methods

Study design

The cost-minimization study compared the care delivered 
using the telemedicine system with the care which would have 
been delivered without it. Considering that equivalence in 
effects will be obtained [5], the main hypothesis was that 
RIRHA enables savings. Only direct costs were taken into 
account [6]. The study was performed from the hospital’s 
point of view.

Study population

Prospective data collection was carried out for 1 year, from 20 
September 2002 to 20 September 2003. The 15 hospitals (17 
workstations) taking part in RIRHA were included in the 
study.

Inclusion criteria

The study population included all patients for whom a remote 
consultation for diagnostic or therapeutic advice in radiology 
took place in emergency (patient admitted in emergency or 
already hospitalized) and also all outpatient or in-patient cases 
outside emergency for whom a remote consultation occurred.

Exclusion criteria

Test transmissions and transmission of images after transfer 
of the patient were excluded. Transmissions for which 
information was lacking at the time of telecollection, or trans-
misions where medical record analysis did not provide 
information on the purpose of the transmission or on patient 
outcome, were also excluded.

Data collection

Data were collected following two steps:
1. Monthly telecollection by the committee for clinical 
evaluation and quality improvement in Aquitaine 
(CCECQA: Comité de Coordination de l’Evaluation Clinique 
et de la Qualité) of the data transmitted by a referring
hospital to a reference hospital, including transmission characteristics (sender and receiver hospitals and units, dates and times, transmission errors) and patient characteristics (identification, clinical data sent by the referring physician, proposals sent by the reference physician).

2. Data from patients’ medical record. Data were collected by a single medical doctor (from CCECQA) in all referring hospitals. When patients were transferred, data were collected from emergency registers and patient medical records in the reference hospitals. In emergency, a questionnaire tested in a pre-pilot study in one hospital was used to collect patients’ diagnosis, examinations, process of care intended by the referring hospital; diagnosis, examinations, and care procedures advised by the reference (receiving) hospital; and finally diagnosis, examinations, and process of care actually delivered. For the non-emergency cases, a questionnaire tested in a pre-pilot study in one hospital was used to collect patients’ clinical and radiological diagnoses having justified the transmission of images, decisions relating to the transfer and the therapeutic intervention, patient care, and final patient outcome. Completeness was checked by comparing the data telecollected and the data available at each transmission workstation.

**Outcome measures**

The main outcome measures were the proportion of transfers, hospitalizations, and consultations avoided. The transfers were defined for patient displacement which includes both patient transfers and visits to the reference hospital. The avoided transfers offered different types of cost savings that have been taken into account in the cost estimation: the avoided costs of transfers according to the means of transport, the avoided costs of hospitalizations and consultations. In emergency, the number of transfers avoided, with telemedicine, is equal to the total number of remote consultations minus the number of remote consultations that were followed by a transfer and the number of transmissions clearly not related to a transfer request. We have considered that, without telemedicine, the patient would have been transferred because it was the standard procedure before the implementation of the teleradiology network. Indeed, this procedure remains so in hospitals which are not part of the network. In emergency, an avoided hospitalization corresponded to remote consultation followed by discharge without hospitalization. For the non-emergency cases, the number of transfers, hospitalizations, and consultations avoided were calculated by comparing care intended by the referring hospital, without telemedicine, and care actually delivered.

**Cost calculations**

Costs taken into account were working costs of the network and costs related to an avoided or added care procedure (transfer, hospitalization, or consultation). When hospitalization was still needed, the costs related to an avoided transfer corresponded solely to transfer costs. In this case, we did not consider the hospitalization costs. To the extent that hospitalization costs in referring hospitals are usually cheaper than in reference hospitals (teaching hospitals who deliver ultra-specialized care), our study underestimated the saving costs because most of the patients remain on site following the teleconsultation.

**Fixed costs.**

1. Equipment costs per workstation: cost of purchase of the equipment necessary for the implementation of the network. The lifespan of the equipment was estimated at 7 years; on the assumption of a straight-line depreciation, the linear rate of depreciation can thus be estimated at 14.3%. The discount rate used was 5%, allowing calculating an equivalent annual cost (due at the end of the year).

