

# Implementation of a Telecardiology System in the State of Minas Gerais: the Minas Telecardio Project

Antonio Luiz P. Ribeiro<sup>1</sup>, Maria Beatriz Alkmim<sup>1</sup>, Clareci Silva Cardoso<sup>2</sup>, Gláucio Galeno R. Carvalho<sup>1</sup>, Waleska Teixeira Caiaffa<sup>1</sup>, Monica Viegas Andrade<sup>1</sup>, Daniel Ferreira da Cunha<sup>3</sup>, Andre Pires Antunes<sup>4</sup>, Adélson Geraldo de A. Resende<sup>5</sup>, Elmiro Santos Resende<sup>6</sup>

*1*Universidade Federal de Minas Gerais - UFMG<sup>1</sup>, Belo Horizonte, MG; *2*Universidade Federal de São João Del Rei - UFSJ<sup>2</sup>, São João Del Rei, MG; *3*Universidade do Triângulo Mineiro<sup>3</sup>, Uberaba, MG; *4*Universidade Estadual de Montes Claros<sup>4</sup>, Montes Claros; *5*Universidade Federal de Juiz de Fora<sup>5</sup>, Juiz de Fora, MG; *6*Universidade Federal de Uberlândia<sup>6</sup>, Uberlândia, MG - Brazil

## Abstract

**Background:** Although cardiovascular diseases are the main cause of morbimortality in Brazil, the access of small-town populations to electrocardiography and cardiology assessment is limited. The use of telecardiology to assist the access of distant towns to electrocardiography and a second opinion in cardiology is promising; however, it has not been formally assessed.

**Objective:** To assess the feasibility of implementing a low-cost public telecardiology system in small Brazilian towns.

**Methods:** A total of 82 towns in the state of Minas Gerais, with a population < 10,500 inhabitants, presenting > 70% coverage by the Family Health Program (*Programa Saúde da Família* - PSF), local government compliance and internet access, were selected. Each town was supplied with digital electrocardiography (ECG) device and a team was trained. The implementation was coordinated by HC/UFMG, together with four university hospitals in the state of Minas Gerais (UFU, UFTM, UFJF and UNIMONTES). The ECG assessments were carried out in the towns and sent through the Internet for prompt analysis by an on-duty telecardiology team. Online and offline discussions on the medical cases were carried out through the Internet, as well as refreshment courses.

**Results:** During the implementation period, a total of 253 health professionals were trained. From July 2006 to November 2008, the project assisted 42,664 patients, with a total of 62,865 ECG assessments being performed. A total of 2,148 emergency cases were treated, as well as 420 teleconsultations. The intermediate evaluation showed good acceptance of the implemented technology and a 70% decrease in patient referrals to other reference centers.

**Conclusion:** The use of the customary resources in informatics to assist the access of small-town populations to electrocardiography and specialized cardiology assessment is feasible. (Arq Bras Cardiol. 2010; [online]. ahead print, PP.0-0)

**Key words:** Electrocardiography; medical informatics; cardiovascular diseases; telemedicine.

## Introduction

Cardiovascular diseases are the main cause of death in Brazil and account for approximately 1/3 of the total deaths. Although commonly associated to the lifestyle of large cities, they are also the main cause of death in small and medium-sized towns, where a high prevalence of cardiovascular risk factors can be observed. In Bambui, a small town in the west region of the state of Minas Gerais, Brazil, which has little more than 20,000 inhabitants, 25% of the individuals are hypertensive<sup>1</sup>, and other risk factors, such as obesity, dyslipidemia, smoking and diabetes are also frequently observed<sup>2</sup>.

Most cardiology and cardiovascular surgery services are concentrated in large cities; thus, it is difficult for small-town inhabitants to have access to simple diagnostic methods, such as the electrocardiogram. Therefore, it is often necessary to travel long distances to have access to these services.

Minas Gerais is the Brazilian state with the largest number of cities and towns, 853, of which 526 had < 10,500 inhabitants in the year 2005. The healthcare structure in many of these cities and towns show significant inequity regarding the access to basic cardiology assessment methods and probably to other more advanced propedeutic and therapeutic methods. As an example, there were no records of electrocardiograms performed in the public health system in 423 cities and towns in the state of Minas Gerais in the year 2004 ([www.datasus.gov.br](http://www.datasus.gov.br), accessed on 11/20/2005).

The electrocardiogram (ECG) is a method of assessment of the cardiovascular system, with established diagnostic and prognostic values, which is easy to perform, low-cost and has a

**Mailing address:** Antônio Luiz Pinho Ribeiro •

Rua Campanha, 98/101 - Carmo - 30310-770 - Belo Horizonte, MG - Brazil

E-mail: [antonior@cardiol.br](mailto:antonior@cardiol.br), [antonior@uai.com.br](mailto:antonior@uai.com.br)

Manuscript received January 23, 2009; revised manuscript received May 17, 2009; accepted June 25, 2009.

significant clinical usefulness. The knowledge of the possibility of transmitting the ECG is as old as the technique itself<sup>3</sup>.

The long-distance ECG transmission can be used in many different clinical settings and transmitted by different methods, such as telephone line and the internet. Although several attempts have been made at tele-electrocardiography in Brazil and the world, the data on the viability of its implementation in the public health system as support to basic healthcare services, are limited.

The hypothesis of the present study defends that the implementation of a low-cost telecardiology system in small towns in the countryside of Brazil is feasible and viable and that it is possible to decrease unnecessary referrals, improving the quality and decreasing the costs of healthcare services.

