Comparison between the time required to generate and type radiology reports by means of VoIP-based system and a traditional paper-based system*

Comparação dos tempos de geração e digitação de laudos radiológicos entre um sistema eletrônico baseado em voz sobre IP (VoIP) e um sistema tradicional baseado em papel

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Abstract **OBJECTIVE: To compare the time required for generation and typing of radiology reports by means of an electronic system based on the technology of voice over internet protocol (VoIP) and the traditional system, in which the report is handwritten by the radiologist. MATERIALS AND METHODS: It was necessary to model, build and deploy the proposed electronic system, capable of recording the reports in a digital audio format and comparing it with the traditional method. Radiologists and transcriptionists recorded the reports generation and typing times for both systems, using appropriate forms. RESULTS: When the mean times between both systems were compared, those from the electronic system presented a reduction of 20% ($p = 0.0410$) in the report generation time as compared with the traditional method. On the other hand, the traditional method was more efficient with respect to typing time, as the mean typing time with the electronic system was three times longer ($p < 0.0001$). CONCLUSION: The results demonstrated a statistically significant difference between the compared systems, with the electronic system being more efficient than the traditional one with respect to report generation time, while the traditional method presented better results with respect to typing time.**

Keywords: Radiology information systems; Medical records; Analog-digital conversion.

Resumo **OBJETIVO: Comparar os tempos de geração e digitação de laudos radiológicos entre um sistema eletrônico baseado na tecnologia de voz sobre o protocolo de internet (VoIP) e o sistema tradicional, em que o radiologista escreve o laudo à mão. MATERIAIS E MÉTODOS: Foi necessário modelar, construir e implantar o sistema eletrônico proposto, capaz de gravar o laudo em formato de áudio digital, e compará-lo com o tradicional já existente. Por meio de formulários, radiologistas e digitadores anotaram os tempos de geração e digitação dos laudos nos dois sistemas. RESULTADOS: Comparadas as médias dos tempos entre os sistemas, o eletrônico apresentou redução de 20% ($p = 0,0410$) do tempo médio de geração do laudo em comparação com o sistema tradicional. O tradicional foi mais eficiente em relação ao tempo de digitação, uma vez que a média de tempo do eletrônico foi três vezes maior ($p < 0,0001$). CONCLUSÃO: Os resultados mostraram diferença estatisticamente significante entre os sistemas comparados, sendo que o eletrônico foi mais eficiente do que o tradicional em relação ao tempo de geração dos laudos, porém, em relação ao tempo de digitação, o tradicional apresentou melhores resultados.**

Unitermos: Sistemas de informação em radiologia; Registros médicos; Conversão análogo-digital.

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INTRODUCTION

The widespread use of computers appears to be decreasing people´s ability to handwrite, causing a change in the way written texts are produced due to computational resources. The use of computers reduces writing times and provides people with the capability of recording much more information in less time[1].

In the health sector, collection, processing, recording and retrieval of patients information can be electronically performed, by means of computers, as well as by traditional paper-based methods. With the growth of data volumes comprised in patients records, and with the need to retrieve such data in a structured and effective manner, it is easy to realize that information technology may contribute to improvements in quality of healthcare provided to patients[2].

Among the data that can be stored in patient records are medical consultations,

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patient progression, demographic information, complications, medications, history, laboratory data, radiological reports, etc.[3]. The radiological report constitutes the documentation and formal communication of the findings in a given imaging diagnosis procedure, besides being the most critical aspect of the service rendered by the radiologist[4].

Over the last decade the quantity and complexity of radiological reports have increased, and historically have been generated by means of different methods such as voice-to-text systems, and dictation on a magnetic tape recorder, for example[5].

The present study compares the report generation times between two different report generation systems and identifies which of them is more efficient with respect to time spent in generation and in typing of such reports. The first is the traditional system in which the radiologist handwrites the report and sends it to a transcriptionist who types and prints the report using an appropriate computer system. The second is the electronic system, in which the radiologist generates his reports by means of a system based on Voice over Internet Protocol (VoIP) using a telephone or computer, and the audio recording of the thus generated report is transcribed (heard and typed) in digital format.

The investigation hypothesis is whether there is a reduction in generation and typing times of the radiological reports when the electronic VoIP system is used.