2. Computer servicing: annual servicing costs per hospital.

3. Running costs per workstation: maintenance and energy costs.

4. Training costs per hospital: annual costs for staff training.

**Variable costs.**

1. Subscription to the system and transmission (connection) costs.

2. Salary costs of physicians during the time of use (transmission): the salary costs of physicians using RIHRA are not taken into account initially, but they are envisaged in the sensitivity analysis. In this case, the salary cost was estimated to be 60 EUR per hour. The time spent for one transmission was estimated to be 20 min for the referring physician and 60 min for the reference physician.

3. Costs related to the transfers of the patients: costs of the transfers supported by hospitals or patients were estimated according to the means of transport. The average cost of a transfer by a private ambulance was estimated to be 67 EUR plus 2 EUR per kilometer. The average cost of a medicalized transfer was estimated at 250 EUR per 30 min for a land medical ambulance transfer and at 60 EUR per 1 min for an air medical helicopter transfer. For each mean of transport, an average cost of transfer was calculated for each referring hospital according to the distance between referring and reference hospital. Next, based on the network use by the different hospitals, we have calculated an average cost of transfer in emergency; for the non-emergency cases, the cost of a transfer was estimated to be the cost of a private ambulance transfer.

4. Costs related to a hospitalization: the average cost of a hospitalization was calculated from a report by the French Technical Agency for hospitalization information; this report fixes the national reference costs per activity for public hospitals [7]. In emergency, the average cost of a hospitalization was estimated, on the basis of the pathologies most frequently encountered, as the average of the costs related to the French Diagnosis.
Related Groups No. 178 and 179 (other intracranial traumatic disorders, except concussion) and No. 170 and 171 (intracranial hemorrhage and stroke) [7]. For non-emergency cases, the average cost of a hospitalization was estimated as the average of the costs related to the French Diagnosis Related Groups No. 7951 and 7952 (Signs and symptoms) [7].

5. Costs related to a consultation: the consultation cost plus 50% (the consultation cost may be raised by certain physicians).

A sensitivity analysis was used to explore the effect of modulating different costs, variable per variable:

1. Annual rate of depreciation: lifespan of the equipment was estimated at 7 years (basic assumption). A time frame of 5 years is frequently used (low assumption). However, RIHRA is still using the same equipment after 10 years in existence (high assumption).

2. Discount rate: the discount rate was estimated at 5% (basic assumption). Two other rates were taken: 3% (low assumption) and 10% (high assumption).

3. Annual number of transmissions: The break-even point of the network was taken as the low assumption and the potential number of transmissions after information and training as the high assumption.

4. Proportion of avoided transfers: the break-even point of the network was taken as the low assumption and the rate of avoided transfers, as the high assumption, corresponding to actually avoided transfers plus transfers followed by a return to referring hospital or discharge.

5. Salary costs: taking these costs into account is arguable; the low assumption was considered taking them into account.

6. Costs related to a hospitalization: taking these costs into account is also arguable; they were not taken into account in the low assumption; in an intermediate assumption, only consumables costs related to a hospitalization were taken into account (25% of hospitalization costs).

**Statistical analysis**

Data collection and analysis were performed by CCECQA. Data were captured on Epi-Info™ software (Center for Disease Control, Atlanta, Georgia) and concordance was ascertained during the data capture procedure. The analysis was then performed on Stata software™ (Stata Corporation, College Station, Texas). A descriptive analysis of avoided transfers was performed using a 95% confidence interval (CI).

**Ethical considerations**

Patients (or families/friends) were informed of the use of the teleradiology network if their clinical status made it possible.

**Results**

Among the 737 transmissions telecollected, 73 (9.9%) were excluded [18 (2.4%) as ‘other transmissions’, and 55 (7.5%) because of missing data]. Six hundred and sixty-four teleradiology consultations were carried out and included in the study period. Transmissions were of two types: remote consultations in emergency ($n = 562, 84.6\%$), remote consultations for non-emergency cases ($n = 102, 15.4\%$).