## Methods

The Minas Telecardio project was planned in response to the 08/2005 announcement of *Fundação de Amparo à Pesquisa de Minas Gerais* (FAPEMIG - the Foundation for Research Support of the state of Minas Gerais), directed at the financial support of a cost-effectiveness study of a Pilot System of Telecardiology in Minas Gerais. In order to do that, the Mineira Network of Telecardiology was created, called Minas Telecardio, through a partnership among public university hospitals of the state of Minas Gerais: the federal universities of the state capital (UFMG, in Belo Horizonte), of Juiz de

Fora (UFJF), of Uberlândia (UFU) and of Triângulo Mineiro (UFTM, in Uberaba), in addition to the State University of Montes Claros (UNIMONTES). The project was approved by the Ethics Committees in Research of each one of the participating institutions.

The general study was classified as “quasi-experimental” (Figure 1)<sup>4</sup> and was divided in four phases:

1) Before the implementation, establishment of a baseline, through the health diagnosis of the 82 towns included in the Minas Telecardio program, compared to the diagnosis of other 311 reference towns and the assessment of the healthcare team’s satisfaction, in the towns participating in the program, regarding the quality of the cardiovascular disease care (before the program);

2) Implementation and follow-up of the Telecardiology System, with occasional trainings and intermediate assessment of the program, including production parameters and satisfaction of the healthcare professional team and service users<sup>5</sup>;

3) Evaluation of the effectiveness of the program: pre and post-intervention comparative studies, considering the baseline, and follow-up study of the patients with suspected acute coronary syndrome (ACS), by assessing the predictors of the worse prognosis of clinical evolution, quality of life and satisfaction with the healthcare quality;

4) Program cost-assessment - costs related to the

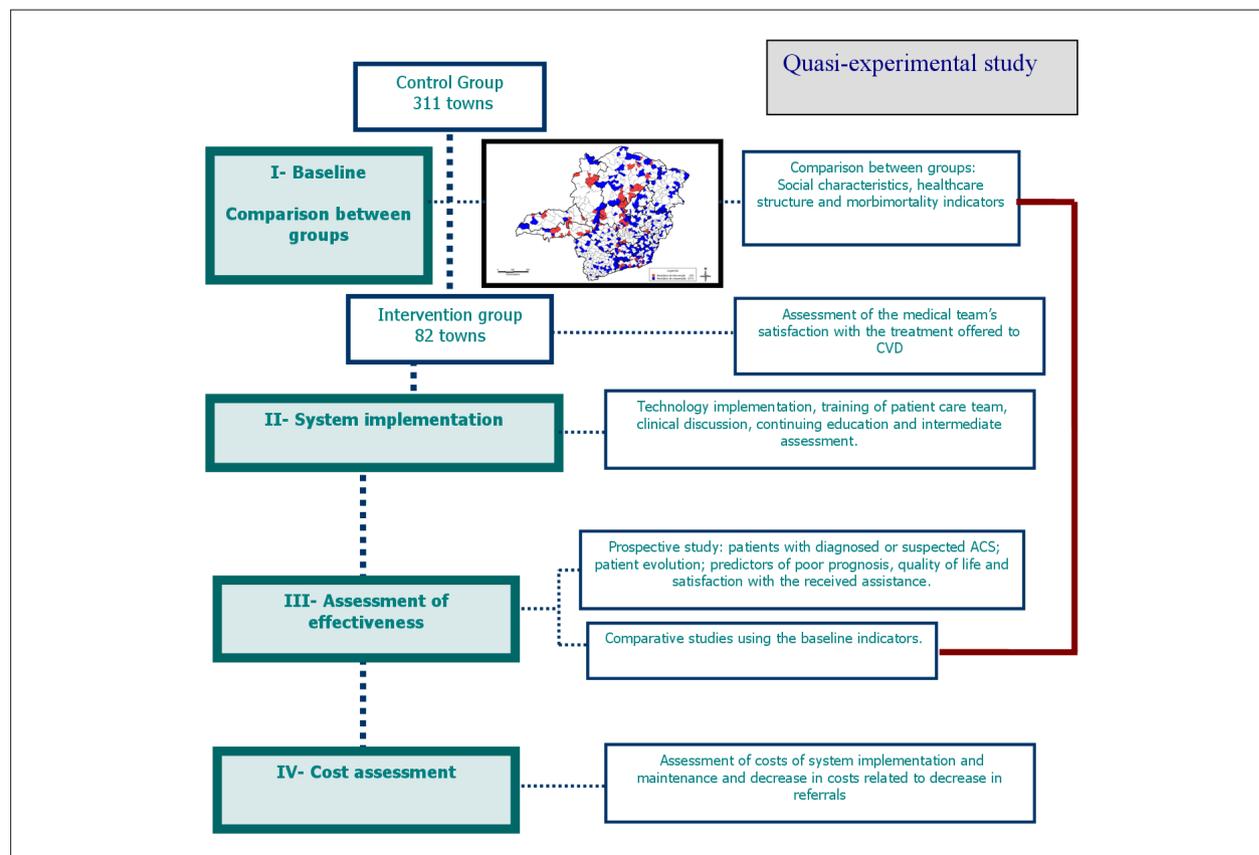


Figure 1 - Minas Telecardio Study Design.

implementation of the program and the effect of the program cost-reduction, under the perspective of a decrease in the number of referrals.

