Mobile application for data collection in health research

Tecnologia móvel para coleta de dados de pesquisas em saúde

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Abstract

Objective: Describe the development of a mobile application for data collection in time and movement research with health professionals from the Family Health Strategy Program when conducting care interventions/activities.

Methods: Applied research of technological production based on the concept of prototyping and the steps of definition, development, and maintenance, for the design and validation of the application: *Instrumento de medida de carga de trabalho dos profissionais de saúde na atenção primária* (*Workload measurement instrument for health professionals in primary care*). This will be for a mobile Motorola® tablet with Android® 3.2 operating system, with the goal of collecting data for a time and movement study, using the work sampling technique, and identifying the workload of health professionals from family health units (FHUs) located in all five Brazilian geographic regions, presenting an excellent performance in the Primary Care Access and Quality Improvement Program - cycle 1.

Results: The application intensified data collection and facilitated data recording and storage; data transmission; and data organization and processing; and ensured greater reliability in the analysis of results, maintaining data integrity in all these steps. Data transmission and extraction were performed on a daily basis, through file synchronization in Dropbox®. The mobile application was used during the observation of all 418 health professionals from the 27 family health units. In total 85,398 observations of interventions/activities were registered.

Conclusion: The application allowed for more dynamic data collection; maintained data integrity; supported data transmission and storage; facilitated data organization and processing; and provided greater reliability in the analysis of results.

Resumo

Objetivo: Descrever o desenvolvimento de aplicativo de tecnologia móvel para coleta de dados em pesquisa de tempo e movimento dos profissionais de saúde do Programa Estratégia de Saúde da Família, na realização das intervenções/atividades de cuidado.

Métodos: Pesquisa aplicada de produção tecnológica fundamentada no conceito de prototipagem e nas fases de definição, desenvolvimento e manutenção, para construção e validação de aplicativo do "*Instrumento de medida de carga de trabalho dos profissionais de saúde na atenção primária*", para dispositivo móvel *tablet* Motorola® com sistema operacional Android® 3.2, com a finalidade de coletar dados em pesquisa de tempo e movimento, por meio da técnica de amostragem do trabalho e identificar a carga de trabalho de profissionais de saúde, lotados em unidades de saúde da família, localizadas nas cinco regiões geográficas do Brasil, consideradas de ótimo desempenho pelo Programa de Melhoria do Acesso e da Qualidade da Atenção Básica - ciclo 1.

Resultados: O aplicativo potencializou a coleta de dados e facilitou as seguintes etapas: registro e armazenamento dos dados; manutenção da integridade da informação; transmissão e armazenamento dos dados; organização e processamento das informações e maior segurança na análise dos resultados. A transmissão e a extração dos dados foram realizadas diariamente, através da sincronização dos arquivos no Dropbox®. O aplicativo eletrônico foi utilizado durante as observações dos 418 profissionais de saúde das 27 unidades de saúde da família, no total foram registrados 85.398 observações de intervenções/atividades.

Conclusão: O aplicativo possibilitou uma coleta de dados mais dinâmica; manteve a integridade da informação; auxiliou a transmissão e o armazenamento de dados; facilitou a organização e o processamento das informações e proporcionou maior segurança na análise dos resultados.

Introduction

Studies addressing time measurement and management observe the duration and movements required to conduct work activities with the goal of identifying the distribution of time spent to perform these activities and thus obtain the parameters to calculate the workload of professionals. From there it is possible to gauge the number of staff members needed to meet the needs of patients, and it is an important source for restructuring health work processes, worker productivity analysis, and the quality of care provided.[1]

One way to obtain information about how workers allocate time for work activities is by using the work sampling technique, which is based on performing direct observations intermittently, instantaneously. and randomly during the workday.[2-5]

To collect data using the work sampling technique, it is essential to develop an instrument that addresses the relation of interventions/activities that should be performed by the professionals to be observed. However, the use of paper instruments to record the time spent by professionals during the workday generates large amounts of data to be entered in electronic spreadsheets, often increasing the possibility of errors.

Thus, a technological tool is required in the conformation of time and movement research, to ensure quick organization and processing of large amounts of data produced, aiming to reach a margin of error equal to zero.[5,6]

Using a mobile application to record significant amounts of data produced in surveys is adequate to optimize the steps of data organization and processing, favors data flow management, and offers security and quick data availability, which contributes to study development and analysis of results.

A study conducted in a primary healthcare environment in Ethiopia compared the precision of patient data collected via electronic forms on smartphones to those collected on printed forms. It observed that well-designed electronic forms significantly improved data completeness by 8% when compared to paper records, concluding that, with training and supervision, health professionals were able to use electronic forms for patient assessment and routine data collection in an appropriate and precise manner.[7]

Considering the above, this study aimed to describe the development of a mobile application to collect data in time and movement studies with health professionals from family health units (FHUs) regarding the performance of care interventions/activities during the workday.