MATERIALS AND METHODS

The proposal for this study has been originated in the need to carry out a modification in the report generation process at an imaging diagnosis unit in such a way to allow the reports to be generated by means of voice recorded in digital format, in addition to the traditional method in which the radiologist handwrites the report.

In order to enable this study, a partnership was established with the Department of Imaging Diagnosis (DID) of Universidade Federal de São Paulo (Unifesp), which provided the information on the traditional method of reports generation, as well as the transcriptionists and radiologists (second year residents) who participated in this study. After that, it was necessary to extend the DID's report generation process, and the modeling, building and deployment of the proposed VoIP-based process. Subsequently, the data regarding to report generation and typing times were collected both for the electronic and traditional methods, for comparison purposes.

Over a four-month the period, the ethnographic[6] method was utilized to observe, detail, describe and document the report generation process at the DID.

After the studies are performed, the films are placed in individual envelopes labeled with the patient and study identification. Such envelopes are taken to the radiologist who analyzes the images and writes the report down on paper. Such handwritten data are then typed. Transcriptionists use a computer system to type and print the report. Periodically, the radiologist reviews and corrects the reports, and those with corrections are retyped and returned to the radiologist for a final check. The reports are then sent to the patient assistance service and are delivered to the patients. The transcriptionists update the reports status in the system, and these are automatically filed in the patient´s electronic medical records.

Based on interviews with radiologists, transcriptionists and DID staff members, it was possible to detect the requirements for modeling the RadVoIP, an information system developed for radiologists and transcriptionists in order to record, type and correct reports. With the use of the Unified Modeling Language (UML®)[7], use case diagrams were built in order to identify the main functionalities that the system should comprise. Thus, it was possible to observe that the RadVoIP should be composed of two modules: a telephone module in order to allow radiologists to record the reports, and a web module for typing, correction and report issuance.

The telephone module relied on the Voice over Internet Protocol technology (VoIP). A server connected to the internet receives calls from regular or cell phones and records these calls in MPEG-1/2 Audio Layer-3 (MP3) digital audio format. In order to install and configure the VoIP server, the Asterisk® tool was chosen, as it deploys in a software the resources found in a Private Automatic Branch Exchange (PABX). It is a freeware open-code software, available for installation in operational systems based on the Unix platform. One of its main functionalities is the possibility of using the Audible Response Unit (ARU), which performs telephone tasks such as automated answering and digit recognition.

The web module was designed in such a way to allow the transcriptionists to access the recorded radiologist's audio reports and type them. This module also allows the radiologists to follow-up the reports typing and to correct inconsistencies or typing errors, and finally release them to be integrated to the patients' electronic medical records. The method adopted in the development of this module was the eXtreme Programming (XP)[8]. The development of the module was based on the MySQL Server® data bank, PHP® programming language and Apache® web Server. It was designed to operate jointly with the electronic medical patient records (EMPR) of Hospital São Paulo (HSP), and the Information System Division (ISD), responsible for the development and maintenance of the EMPR provided the necessary permits for the reading and writing data from RadVoIP in the EMPR data bank worksheets.

Five radiologists were selected to prepare the reports in this research on 40 studies – 20 radiographs and 20 tomographs – which were selected regardless of being studies with normal or abnormal results, with the possibility of both cases in the sample universe. The radiologists and transcriptionists received a single training, in which they had the opportunity to record some reports and operate the web system.

In order to compare the electronic report generation system with the traditional one, the following times were collected and recorded:

Report generation time – Time required by the radiologist to record the report in the case of the electronic report and to handwrite the report in the case of traditional reports. For both cases the radiologists recorded in appropriate forms the time when they started recording or handwriting the reports (hour and minutes) and the time when the task was completed.

Report transcription time – Time required by the transcriptionists to listen to and type the electronic report or to read and type the traditional reports. The transcriptionists also recorded the start and completion times of the transcriptions. The final result of this process was the typed report available for review by the radiologists.

Such data were submitted to the statistical Mann-Whitney test with the objective of identifying whether or not there were statistically significant differences between the reports generation and typing times.

RESULTS

After building the use case diagrams, the modules development was started. In the telephone module (Figure 1) there are two communication channels with the VoIP server (Block A). The first one receives calls from regular and cell phones (Block B), while the second one receives calls from the digital extensions (Blocks A, C and D).

As soon as the report recording was finished, the generated digital audio file was sent from the VoIP server (Block A) to the web page server, which hosted the web module of the RadVoIP (Block C).