The present study refers to the predicted second phase, with the assessment of the viability of the telecardiology system, including a description of the implementation process and attained production, as well as the effectiveness of the decrease in referrals. The cost-effectiveness assessment and other aspects of the project will be analyzed in specific subsequent studies.

### Selection of the participating towns and implementation methodology

The Minas Telecardio project was implemented in 82 towns distributed in the state of Minas Gerais (Figure 2), selected according to the following criteria, which were pre-determined by the State Health Secretary of Minas Gerais (SES/MG):

- Healthcare service coverage rate by the Family Health Program (FHP) > 70%;
- Population of up to 10,500 inhabitants;
- Poor towns with small rates of morbimortality due to acute myocardial infarction, as a way to control the subnotification bias, usually more significant in poorer regions;

In addition to these initially adopted criteria, it was necessary to include new criteria throughout the process of implementation, among them:

- The town's interest in participating in the study, demonstrated by taking part in sensibilization meetings

and connection tests;

- Actual situation of the town's healthcare system, defining the need for telecardiology;
- Internet connection in the town with sufficient bandwidth to implement the system, or local initiative to adapt it;

To assist the activities of system implementation and maintenance, the towns were divided by the geographic proximity in relation to the centers.

When the professionals in charge of the project were identified in the participating towns, regional meetings with the managers were carried out in each center, together with the clinical team of the reference towns, which consisted of a general manager in charge of the operation, a research technician and an informatics technician.

Based on the definition of the towns, a methodology was followed to implement the Telemedicine System, which comprehended the following phases: Internet connection tests, technical visits, training of clinical and technical teams in all towns, equipment delivery, installation at the determined site - together with the town managers - and the clinical team.

The flowchart of the system implementation is shown in Figure 3<sup>6</sup>.

### Team structure

In 2005, the project teams were constituted: general coordination of the university centers, teams in charge of the epidemiological and economical study, technical and administrative team. All teams worked in the design and

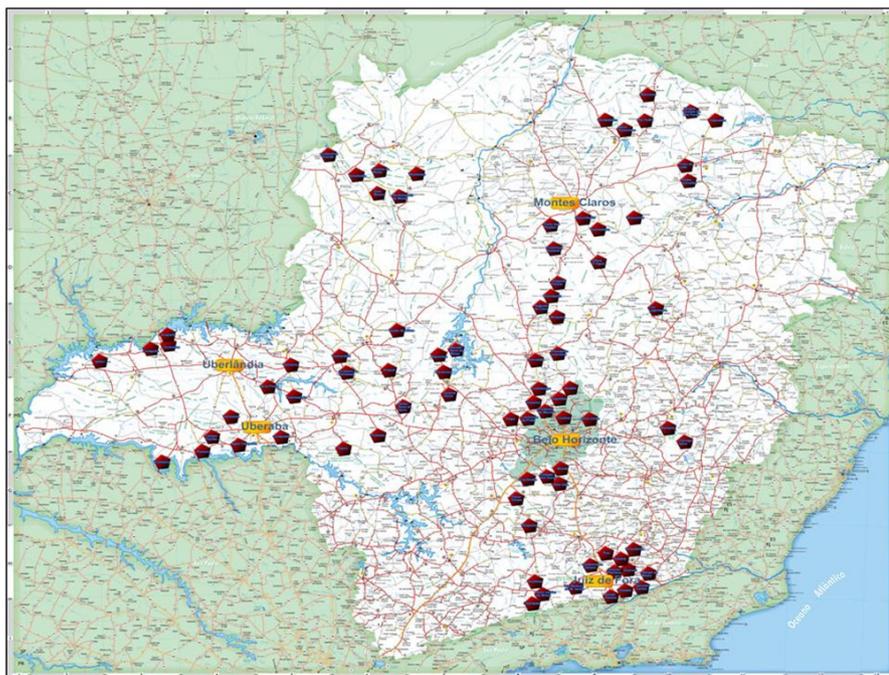


Figure 2 - Towns selected for the implementation of the Minas Telecardio Project and the five university centers.