**Outcome measures applied for emergency cases**

Among the 562 remote consultations in emergency, five were clearly not related to a transfer request, 272 were followed by a transfer that had been initially recommended, and 14 were followed by a transfer that had not been recommended. Thus, the number of transfers avoided is $[(562 – 5) – (272 + 14)] = 271 [48.2% (44.0 – 52.4)]$. Hospitalization was avoided for 15 patients after remote consultation in emergency [2.7% (1.5–4.4)].

**Outcome measures applied for non-emergency cases**

Among the 102 non-emergency cases, 38 [37.3% (27.9–47.4)], transfers were avoided. Hospitalization was avoided for 12 patients [11.8% (6.2–19.6)]. Two additional consultations were carried out [2.0% (0.2–6.9)].

**Cost-minimization study**

The values of the fixed and variable costs are presented in Table 1.

The compared costs between cares delivered using the telemedicine system and cares which would have been delivered without it are presented in Table 2.

Savings with RIRHA can be estimated at 102 779 EUR per year. If the lower and higher confidence intervals for each outcome measure are taken into account, total savings range between 38 115 EUR and 188 041 EUR. The sensitivity analysis is presented in Table 3.

The cost-minimization study was performed for each hospital taking part in RIHRA: nine hospitals make savings (from 3 252 to 30 857 EUR), and six do not (additional cost from 875 to 11 208 EUR).

**Discussion**

RIHRA enables savings, despite the large initial equipment outlay. However the expected savings did not exceed the equipment and servicing costs in some hospitals: our results per hospital may be a useful decision aid, in these hospitals particularly, for either leaving the network or increasing its use. Indeed, the six hospitals concerned are those which carry out less remote consultations. The proportion of transfers avoided using RIHRA was close to 50%; this large proportion shows the effectiveness of the network in avoiding patient transfers. These results can be favorably compared with other studies, showing percentages of transfers avoided varying between 15 and 80% [5,8–11]. In France, the use of teleradiology reduced the unnecessary transfers to a neurosurgical unit from 65 to 18% [12]. A before–after study carried out in
1998 showed that the use of a teleradiology system similar to RIHRA made it possible to reduce the percentage of unnecessary transfers from 36 to 16% [13]. A prospective study in a hospital which was part of RIHRA showed that the use of teleradiology made it possible to avoid transfers for 14% of the included patients [14]. For non-emergency cases, the use of the network resulted in avoiding numerous transfers and hospitalizations (frequently converted into consultations) [8].

One limitation of our study is the absence of randomization for obvious ethical reasons, and the use of intermediate outcomes, rather than clinical improvement. However, this is

Table 1  Values of the fixed and variable costs (in EUR)

<table>
<thead>
<tr>
<th>Costs</th>
<th>Value (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed costs</strong></td>
<td></td>
</tr>
<tr>
<td>Annual investment costs of equipment per workstation, with a discount rate of 5%</td>
<td>6913</td>
</tr>
<tr>
<td>Annual servicing costs per hospital</td>
<td>2735</td>
</tr>
<tr>
<td>Running costs per workstation</td>
<td></td>
</tr>
<tr>
<td>Annual costs of maintenance</td>
<td>500</td>
</tr>
<tr>
<td>Annual costs of energy</td>
<td>180</td>
</tr>
<tr>
<td>Annual subscription for transmission system per workstation</td>
<td>480</td>
</tr>
<tr>
<td>Training costs per hospital</td>
<td>912</td>
</tr>
<tr>
<td><strong>Variable costs</strong></td>
<td></td>
</tr>
<tr>
<td>Transmissions system (unit cost)</td>
<td>1</td>
</tr>
<tr>
<td>Salary costs</td>
<td></td>
</tr>
<tr>
<td>For the referring physician (one transmission)</td>
<td>20</td>
</tr>
<tr>
<td>For the reference physician (one transmission)</td>
<td>60</td>
</tr>
<tr>
<td><strong>Hospitalization costs</strong></td>
<td></td>
</tr>
<tr>
<td>In emergency</td>
<td>4084</td>
</tr>
<tr>
<td>Non-emergency cases</td>
<td>3337</td>
</tr>
<tr>
<td><strong>Consultation costs</strong></td>
<td>30</td>
</tr>
<tr>
<td><strong>Transfer costs</strong></td>
<td></td>
</tr>
<tr>
<td>In emergency</td>
<td>677</td>
</tr>
<tr>
<td>Non-emergency cases</td>
<td>281</td>
</tr>
</tbody>
</table>