The web module was developed soon after the conclusion of the telephone module, as it was necessary to record the first reports so that they could be accessed. Figure 2 shows the web module development scenario. The PHP pages were hosted in the web page server of the ISD (Block C), while the database was stored in the data bank server at the Department of Information Technology in Health (Block A). The communication between both servers was carried out over the Unifesp intranet.

Out of the five residents participating in the study, two completed the entire spoken and written report generation process, and one prepared the reports on half the studies. The three residents that prepared the reports returned the forms with the recorded times, and so did the transcriptionist.

In the traditional report generation system, the radiologists recorded the generation times for 46 reports, the same number of reports generated in the electronic system. When submitted to the Mann-Whitney statistical test, the samples with times longer than 15 minutes were excluded for both systems, as such times were considered extreme values. Three cases were excluded in the electronic system and one in the traditional system. The difference between the mean report generation times in the compared systems was one minute and

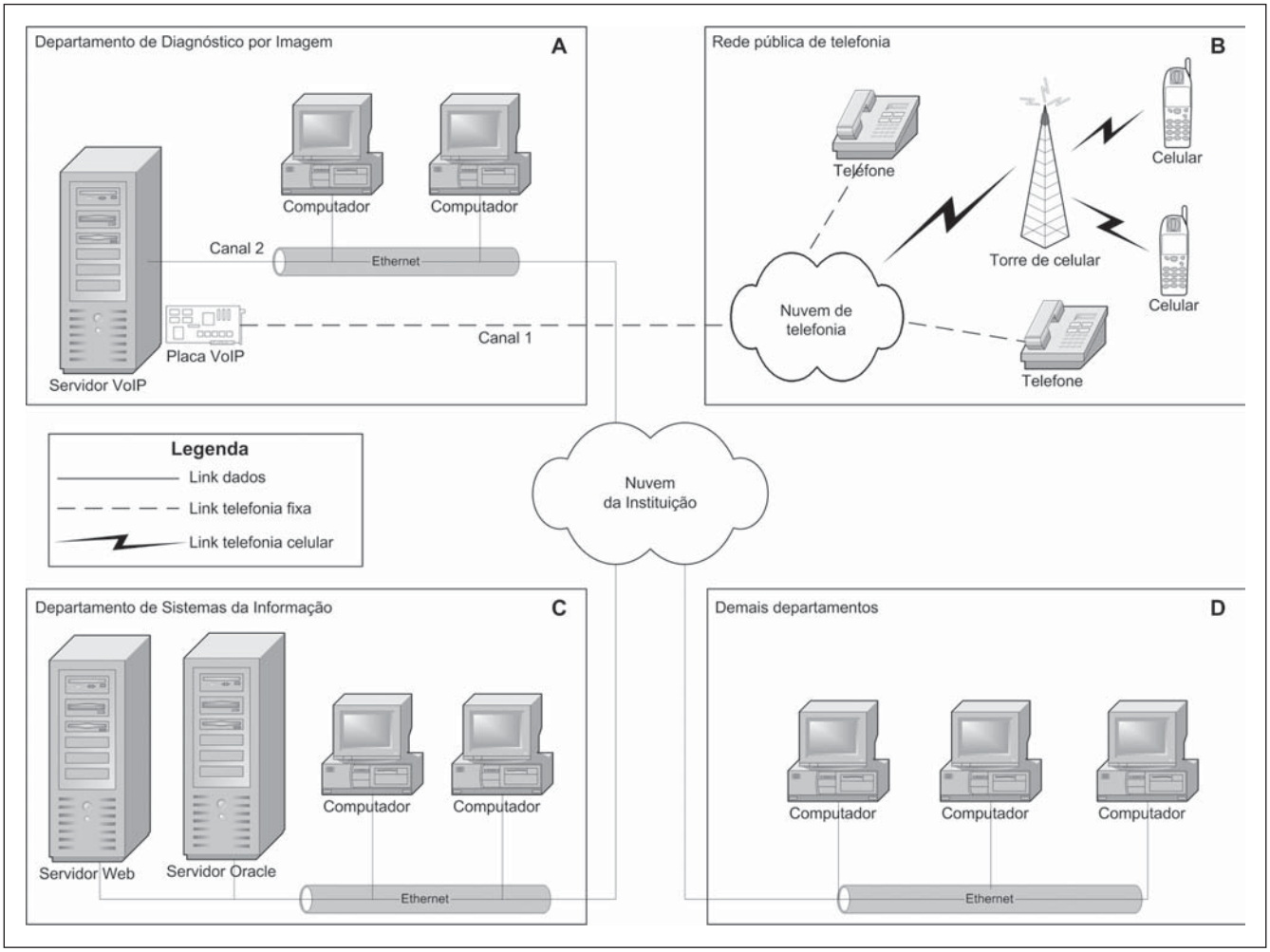

Figure 1. Scenario of the RadVoIP telephone module development.