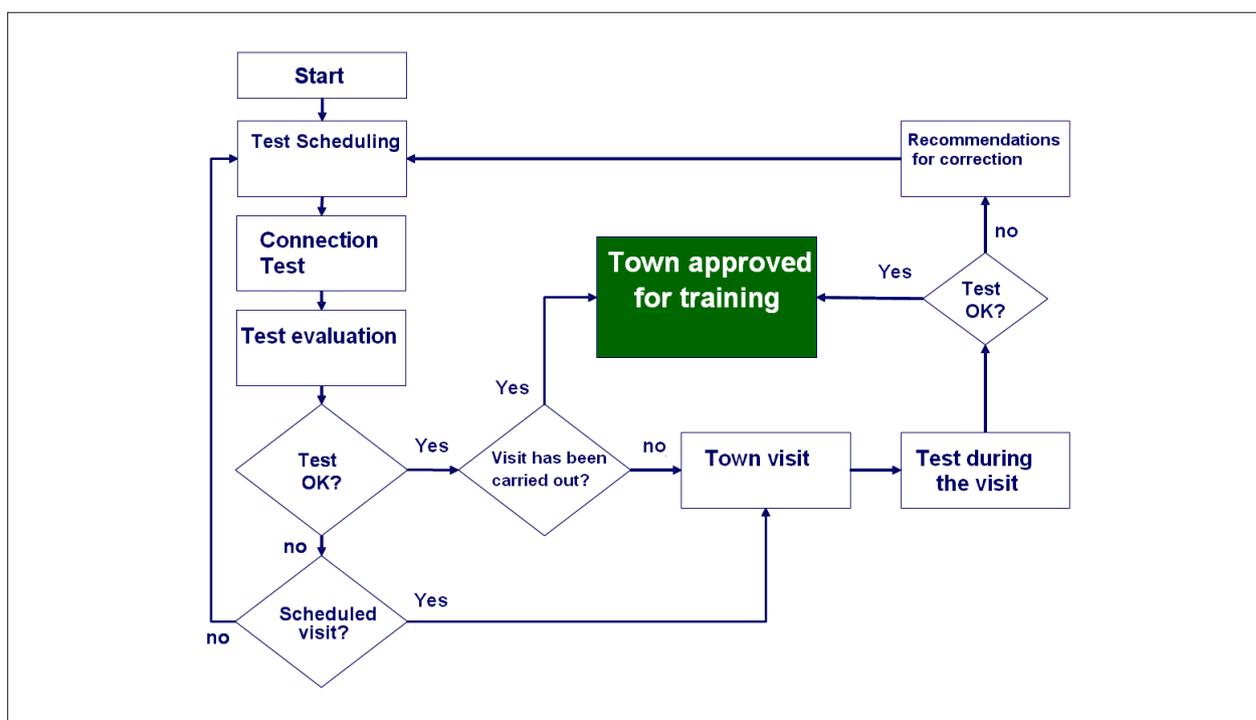


Figure 3 - Flowchart of the telemedicine system implementation in the Minas Telecardio Project.

construction of the model to be implemented.

The UFMG, as the coordinating center, constituted the central team of coordination, the medical team, the technical team and the research team and was in charge of the organization of the project activities in the participating institutions.

The Tele-health Center of *Hospital das Clínicas* was in charge of the activities to implement the project in the other four university centers and 82 towns.

Each university center team included a coordinator, a research reference technician, an informatics technician, a secretary and two fellows from the scientific initiation program. The clinical team was coordinated by Hospital das Clínicas of UFMG, which was in charge of the cardiology duty shifts and the definition of protocols, in addition to the standardization of conducts.

The epidemiological study was coordinated by the Urban Health Observatory of Belo Horizonte, located in the Epidemiology Study Group (OBSUBH-GPE-UFMG). The economical study was coordinated by the team from the School of Economic Sciences of UFMG.

The project received the assistance of the Laboratory of Scientific Computation (LCC)/National Center of High-Performance Data Processing (CENAPAD) of UFMG.

### Training

The system use training, which lasted 8 hours, was given to three professionals from each town: a physician, an informatics technician and a research technician. This training was specific for each professional category. Concomitantly to these

activities, trainings were also carried out in the coordination centers, including the on-duty physicians, the informatics and research technicians from the university centers and the fellows from the scientific initiation program.

During the implementation phase, 7 training cycles were carried out for the professionals from the 82 towns, at the Tele-health Center of *Hospital das Clínicas*, in Belo Horizonte, between June and September 2006. A total of 253 professionals were trained during the initial phase of the project.

Equipment release was carried out after a Declaration of Adhesion was signed by the local government and after the professionals participated in the training sessions. The town was then integrated to the project and the equipment was installed locally.

Due to the high rate of professional turnover among the professionals chosen by the towns to perform the research activities, new training sessions were scheduled, according to the necessity observed by the research technicians and after requests by the towns, totaling 120 isolated training sessions from October 2006 to September 2008.

### Technological infrastructure

The project had a hardware structure that consisted of 12 servers, which were intended not only for the needs of the number of towns (82), but also capable of undergoing expansion without compromising the performance and safety of information. The servers considered essential for the consultations were clustered, which gave reliability and stability to the at-distance clinical care.

Each university center was equipped with two workstations, which consisted of a microcomputer, a webcam and videoconference equipment. Each town received an advanced-configuration microcomputer, a webcam, a printer and a 12-lead digital electrocardiograph. The technological structure implemented in the university centers is shown in Figure 4.

The software used by the project were: 1) commercial communication software for interaction by chat, voice, image and file exchange among the users, also allowing the recording of the activities for the sake of safety on both parts; 2) 12-lead digital electrocardiogram software, specifically adapted for the prospective collection of clinical and epidemiological data (WinCardio System, Micromed, Brasília, Brazil), 3) web software for the management of tele-consultations, developed by the project team; and 4) web system of Tele-health Management, developed by the project team in charge of the management of the clinical and administrative activities of the Tele-health Center.

Two web sites were developed: 1) the [www.minastelecardio.hc.ufmg.br](http://www.minastelecardio.hc.ufmg.br) contained information and news on the project, partners and users, which initially represented the access to the tele-consulting system; 2) the [www.telessaude.hc.ufmg.br](http://www.telessaude.hc.ufmg.br), which included all services offered to the towns, i.e., sending and receiving electrocardiograms, tele-consultations and permanent education program.

This structure allowed the towns to obtain fast and simple access to the services, in addition to obtaining information, news, schedules and correlated links.

#### Operational flowchart of the Minas Telecardio Project

The project offered clinical activities in telecardiology by

providing on-duty medical care, carried out by physicians from the university centers, including professors and cardiology specialists. The physicians were in charge of the analysis of the sent electrocardiograms and online discussion of clinical cases, justified by the case complexity/urgency or the requesting physician's need. Teleconference activities were also carried out with the healthcare teams in the participating towns.