Methods

This study refers to applied research of technological production whose purpose was to find immediate solutions for an existing problem through product development.[8]

This particular design was adopted in this study because it involved the development of a mobile application to help collect data regarding the distribution of time spent with interventions/activities of FHS teams during the workday, using the work sampling technique as part of a nationwide study titled: *Método de Dimensionamento da Força de Trabalho na Atenção Primária à Saúde* (Workforce sizing method in primary care), developed by *Estações de Trabalho da Rede de Observatórios em Recursos Humanos* of the Nursing Schools at USP in São Paulo and Ribeirão Preto, the Odontology School at USP, and the Instituto de Medicina Social, and the Odontology and Nursing Schools at UERJ, financed by the Pan American Health Organization and the Brazilian Ministry of Health.[5]

In this study, the researchers from the *Estações de Trabalho da Rede de Observatórios em Recursos Humanos* designed and validated an instrument to measure the workload of health professionals in primary care, consisting of care interventions/activities for the following professional categories: physician; dental surgeon; nurse; dental technician/assistant; nurse technician/assistant; and community health agent.[9]

The instrument included interventions of direct and indirect care, work-related activities, personal activities, waiting time, absence, and no observation (Chart 1).

Direct and indirect care interventions correspond, respectively, to treatments provided through interaction with the patient, family, and community, configured in the actions of physiological and psychosocial aspects that involve practical, supporting,

and counseling actions. They also include treatments provided far from the user, family, and community, but to their benefit, that involve actions for the site management and interdisciplinary collaboration.[10]

Work-related activities refer to those that can be performed by workers in other categories, but that are assumed by health professionals. Personal activities are the breaks during the workday related to the physiological and personal communication needs of health professionals.[11,12]

The content of the workload measurement instrument was tested in three family health units located in the Southeast region of Brazil, and validated to include 100% of the interventions observed in the practice of health professionals, with 90.4% agreement among field observers in parallel observations.[5,9]

The interventions and activities were grouped into 20 direct care interventions; 19 indirect care interventions; 14 work-related activities, seven personal activities; and waiting time, absence, and no observation, as indicated in chart 1.

The characterization of studied sites and observed professionals was identified through specific instruments.

In order to operationalize data collection of the *Método de Dimensionamento da Força de Trabalho na Atenção Primária à Saúd*e (Workforce sizing method in primary care), a study conducted in the five geographic regions of Brazil, the measurement instrument of the workload of health professionals in primary care had to be converted into an application, based on the system development lifecycle that starts with prototyping, considering the steps of definition, development, and maintenance.[13]

These steps are present in any application's development, regardless of its lifecycle, application area, project size and complexity, and support the developer in the construction of a system with quality and resources for control during the whole process.[13]

Definition

In this step, the information to be processed was identified, the instrument was coded (Chart 2), the application function and performance were de-

Chart 1. Interventions and activities of the workload measurement instrument for health professionals in primary health care

Interventions	
Direct care interventions	**Indirect care interventions**
Medication administration	Educational actions of health professionals
Support to physician	Support to student
Support in tests/procedures	Performance assessment
Breastfeeding support	Data collection for scientific research
Attention to spontaneous demand	Infection control
Doctor's appointment	Control of supplies
Control of infectious diseases	Work process organization
Control of electrolyte imbalance	Development of administrative processes and routines
Immunization/vaccination control	Development of care protocols
Urgent/emergency care	Documentation
Development of community health	Risk identification
Monitoring of vital signs	Laboratory test interpretation
Guidance regarding the health system	Mapping and territorialization
Outpatient procedures	Referral and counter-referral
Collective procedures	Administrative meeting
Promotion of educational actions	Meeting for the evaluation of multiprofessional care
Vessel puncture: venous blood sampling	Supervision of site workers
Interinstitutional transport	Security supervision
Health surveillance	Exchange of information on health care
Home visit	
Activities	
Work-related activities	**Personal activities**
Answer the phone/call from other sites	Meal/hydration
Check emails of the site	Answer phone/make personal calls
Site cleaning	Socialization with colleagues
Schedule doctor's appointments	Read the newspaper or magazine, use the internet
Schedule tests	Use the toilet
Reception	Interaction event
Provision of doctor's statement	Other personal activities
Audit of clinical records	
Call users with test result alteration	
Conference for test result receipt	
Product distribution to users	
Choose/look for tests and clinical records	
Other related activities	
Room organization	
Waiting time	
Absence	
No observation	

Source: Bonfim D, Pereira MJ, Pierantoni CR, Haddad AE, Gaidzinski RR. Instrumento de medida de carga de trabalho dos profissionais de saúde na atenção primária: desenvolvimento e validação. Rev Esc Enferm USP. 2015; 49(Esp 2): 25-34.[9]

fined, and possible interfaces were created to record the information required for the analysis.

Therefore, the analysis of all requirements for the application development was based on information from the workload measurement instrument of health professionals in primary care, which included the interventions and activities identified for the health professionals from the FHS teams (Chart 1).[9]

The interventions/activities included in the instrument were coded for easy recording of observations and local and virtual storage of information using mobile devices (Chart 2).[9]

Development

In this step, data entry and project architecture were structured, as well as the procedural details to implement the programming language and conduct required testing.