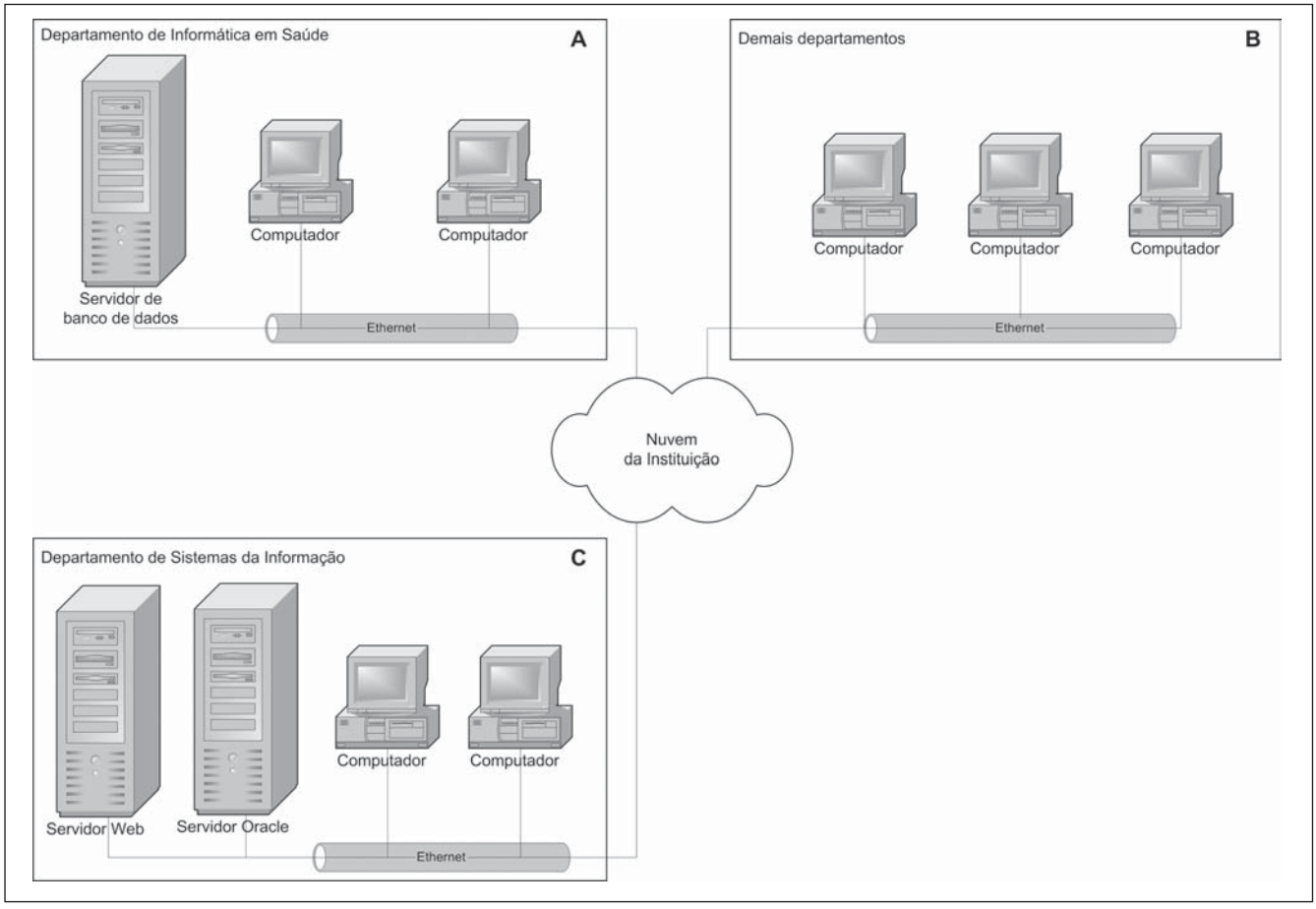

Figure 2. Scenario of the RadVoIP web module development.