The patient was treated at the town of origin and the ECG was sent to be assessed by the Minas Telecardio project specialists. The Telecardiology activities were developed using a digital electrocardiograph installed in the towns, usually at the Basic Health Units of the public healthcare system. The examination was always carried out after being requested by a physician, as the program was implemented only in towns that presented the FHP coverage.

The ECG was then sent using the communication software to the on-duty virtual reception, which remained in close contact with the towns. As the number of examination requests increased, it became necessary to implement the process automation. The management system was in charge for checking the received ECG, its sequential distribution among the on-duty physicians (first come, first served basis), prioritization of emergency cases and delivery of results to the towns through a restricted area on the site.

The results were kept online and could be accessed at any time. The virtual cardiology duty took place simultaneously in the different university centers, from 7 AM to 7 PM, from Monday to Friday and included all participating towns, regardless of their geographic location. The consultation flowchart is shown in Figure 5.

In case of need of clinical case discussion, the specialist

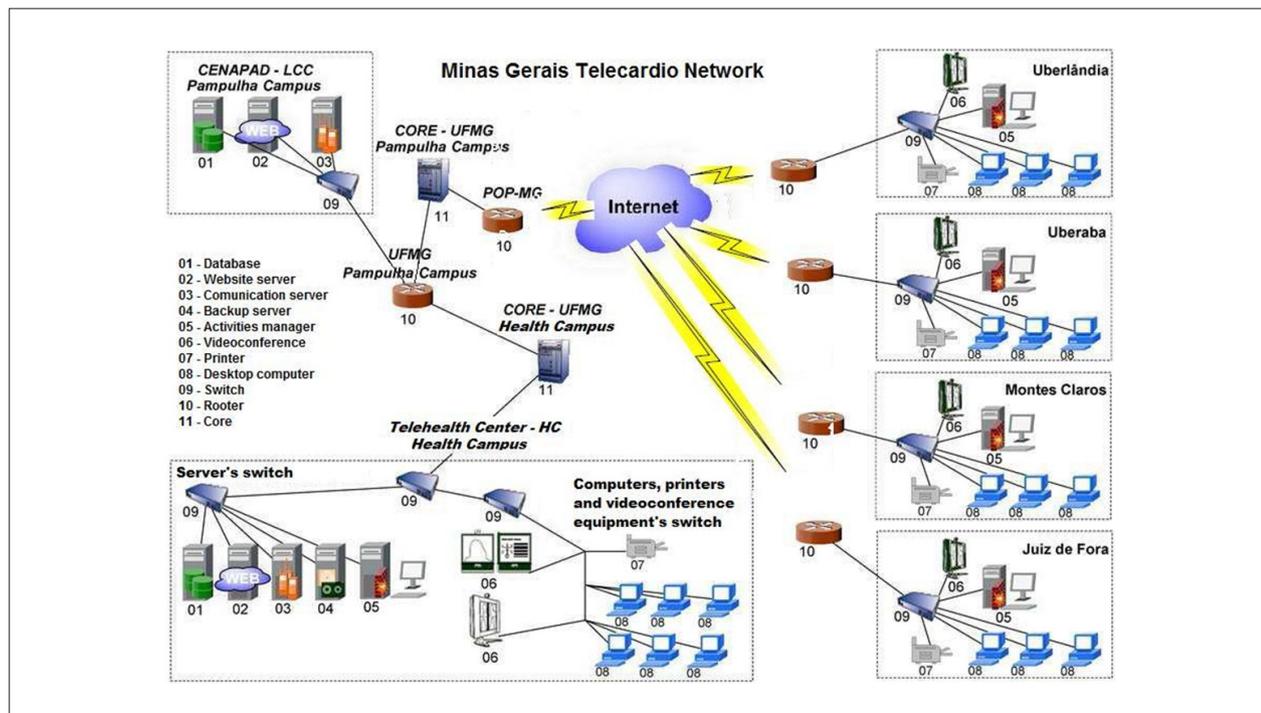


Figure 4 - Technological structure implemented in the university centers to assist the Minas Telecardio Project.

and the requesting physician met during a private meeting using the communication software. A personal password was necessary in these cases and the meeting was recorded, for the sake of the participants' safety. The entire process was carried out following strict confidential criteria.

### Partial assessment of the project performance

A partial assessment of the project was carried out by all towns, including the ones using the system and those with operational problems. The assessment protocol included information on the general satisfaction with the project performance, the positive and negative points. The protocol also included information on the impact of the system on the town regarding the referral of patients to the secondary level of healthcare and questions related to the operational simplicity or difficulty presented by the system.

### Ethical aspects

This investigation was approved by the Institutional Review Board/ Research Ethics Committee of the Federal University in Minas Gerais, file number 0507/2006 and Free and Informed Consent was obtained from all study participants, including managers, healthcare team and patients. All professionals involved with the handling of data concerning this investigation signed a confidentiality agreement, agreeing to safeguard the patients' electronic medical files.

The Tele-health Center of Hospital das Clinicas, in charge of the implementation of the telecardiology system, is registered at the Regional Council of Medicine, according to the resolution norms CFM# 1.643/2002.

## Results

The on-duty cardiology activities started on June 20, 2006, assisting the first 10 towns that met the requirements that were necessary for system implementation. Gradually, after the local technical problems were solved, the towns started

adhering to the program, so that on March 2007, all towns were capable of using the system.

