IMPLEMENTING AN ELECTROCARDIOGRAPHY TELEDIAGNOSTIC SERVICE IN PERNAMBUCO, BRAZIL

Keilla Taciane Martins de Melo RN[1], Daianny de Paula Santos RN[1], Claudinalle Farias Queiroz de Souza PhD[1], Paula RejaneBeserra Diniz PhD[1,2], Magdala de Araujo Novaes PhD[1,2]

[1] Núcleo de Telessaúde, Hospital das Clínicas, Universidade Federal de Pernambuco. Recife, Pernambuco/ Brazil
[2] Departamento de MedicinaClínica, Universidade Federal de Pernambuco. Recife, Pernambuco/ Brazil

Abstract

In Brazil, cardiovascular diseases account for more than 10% of hospital admissions, and are considered a significant contributor to healthcare costs. One of the most frequently ordered diagnostic tests in the investigation of cardiovascular diseases is the 12-lead electrocardiogram (ECG). Cardiologists are not widely available to provide reports in small municipalities in Brazil, and eHealth services can be a feasible alternative to low resource environments. The use of tele-electrocardiography (Tele-ECG) can improve the management of patients and support decision making regarding referral to advanced medical centres. This study describes the implementation of a telediagnostic service for Tele-ECG in the state of Pernambuco, Brazil. The service was provided as a campaign in each community and was conducted by a team composed of a nurse and a technician from the university telehealth unit using a telehealth platform HealthNet, a laptop and a mobile digital electrocardiograph. In 2016, 34 visits were held to municipalities in Pernambuco, with 6,138 ECGs performed on patients from waiting lists, 63.5% of whom had never had an ECG, with 39.6%of the tests showing evidences of abnormal clinical situations and 0.1%) showing artefacts. The field interventions highlighted the contribution of telehealth as a feasible strategy to enhance access to care and reducing time to ECG reports, the need for patient transportation and costs for the Brazilian healthcare system, the Unified Health System. Considering the restricted budgets of the municipalities to acquire digital devices to perform ECGs and the shortage of specialised medical staff, the success of this field intervention increased the interest of public managers for telediagnostic services.

Keywords: telemedicine**;** electrocardiography; primary healthcare; Brazil.

Introduction

Cardiovascular diseases are frequently found in most populations and are one of the main causes of death in the world. These diseases are responsible for high levels of morbidity and mortality, with impairment of autonomy and decreased quality of life, together with increased social and economic costs for the healthcare system.[1] Systemic arterial hypertension is one of the major factors that contributes significantly to the risk of an individual developing cardiovascular diseases such as heart problems or stroke. In primary care, systemic arterial hypertension is a treatable and clinically measurable condition.[2]

In Brazil, cardiovascular diseases account for more than 10% of hospital admissions, and are considered a significant factor for healthcare costs. Despite the recent decline, cardiovascular diseases are still among the main causes of death in Brazil.[2] The prevalence of arterial hypertension in the Brazilian population varies from 22.3% to 43.9%, based on a blood pressure ≥140/90 mmHg. During the course of the hypertensive disease, it is necessary to investigate possible lesions in target organs, especially cardiac damage.[3]

One of the most widely ordered diagnostic tests to investigate cardiovascular disease is the 12-lead electrocardiogram (ECG). This method is recommended by the Brazilian guideline for the control of arterial hypertension to evaluate cardiac damage in patients with arterial hypertension (VII Brazilian Guideline for Hypertension Management).[4] Besides that, the ECG has been shown to be cost-effective because it has the potential to reduce the rate of sudden cardiac death.[5,6] In cases of acute myocardial infarction, the combination of clinical evaluation together with an ECG allows a diagnostic accuracy of 90-95%.[7] In general, cardiologists are responsible for formally interpreting ECGs and writing reports. These specialists are not widely available in smaller Brazilian

municipalities[8] and thus, the use of eHealth services can be a viable alternative in low resource environments.[9]

eHealth is the use of information and communication technologies (ICT) for health. It includes the relationship between medical informatics, public health and management, enabling improvement and/or qualified care for health services and systems through the Internet and related technologies.[10]