21 seconds, corresponding to a reduction of 20% in the report generation time when the electronic system was utilized. The distribution of report generation times is not normal, and the difference between the averages in the electronic and traditional systems generated the value of $p = 0.0410$ for a confidence interval of 95%. Other statistical indicators related to the report generation time were: U = 725.000 and Z = –2.041.

The chart on Figure 3 shows the relation between the report generation times in each system, with the extreme values already excluded. The X axis in the chart represents the time in minutes required by the radiologist to generate the report, while the Y axis represents the number of reports generated within that particular time. By observing the chart, one notices that most of the reports were generated within the 3 to 6 minutes interval. Of the 43 electronic reports, 29 were generated within this interval, approximately 67.5% of them. Within this same interval are 23 of the 45 traditional reports, or approximately 51% of them. The number of reports that took 10 minutes or more to be generated was 13 in the traditional system and only five in the electronic system, approximately 29% and 11.6% respectively. In both systems most of the reports were generated in up to 10 minutes, 38 (88.4%) of the 43 reports in the electronic system and 32 (71.1%) of the 45 reports generated in the traditional system.

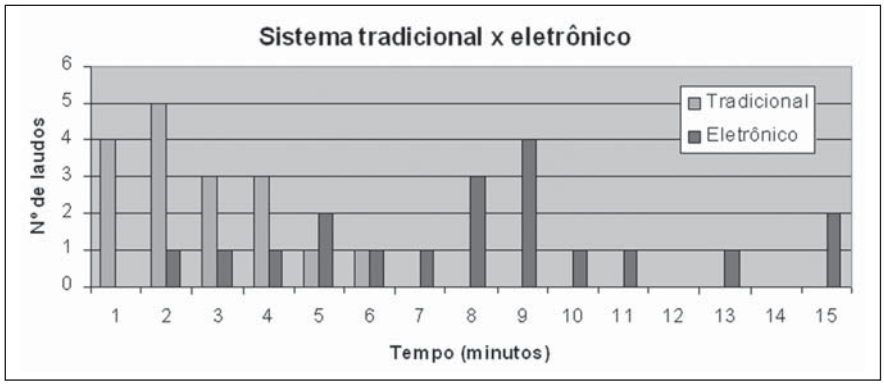

Figure 3. Chart with the number of reports generated in each one of the systems in relation to generation time.

With respect to transcription time, the transcriptionist recorded the times relative to 17 reports in the traditional system and 19 reports generated through the electronic system. In order to apply the Mann-Whitney statistical test, a time longer than 450 seconds was excluded from the handwritten sample. In the electronically gen-

erated sample, there was no extreme value exclusion.

The typing of reports made in the electronic system required an average time above 5 minutes or three times longer (303%) than it did in the traditional system. The distribution of times is not normal either, and the same confidence interval applied for the generation times was applied to this case, resulting in the value $p < 0.0001$. Other statistical indicators related to typing time were: U = 24.000 and Z = –4.381.

The chart on Figure 4 shows the relation between the typing times in each system. By observing the chart it is possible to see that 15 of the 17 reports prepared in the traditional system took between 1 and 4 minutes, approximately 88%. Within this same interval, only three of the 19 reports prepared in the electronic system were typed, 15% of the total. Most of the reports in the electronic system, or 12 out of 19, took between eight and 15 minutes to be typed while in the traditional system there were no occurrences in that same interval.

DISCUSSION

The report times obtained from the Mann-Whitney statistical tests demonstrated a statistically significant difference between the mean times of report generation, when comparing the reports generated in the electronic system with those in the traditional system. The difference between the mean times was one minute and 21 seconds, with $p = 0.0410$, indicating that the electronic system is more efficient in the process of radiological report generation, compared with the traditional system. The one minute and 21 seconds difference provides the radiologist that prepares 20 reports per day, a saving in time that totals approximately 26 minutes. With that in mind, the radiologist can use that time in a more thorough analysis of the images, or alternatively preparing a higher number of reports during the work day, thus reducing the study queues and speeding up the release of the reports to patients.