Chart 1 shows the monthly number of electrocardiograms performed by the Minas Telecardio Project. From June 2006 to November 2008 (30 months), a total of 62,865 electrocardiograms were carried out in 42,664 patients. During the first month of the project activities (June/2006), only 27 electrocardiograms were performed, which shows the small number of active towns in the system. In the last year, the mean monthly number of electrocardiograms remained around 2,500. Of the 62,865 electrocardiograms, 83.3% were classified as the first performed through the system; 12.8% referred to a second assessment. More than two assessments were performed in 3.9% of the cases.

A large variation was observed regarding the absolute number of electrocardiograms per town. The largest number of electrocardiograms was carried out by the towns of Nova Ponte (2,347), Prudente de Morais (2,008), Arapora (1,886) and Claro das Picoes (1.806). However, the rate of system's use per thousand inhabitants demonstrates that the town of Arapora had the higher rate per inhabitant (366.0), followed by Moeda (354.0), Confins (298.4) and Pequi (298.4).

A total of 2,148 emergency consultations and 720 tele-consultations were carried out, with 420 clinical case discussions during the cardiology duties and 300 offline tele-consultations (Chart 2). Additionally, in 2007, teleconferences in cardiology were carried out every two weeks and the themes were defined together with the town clinical teams.

The towns rated the telecardiology system as "very good or excellent" (76.5%) and the healthcare professionals indicated the opportunity to attain an early diagnosis, the discussion of clinical cases and the continuing education as the main advantages of the project. According to the perception of the healthcare team of each town, the Minas Telecardio Project resulted in a 70% decrease in patient referral for assessment in specialized medical centers.

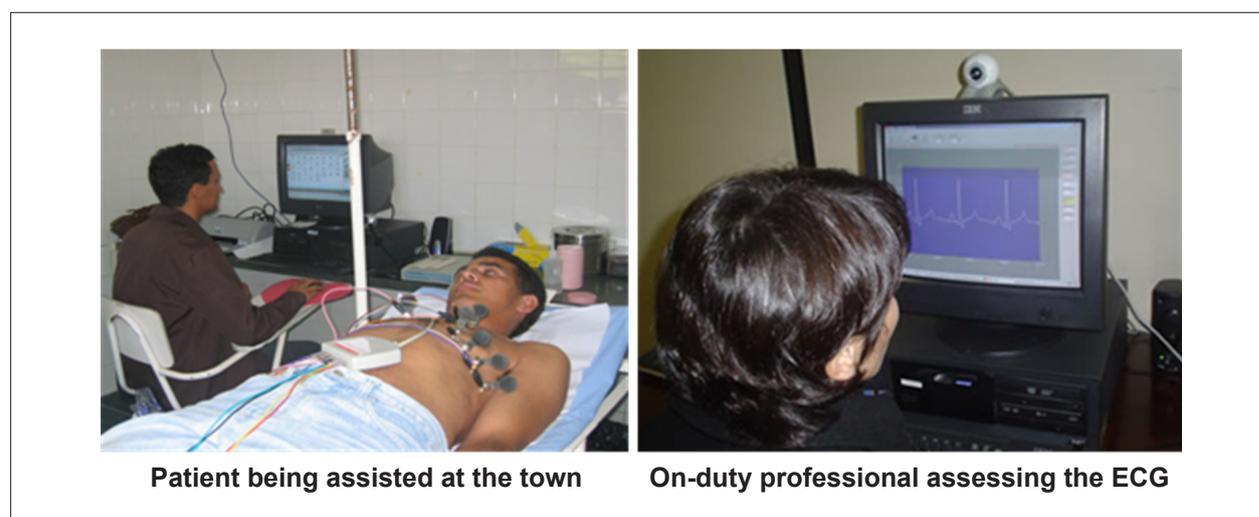


Fig. 5 - Assistance flowchart of the Minas Telecardio Project.

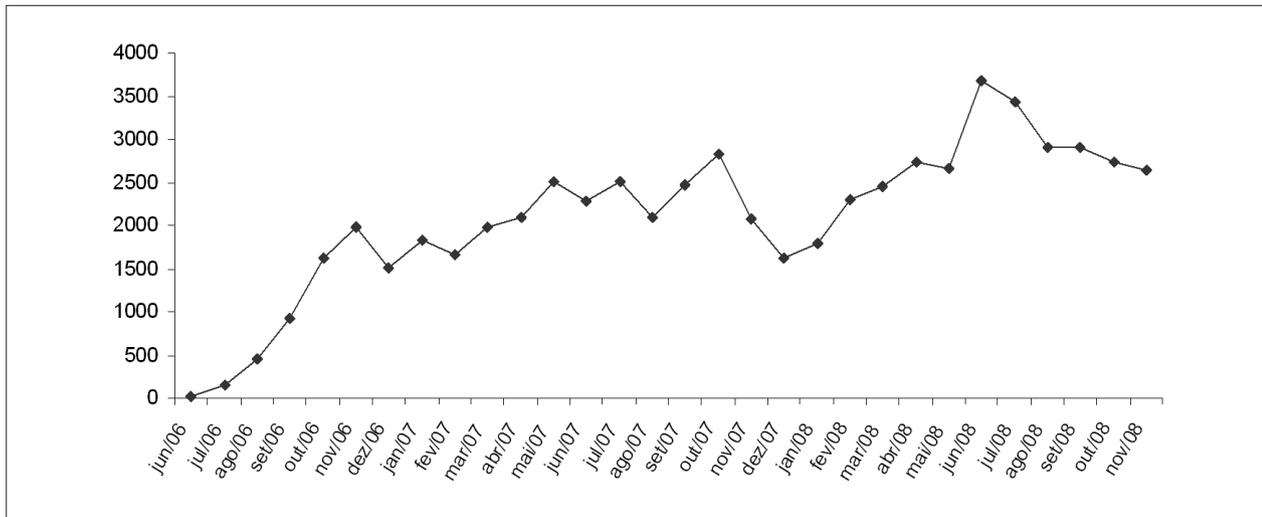


Chart 1 - Number of ECGs performed during the Minas Telecardio Project from June 2006 to November 2008.