It is reported in the literature that the use of remote ECGs in rural areas enables a significant reduction in the time required for the electrocardiographic diagnosis of cardiac emergencies. Accordingly, the use of tele-ECG (Tele-ECG) can improve the clinical management of patients with ECG-sensitive cardiovascular diseases, as well as assisting health professionals in decision making for a qualified referral of these patients to specialised medical centres.[7] In Brazil, Telemedicine and Telehealth initiatives have increased over the last decade, particularly through the Telehealth Network Brazil Programme (TNBP). This programme was created in 2007, by the Brazilian Ministry of Health, which implemented telehealth to support continuing education and improve the quality of care in the primary care network. TNBP began in nine states, and today is deployed throughout the country.[11] The state of Pernambuco, located in north-eastern Brazil, was one of the pioneers in implementing the programme through the Telehealth Center (NUTES) of the Clinical Hospital of the Federal University of Pernambuco.[12,13]

Each state adopted different strategies to offering telehealth services, based on the local health characteristics and available budget from the Federal and State Government. NUTES is the oldest telehealth centre working in a public university hospital in the country. It began its activities in telehealth in 2003, implementing the NUTES Network (RedeNUTES) offering tele-assistance (inter-professional consultations) and tele-education services in several health-related specialties to primary care settings in Pernambuco.[14] ECG telediagnostic has been offered through RedeNUTES since 2013. The logic behind the telediagnostic service is based on the offer of complementary examinations (mainly in the scope of primary care), by means of ICT. The telediagnostic service enables the specialist physician to write ECG reports without the need to be in the same environment as the patients whose ECG signals are being collected. This provides a way to expand access to skilled and qualify health care in remote locations of overcoming an old barrier of the uneven distribution of specialists capable of writing ECG reports. Preliminary assessments indicate an increasing interest from the public managers of small municipalities in investing in acquiring Tele-ECG devices and providing this service in their communities. The aim of this paper is to describe the implementation process of a telediagnostic service, specifically Tele-ECG, in municipalities of Pernambuco State, in Brazil.

Methods

This is a descriptive study based on the process of implementing the Tele-ECG, a telediagnostic service in cardiology, through RedeNUTES for municipalities of the state of Pernambuco in 2016. NUTES provided telehealth infrastructure and consultants specialised in cardiology, technical professionals and service logistics. A medical device company, was a partner in the implementation and provided two 12-lead electrocardiographs for implementation of Tele –ECG, as the NUTES budget from the Ministry of Health did not cover the acquisition of medical devices for examinations.

Municipalities did not have knowledge of the potential of the telediagnostic service, nor the resources to acquire digital devices for its practice. Due to these limitations, we adopted a strategy based on visiting municipalities to deliver the Tele-ECG service as a campaign by an itinerant team from the university. This strategy aimed to demonstrate to public health managers and health professionals the benefits brought by telediagnostic practices.

Additionally, the team's activity stimulates future deployment by the municipality of telediagnostic fixed sites for the continuous provision of the service to the population. To carry out the service, the municipalities were selected based on five requirements: the frequency of their use of Internet based inter-professional consultation and tele-education services; the local infrastructure to receive the itinerant team; the size of the population (less than 50,000 inhabitants); remote and/or isolated locations; unmet demand and access to the exam *in loco*.

The itineraries of the telemedicine team were defined according to the municipalities' eligibility to receive the service, compatible schedules and availability of transportation for the team. For each municipality selected, Tele-ECGs were performed during the visit on patients on waiting lists. (Figure 1)

The infrastructure of the Tele-ECG service consists

Figure 1. Electrocardiogram test being performed on a patient.

of a nurse, a nursing technician, 12-lead digital electrocardiogram equipment and a laptop connected to the Internet with access to the telehealth platform HealthNet. This platform is used to transmit relevant information and the ECG signals and also gives the primary care team secure access to the report. Each municipality was responsible for inviting the patients who were on their waiting list for an ECG and also for arranging for the healthcare unit to accommodate the telehealth team and their equipment. As an effort to stimulate the acquisition of the digital equipment, the local healthcare practitioners also participated in the action and received training *in loco* to carry out the examination. (Figure 2)

Figure 2. Training for the test at the primary care setting.

Communication between the team and the cardiology specialist (also called the cardiology teleconsultant) was carried out through the telehealth HealthNet platform, a cloud application developed by NUTES. This platform is device independent and is based on Brazilian telehealth standards to provide structured reports. By means of this platform, NUTES provides several telehealth services, among them inter-professional consultation and telediagnostics.

During a visit, the team accessed the telediagnostics platform to include the request, filled in the patient's clinical data and the requesting healthcare practitioner's (e.g. physician's) data, attached the ECG (as an image or pdf file), and forwarded the request for report. Requests were received by the NUTES teleregulation team and after evaluating the technical quality of the examination, were sent to the medical teleconsultant. When completed, the report was made available through the platform to be accessed by the physician who requested the test. (Figure 3) At any time, the actors in this process could connect through the platform to request more clinical information about the patient or attach other information that supported the issuance of the report or the clinical discussion that may have been generated from the result of the test.