The Mann-Whitney test have also demonstrated a statistically significant difference between the mean report typing times in both systems, when comparing the reports from the electronic system with those from the traditional method. That difference corresponded to five minutes and 30 seconds, with $p < 0.0001$, indicating that the traditional system is more efficient as far as the typing of reports is concerned.

Actually, it was already expected that the traditional system would result in better typing times, as the transcriptionists had been utilizing the system for more than two years, and had to quickly adapt to a new typing process. It was possible to observe the transcriptionist's difficulty in manipulating the control buttons in the web plug-in of the Windows Media Player which allowed him to execute, advance, review, pause and adjust the reproduction volume of the recorded report. For being used to the traditional system, the transcriptionist experienced difficulties in manipulating the controls and buttons mainly because she could not type as fast as the recorded contents were reproduced. Thus it was necessary to utilize the mouse to click on the pause button, and also to drag the review button back to the desired point. This process significantly increased the typing time.

In order to reduce such time, a process to eliminate the need to use the mouse by using shortcut keys such as ctrl+p to pause and reinitiate reproduction was devised so that the transcriptionist would not need to remove one hand from the keyboard to manipulate the mouse, thus reducing typing time. However this process was not successful as the shortcut key combination did not work with the web plug in, in spite of the fact that it did with the Windows Media Player

The 19 reports typed from the electronic system were not enough to provide the transcriptionist with the required dexterity to type the reports more swiftly. This factor has certainly contributed to an increase in the report typing time.

An interesting fact could be observed during the use of the electronic system: the shyness demonstrated by the radiologist when using it. The system was utilized in the same room where the routine reports are prepared, and an embarrassment by the radiologist when preparing the report was evident as his colleagues in the room could listen to him during the report recording. This does not happen in the traditional system, as the process is inherently private and the privacy is only broken with the radiologist´s consent when he asks for a colleague´s opinion, for example. The observed constraint had a direct impact in the quality of the recordings, as in many cases it was necessary to increase sound volume or even use more powerful speakers in order to properly listen to the recording made by the radiologist. When the reports were recorded with a natural voice tone and volume, there was no problem affecting comprehension.

Most of the studies comparing different report generation methods[9–15] involve voice recognition with other some other

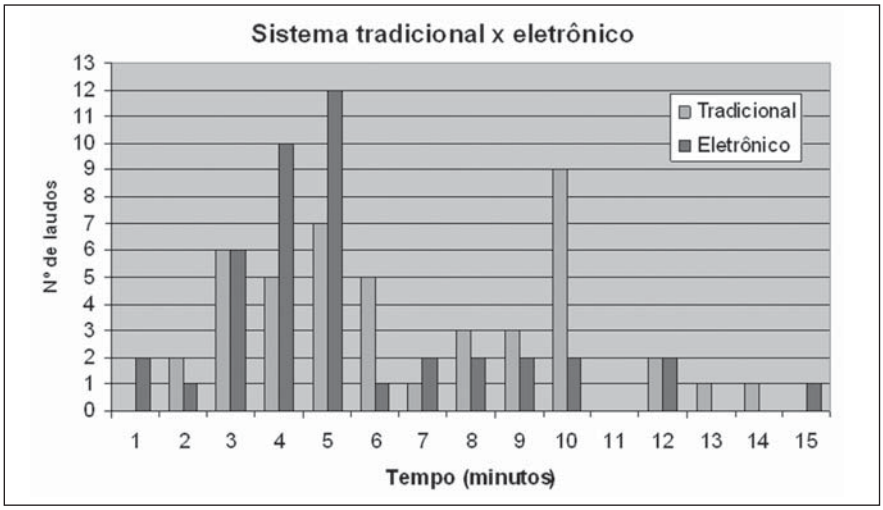

Figure 4. Chart with the number of reports typed in each one of the systems in relation to generation time.

kind of system. These studies mainly report the advantages and shortcomings of voice recognition over other systems. The authors have not found any study reporting radiologist voice recording in digital format, making the recordings available through a web interface for typing, correction and release of the report.

CONCLUSIONS

The proposed electronic report generation system presented a statistically significant difference in the mean report generation and typing time, when compared with the traditional system. In the electronic system there was a reduction of 20% in the report generation time; however the typing time increased by 303%. Therefore the time reduction hypothesis was only partially confirmed, as it proved valid for the radiological report generation time but failed with respect to typing time.

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