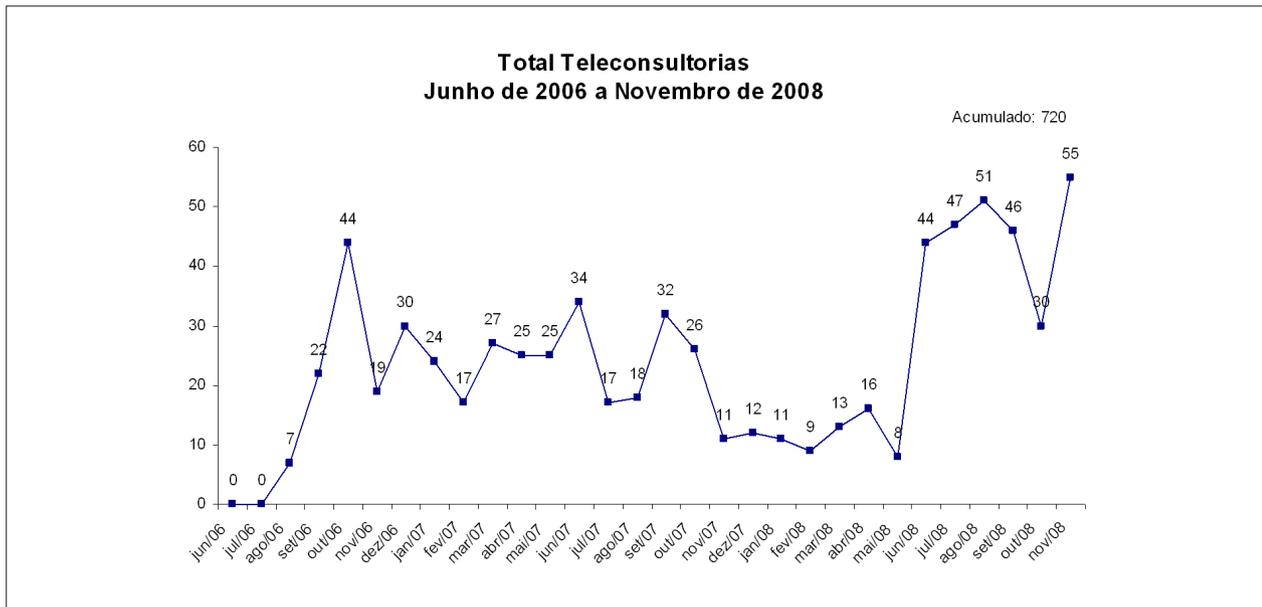


Chart 2 - Number of teleconsultations performed during the Minas Telecardio Project from June 2006 to November 2008.

## Discussion

Based on the obtained results, it can be observed that the implementation of a telemedicine system directed at cardiology in 82 towns in the state of Minas Gerais is feasible, allowing the diagnostic support for the primary care physician and the prioritization of referral of complex cases, in addition to assisting the permanent education of professionals working in isolated communities. This is a pioneering project in Brazil, considering that the institutions involved are public ones, the joint work of the healthcare services and the academic institutions as well as the use of low-cost technology. It is also innovative when considering the high productivity attained by the project. Moreover, it constitutes an example of success of the perennial use of Telemedicine in the Brazilian Public Healthcare System (SUS).

As a consequence, the project was assimilated by the State Health Secretary of the state of Minas Gerais and it has become a permanent state program, with possible coverage expansion in the future.

Cardiology and electrocardiography have always been privileged fields for Telemedicine use. Einthoven himself, the founder of modern electrocardiography, described the transmission of the ECG by telephone line as early as 1906 and created the term “*telécardiogramme*” to designate the electrocardiographic recording transmitted long-distance<sup>7</sup>. The cardiologic uses of Telemedicine have increased significantly after the Internet and mobile telephone services appeared, which greatly increased the communication and interaction possibilities for healthcare professionals.

However, the advances and the popularity of Telemedicine,

in general or in cardiology, have not been followed by systematic studies, adequately designed and conducted to assess their efficacy and cost-effectiveness. Roine and cols.<sup>8</sup> carried out a systematic review of studies evaluating telemedicine, published between 1966 and 2000 and found only 50 articles that objectively assessed the efficacy and cost-effectiveness of telemedicine. Most of the more than 1,000 articles initially selected for the review were pilot-projects or had short-time outcomes and most presented questionable methodological quality<sup>8</sup>.

In a subsequent study, the same authors carried out a systematic review of the studies in telecardiology published between 1992 and 2003. A total of 44 references were found and most (59%) were considered as having poor or reasonable methodology<sup>9</sup>.