The teleconsultants were professionals (physician, nurse) hired and trained by NUTES in the use of the platform and other associated resources. The health professionals of the municipalities involved in this service were previously registered and trained in the use of the HealthNet Telehealth Platform.

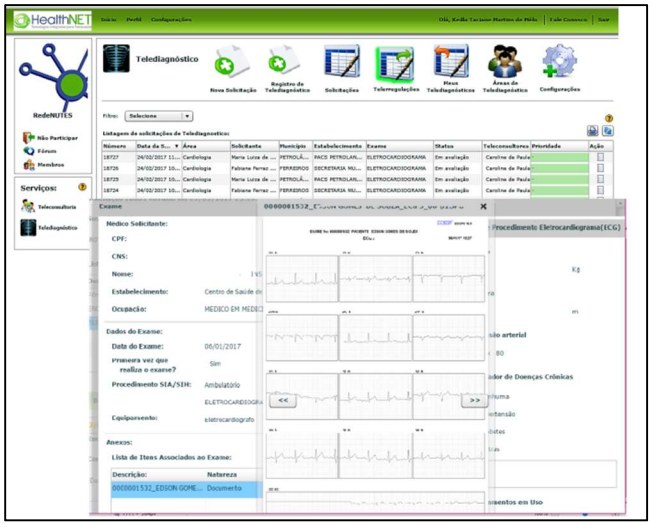

Figure 3. HealthNetTelehealth Platform interface for telediagnostic.

Results and Discussion

In 2016, visits to 34 municipalities were undertaken to perform the ECG test on patients who were on the waiting list. (Figure 4) At each visit, 40 to 60 patients were seen. During this period 6,138 electrocardiograms were performed on these patients, of whom 63.5% had never had an ECG before.

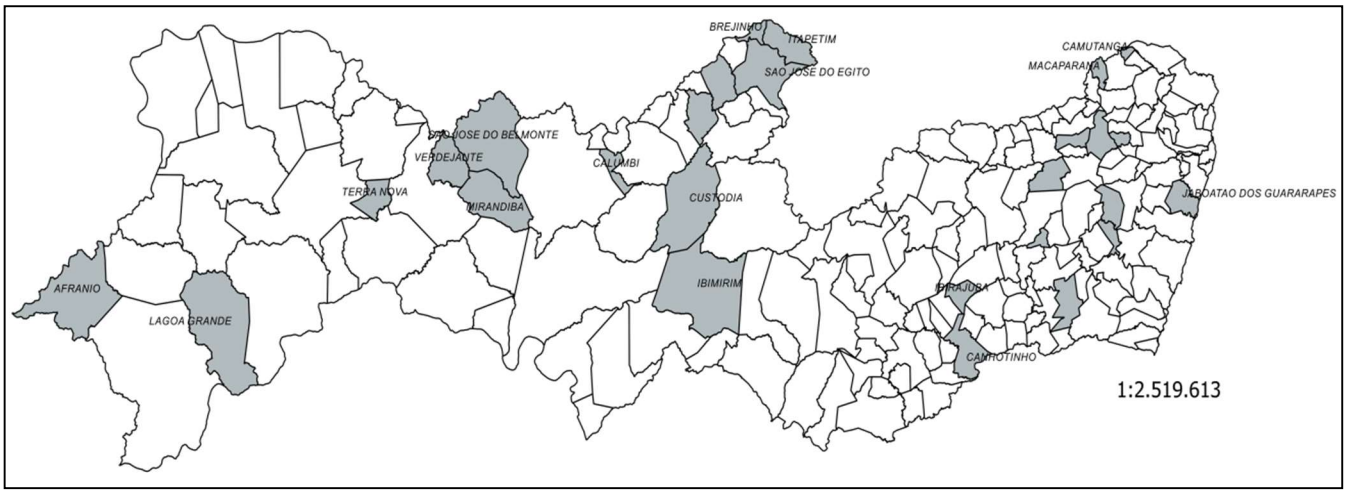

Figure 4: Municipalities visited in Pernambuco by the Tele-ECG in 2016.

ECG abnormalities were present in 2,537 cases (39.6%) and 0.1% of the ECGs had artefacts that impaired reporting. (Table 1)

Table 1. Diagnoses made by Tele-ECG.