Table 2  Cost savings with RIHRA over 1 year (in EUR)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed costs (15 hospitals, 17 workstations)</strong></td>
<td>0</td>
<td>117 521</td>
<td>–117 521</td>
</tr>
<tr>
<td>Annual investment costs of equipment, with a discount rate of 5%</td>
<td>0</td>
<td>41 025</td>
<td>–41 025</td>
</tr>
<tr>
<td>Servicing</td>
<td>0</td>
<td>11 560</td>
<td>–11 560</td>
</tr>
<tr>
<td>Running</td>
<td>0</td>
<td>8160</td>
<td>–8160</td>
</tr>
<tr>
<td>Subscription for transmission system</td>
<td>0</td>
<td>13 680</td>
<td>–13 680</td>
</tr>
<tr>
<td>Training</td>
<td>0</td>
<td>664</td>
<td>–664</td>
</tr>
<tr>
<td><strong>Variable costs</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Avoided hospitalization costs</td>
<td>2 250 080</td>
<td>2 188 820</td>
<td>61 260</td>
</tr>
<tr>
<td>In emergency</td>
<td>249 474</td>
<td>209 430</td>
<td>40 044</td>
</tr>
<tr>
<td>Avoided consultation costs</td>
<td>750</td>
<td>810</td>
<td>–60</td>
</tr>
<tr>
<td>Avoided transfer costs</td>
<td>373 190</td>
<td>189 723</td>
<td>183 467</td>
</tr>
<tr>
<td>In emergency</td>
<td>24 802</td>
<td>14 124</td>
<td>10 678</td>
</tr>
<tr>
<td>Non-emergency cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2 898 296</td>
<td>2 795 517</td>
<td>102 779</td>
</tr>
</tbody>
</table>
a worthwhile contribution, because it was carried out on a network including many centers over a long duration, making it possible to obtain a significant sample. Another limitation is the significant proportion of transmissions excluded for lack of information, amounting to 9% of all the teleconsultations and 14% for the elective cases. This can be in part explained by the diversity of the data sources required for data collection (telecollection, consultation of the patients’ medical records in referring and reference hospitals). The option of considering all patients not transferred as avoided transfers after remote consultation in emergency may appear excessive for some but it corresponds to the policy applied before the introduction of the teleradiology network and it is still the policy in force for the hospitals not taking part in RIHRA. The method selected for cost assessment is in line with many authors’ suggestions [15–19]. The choice of a cost-minimization study was retained because other cost-effectiveness study models are difficult to use in the absence of reliable and valid indicators concerning degree of care improvement. The reference situation selected to compare with RIHRA was the situation before RIHRA was established, because no other suitable alternative appeared feasible. Although caution is required, the results of cost-effectiveness studies published [3,18,20] tend to show the efficiency of teleradiology systems, in particular concerning neurosurgical emergencies. However, the efficiency of a network is greatly dependent on the country or the district concerned (doses, relief), on the volume of transmissions, on the initial investment and on equipment lifespan [3,21]. Our survey confirms these findings.

The savings generated by RIHRA could be greater if the network was more widely used, especially for non-emergency cases. Considering variations in use from one hospital to another, it is plausible that many physicians under-use the teleradiology network. Reasons are numerous: lack of information, interest, or familiarity with the technology, no contact with the reference physicians, delays in obtaining a reply for non-emergency cases. In addition, there is the lack of financial recognition for the reference physician. These factors correspond to the many organizational barriers to the development of telemedicine that have been described in the literature [22–26]. To make up for this under-utilization and to improve RIHRA efficiency, several solutions could be suggested. Better information should be given to the professionals concerned and regular training is required. From a technical viewpoint, the number of workstations for sending and receiving transmissions would be increased, and the data transmission through a regional network server should be offered. In this way, the development program for telehealth in the Aquitaine administrative area (Télésanté Aquitaine) would pursue integration of RIHRA into a wider regional system of telemedicine intended to facilitate transmissions between the various health professionals, ensuring reliability and safety for data transmissions.

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References


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