Regarding the use of tele-electrocardiology as support to the general practitioner, only one study was considered as having acceptable quality<sup>9,10</sup>, suggesting a benefit of the electrocardiographic interpretation made by a specialist in the clinical decision of the general practitioner.

More recently, a subsequent systematic review on telecardiology carried out by Bonacina et al<sup>11</sup> confirmed the scarcity of studies assessing the quality of the intervention in this subject.

In this context, the Minas Telecardio project, by using a controlled method as well as carrying out a cost-effectiveness study to assess the implementation of a telecardiology system in Brazil, becomes of great importance. Although commercial systems of tele-electrocardiography are currently being used in the country, we are unaware of systematic Brazilian studies that have been published in journals indexed in the Medline, SciElo and Lilacs databases on the efficacy and cost-effectiveness of telecardiology.

Considering the continental dimensions of Brazil, the clinical-epidemiological importance of cardiovascular diseases in our country and the constitutional mission of the Brazilian Government to provide good-quality, equivalent and universal healthcare services to all states, the Minas Telecardio study becomes particularly important and interesting.

The main finding of the present study concerns the feasibility of implementing a telecardiology system in small towns, far from large urban centers and devoid of major resources, using simple and commercially available technology, with relatively low costs. The healthcare professionals from the towns included in the study rapidly adapted to the use of the digital electrocardiogram and systems tools, using them

easily and efficiently. User-friendly computer interfaces, the possibility of direct contact with the on-duty physician at the university center and a decentralized and efficient organization<sup>6</sup>, in addition to the important decrease in the number of patient referrals for assessment in other medical centers were certainly some of the key-points for the successful outcome of the project.

In conclusion, the implementation of a telecardiology system in small towns distant from large centers using the public healthcare services, establishing telecardiology networks, sending electrocardiograms by the Internet and carrying out other telemedicine activities using commercially available equipment and at a reasonable cost is feasible. Such system was approved by the medical team and significantly decreased unnecessary referrals. Although the viability and good acceptance of the program have been established in the present study, it is essential to carry out a cost-effectiveness assessment of the proposed strategy.

## Acknowledgements

To Fundação de Amparo a Pesquisa do Estado de Minas Gerais (FAPEMIG, processes #EDT 2372/05 and PPM-00328-08), to Conselho Nacional de Desenvolvimento Científico and Tecnológico (CNPq, process # 400934/2005-1) for the financial support to the Minas Telecardio project, to FINEP and to the State Health Secretary of the State of Minas Gerais and all collaborators from the university centers (UFJF, UFTM, UFU, UFMG, UNIMONTES) and towns involved in this investigation.

The Minas Telecardio project received the 2008 Health Award from Editora Abril, in the *Heart Health* category.

ALPR and WTC receive research grants from CNPq.

## Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

## Sources of Funding

This study was funded by FAPEMIG, FINEP, CNPq and Secretaria de Estado da Saúde de Minas Gerais.

## Study Association

This study is not associated with any post-graduation program.

## References

1. Barreto SM, Passos VM, Firmo JO, Guerra HL, Vidigal PG, Lima-Costa MF. Hypertension and clustering of cardiovascular risk factors in a community in Southeast Brazil--The Bambui Health and Ageing Study. *Arq Bras Cardiol.* 2001; 77(6):576-81.
2. Lima-Costa MF, Barreto SM, Uchoa E, Firmo JO, Vidigal PG, Guerra HL. The Bambui Health and Aging Study (BHAS): prevalence of risk factors and use of preventive health care services. *Rev Panam Salud Publica.* 2001; 9(4):219-27.
3. Hjelm NM, Julius HW. Centenary of tele-electrocardiography and telephonocardiography. *J Telemed Telecare.* 2005; 11(7):336-8.
4. Des J, Lyles C, Crepaz N. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: the TREND statement. *Am J Public Health.* 2004; 94(3):361-6.
5. Cardoso CS, Bandeira M, Caiaffa WT, Oliveira GL, Ribeiro AL. Escalas de satisfação com o atendimento às doenças cardiovasculares: CARDIOSATIS

- 
- Usuário e Equipe. *Ciência & Saúde Coletiva*. 2008; 30:38-41.
6. Alkmim MB, Ribeiro AL, Carvalho GG, Pena M, Figueira RM, Carvalho MB. Success factors and difficulties for implementation of a telehealth system for remote villages: Minas Telecardio Project Case in Brazil. *J Health Technol Appl*. 2007; 5(3):197-202.
  7. Barold SS. Willem Einthoven and the birth of clinical electrocardiography a hundred years ago. *Card Electrophysiol Rev*. 2003; 7(1):99-104.
  8. Roine R, Ohinmaa A, Hailey D. Assessing telemedicine: a systematic review of the literature. *CMAJ*. 2001; 165(6):765-71.
  9. Hailey D, Ohinmaa A, Roine R. Evidence for the benefits of telecardiology applications: a systematic review. Edmonton, Alberta Heritage Foundation for Medical Research; (AHFMR) 2004:60.
  10. Molinari G, Reboa G, Frascio M, Leoncini M, Rolandi A, Balzan C et al. The role of telecardiology in supporting the decision-making process of general practitioners during the management of patients with suspected cardiac events. *J Telemed Telecare*. 2002; 8(2):97-101.
  11. Bonacina S, Draghi L, Masseroli M, Pincioli F. Understanding telecardiology success and pitfalls by a systematic review. *Stud Health Technol Inform*. 2005; 116:373-378.