Most frequent diagnosis	(n)	%
Overload of the heart chambers	635	25.0
Arrhythmias	489	19.3
Ventricular repolarisation	382	15.1
Conduction disorders IV	355	14.0
Conduct disorders AV	256	10.1
Electrically inactive areas	189	8.0
Ischemic heart disease	125	4.9
Voltage	106	4.2

The electrocardiogram (ECG) is an important diagnostic procedure in the investigation of cardiovascular events in primary care. Tele-ECG allows a medical diagnosis of pathologies related to the cardiovascular system and consequently contributes to a favourable prognosis and reduction of morbidity and mortality. Small changes detected by Tele-ECG can be characterised as "predictors" of clinical manifestations of coronary diseases.[7,15]

In addition, Tele-ECG allows healthcare professionals to better manage their patients through early identification of clinical manifestations of cardiovascular diseases and timely and appropriate referrals, as in many instances patients can be managed locally without the need to be sent to specialised centres.

In addition, the inclusion of Tele-ECG as a routine in healthcare service has the potential to reduce health costs and the distance between patients and health professionals. According to Andrade et al telecardiology is a useful strategy for municipalities in remote areas without local diagnostic infrastructure.[9] In these contexts, in addition to history and clinical examination, the Tele-ECG can also be used in cardiovascular epidemiology, being a simple and low-cost examination that provides data on myocardial status, allowing diagnosis of cardiac manifestations such as myocardial infarction, ischaemia and cardiac hypertrophy and detecting the risk of future cardiac events or mortality from heart disease.[15,16]

Of the 34 municipalities visited, 12 (35.2%) have deployed fixed telediagnostic sites and offer the service on a continuous basis. The acquisition of digital devices was carried out by the municipalities themselves. In these cases, the health team returned to the municipality to carry out training for the professionals who were responsible for performing the test on a daily basis. In some cases, the municipality implemented both, fixed and a mobile telediagnostic site, e.g. a primary care unit with a higher demand received a fixed site, and the others receive the visit of the itinerant team as needed.

In such cases, the NUTES team continues to provide support to the municipality, whether for technical and operational questions, through call centre. Additionally, reports are delivered through the platform and teleconsultants are made available to discuss cases of patients that need more monitoring.

Conclusion

The implementation of the Tele-ECG service developed by NUTES has proved to be a crucial tool in the diagnostic support for municipalities in the state of

Pernambuco. These municipalities are mostly small to medium-sized and have no health diagnostic services as a routine. Since the implementation of Tele-ECG, public health managers frequently report the cost-effectiveness of the telediagnostic service through reduction of personnel costs, less transportation of patients, less diagnostic delay, qualification of referrals to the specialised network.

From the experience described, we highlight the contribution of telehealth as a safe and economically viable alternative to broaden access to diagnostic tests. By means of telediagnostics and specifically Tele-ECG, specialised care can be provided to communities in areas with restricted access, as well as supporting clinical decision making through specialised teleconsultation in cardiology.

The managers are enthusiastic to join the telediagnostic service, but its implementation faces problems such as the acquisition of equipment (basic technological infrastructure) and hiring human resources to perform the tests. The combined strategy of fixed and mobile sites of telediagnostic will be routinely offered by RedeNUTES, and new telediagnostic procedures will be made available.

……

Corresponding author:
Keilla Taciane Martins de Melo
Núcleo de Telessaúde
Hospital das Clínicas
Universidade Federal de Pernambuco (UFPE)
Av. Prof.MoraesRego, s/n, CidadeUniversitária,
Recife-PE, Brazil
CEP: 50.670-420
+55 81 2126-3912
Email: keilla.melo@nutes.ufpe.br

Acknowledgments. We appreciate the support of the Municipal Health Secretariats; the dissemination and active research of patients by professionals of the Health Care Units; the grant of electrocardiogram equipment by LinkMed Medical Solutions and all people who participated in this study.

Conflict of Interest. The authors declare no conflicts of interest.

References

1. Labarthe DR. Epidemiology and prevention of cardiovascular diseases: a global challenge. Jones and Bartlett Publishers, 2010.
2. Schmidt MI, Duncan BB, e Silva GA, et al. Chronic non-communicable diseases in Brazil: burden and current challenges. *Lancet* 2011;377(9781):1949-1961. Available at: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(11)60135-9/abstract accessed 1 February 2017.
3. Gus I. Enhancement of ECG changes in hypertension. *Braz J Hyperten* 2007;14(3):158-161. Available at: http://departamentos.cardiol.br/dha/revista/14-3/06_aprimoramento.pdf accessed 1February 2017.
4. Brazilian Society of Cardiology. VII Brazilian Direction of Hypertension. *J Braz Soc Cardiol* 2016;107(3):53-75. Available at: http://publicacoes.cardiol.br/2014/diretrizes/2016/05_HIPERTENSAO_ARTERIAL.pdf accessed 1 February 2017.
5. Asif IM, Drezner JA. Sudden cardiac death and preparticipation screening: the debate continues-in support of electrocardiogram-inclusive preparticipation screening. *Prog Cardiovasc Dis* 2012;54(5):445-450. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22386296 accessed 1 February 2017.
6. Vanderlei LCM, Pastre CM, Hoshi RA, Carvalho TD, Godoy MF. Basic notions of heart rate variability and its clinical applicability. *Rev Bras Cir Cardiovasc* 2009;24(2): 205-217. Available at: http://www.scielo.br/pdf/rbccv/v24n2/en_v24n2a18.pdf accessed 1 February 2017.
7. Sparenberg ALF, Russomano T, Azevedo DFGD, Soares ER, Schaun TR. Establishment of a Digital Tele-Electrocardiographic System in southern Brazil. *Scientia Medica* 2005;15(3):9. Available at: http://revistaseletronicas.pucrs.br/ojs/index.php/scientiamedica/article/viewFile/1563/1166 accessed 1 February 2017.
8. Scheffer et al. Medical Demography in Brazil 2015. São Paulo: Department of Preventive Medicine, Faculty of Medicine, USP; Regional Council of Medicine of the State of São Paulo; Federal Council of Medicine, 2015. 284p.

Available at: http://www.usp.br/agen/wp-content/uploads/DemografiaMedica30nov2015.pdf accessed 2 February 2017.

9. Andrade MV, Maia AC, Cardoso CS, Alkmin MB, Ribeiro AL. Cost-Benefit of the Telecardiology Service in the State of Minas Gerais: Minas Telecardio Project. *Arq Bras Cardiol* 2011;97(4):307-316. Available at: http://www.scielo.br/pdf/abc/v97n4/en_aop7111.pdf accessed 2 February 2017.
10. Wen CL. Telemedicine and telehealth - A panorama in Brazil. *Rev Public Computer* 2008;10(2):7-15. Available at: http://www.ip.pbh.gov.br/ANO10_N2_PDF/telemedicina_telesaude.pdf accessed 3 February 2017.
11. Brazil. Ministry of Health. Ordinance No. 2,546, dated October 27, 2011, which provides for Redefining and expanding the Telehealth Brazil Program, which is now called the National Telehealth Brazil Networks Program (Telehealth Brazil Networks). Available at: http://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt2546_27_10_2011.html accessed 1 February 2017.
12. Diniz PRB, Sales FJR, Novaes, MA. Providing telehealth services to a public primary care network: the experience of RedeNUTES in Pernambuco, Brazil. *Telemed J e-Health* 2016;22(8):694-698. Available at: http://online.liebertpub.com/doi/pdf/10.1089/tmj.2015.0209 accessed 2 February 2017.
13. Portal Telehealth Nucleus of Hospital das Clínicas. (2017). Available at: www.nutes.ufpe.br accessed 2 February 2017.
14. Barbosa AKP, Novaes MA,Vasconcelos AL. The Web application to support telemedicina services in Brazil. In: AMIA 2003 - American Medical Informatics Association Annual Symposium, 2003, Washington. AMIA 2003 Symposium Proceedings 2003; p. 56-60.Available at: https://www.researchgate.net/publication/237593449_Integracao_de_Sistemas_de_Servicos_de_Telessaude accessed 2 February 2017.
15. Souza KT, Duarte NO, Silva TMD. Itinerant electrocardiogram tests done in Primary Health Care by telemedicine. *Latin Am J Telehealth* 2016;3(1):55-59. Available at: http://cetes.medicina.ufmg.br/revista/index.php/rlat/article/viewFile/117/263 accessed 2 February 2017.
16. Cardoso E, Martins IS, Fornarh L et al. Electrocardiographic alterations and its relation with the risk factors for ischemic heart disease in a population of the metropolitan area of São Paulo. *Rev Assoc Brazilian Med*2002;48(3):231-236. Available at: http://www.scielo.br/pdf/ramb/v48n3/11821.pdf accessed 2 February 2017.