The application development considered the use of a Motorola® tablet, with an Android® operating system version 3.2, and web interface.

The information about each coded intervention was stored in a database developed in a database management system named My Structured Query Language (MySQL®) version 5.4, which uses the Structured Query Language (SQL) as the tool to export data to other programs to analyze data collected during field research.

To synchronize the collected information for proper data storage in its own server, DropSync® and Dropbox® were used on a Wi-Fi or 3G connection, according to the characteristics of each observed field. DropSync® is an application that allows a user to synchronize his/her tablet account with Dropbox® folders, which is a cloud data storage and management service.

The web interface was developed in Hypertext Preprocessor® (PHP®) version 5.3.6, which is a free open source software used in applications that can generate dynamic content. It supported data entry in adverse situations when, for example, the researcher's equipment stopped working due to battery failure. The database and data management were organized according to the security protocols foreseen for the online resources used.

The application was tested by the research supervisor and a field observer. The test lasted three hours, In this period, the supervisor and the observer performed observations regarding the health professionals from one FHU to check the application for proper registration of health professionals, proper data recording, entry and storage, and proper identification of data transmission failure.

Maintenance

In the maintenance step, the adaptations, corrections, and alterations identified in the test conducted by the research supervisor and the observer were performed to improve the application.

Then, all field observers (n=16) underwent a theoretical-practical training whose program addressed the objectives of the *Método de Dimensionamento da Força de Trabalho na Atenção Primária à Saúde* (Workforce sizing method in primary care) study: methodological steps; sampling technique; filling and meaning of the instrument in the field; and use of the application for data collection.

The practical training was conducted in two FHUs, which allowed a new test of the application to identify the feasibility and dynamics of data collection, the application potentialities, and the evaluation and analysis of the interface expressed in the opinions of the observers.[5,9]

Application use in data collection

Studies that address work time should be conducted in environments of good care practices.

In this sense, the Department of Basic Attention of the Ministry of Health created the sample plan of 45 FHUs, distributed in all five Brazilian geographic regions, selecting 27 units that comprised an intentional sample, according to the following criteria: include three municipalities from each geographic region, preferably not in the same state; presenting an excellent performance in the evaluation of the Primary Care Access and Quality Improvement Program (PMAQ-AB, cycle 1); and offering at least three family health units with complete staff (physician, nurse, nursing technician/assistant, community health agent, dentist, and dental technician/assistant).

Chart 2. Codes of interventions/activities when using the tablet during data collection

Interventions in Primary Health Care	
Educational actions of health professionals Medication administration Support to student Support to physician Support in tests/procedures Breastfeeding support Attention to spontaneous demand Performance assessment Data collection for scientific research Doctor's appointment Control of infectious diseases Control of electrolyte imbalance Immunization/vaccination control Infection control Control of supplies Work process organization Urgent/emergency care Development of community health Development of administrative processes and routines Development of care protocols Documentation (administrative material) 211 - Records related to doctor's appointment and clinical procedures 212 - Records related to home visit 213 - Records related to surveillance	Risk identification Laboratory test interpretation Mapping and territorialization Monitoring of vital signs Guidance regarding the health system Outpatient procedures Collective procedures Promotion of educational actions Vessel puncture: venous blood sampling Referral and counter-referral Administrative meeting Meeting for the evaluation of multiprofessional care Supervision of site workers Security supervision Interinstitutional transport Exchange of information on health care Health surveillance Home visit 80.Room organization
Waiting time	**Personal activities**
51. Waiting time	Meal/hydration Answer phone/make personal calls Socialization with colleagues Rest (read magazines, use the Internet) Use the toilet Organize/participate in interaction events
Work-related activities	**Other activities**
Answer the phone/call other sites/check emails of the site Site cleaning Schedule doctor's appointments Schedule tests Reception Provision of doctor's statement Audit of clinical records Call users with test result alteration Conference for test result receipt Product distribution to users Pick/look for tests and clinical records	60 to 79. Reclassified according to the observation 97.Other work-related activities 98.Other personal activities 94.No observation 95.Absence (health professional was not at the unit, due to delayed arrival or early departure) 96.Not found (health professional was not found at the unit at the moment of observation) 99.Lunch time of professional to be observed
Answer the phone/call other sites/check emails of the site Site cleaning Schedule doctor's appointments Schedule tests Reception Provision of doctor's statement Audit of clinical records Call users with test result alteration s Conference for test result receipt Product distribution to users Pick/look for tests and clinical records	60 to 79. Reclassified according to observation 97.Other work-related activities 98.Other personal activities 94.No observation 95.Absence (health professional was not at the unit, due to delayed arrival or early departure) 96.Not found (health professional was not found at the unit at the moment of observation) 99.Lunch time of professional to be observed

Source: Bonfim D, Pereira MJ, Pierantoni CR, Haddad AE, Gaidzinski RR. *Instrumento de medida de carga de trabalho dos profissionais de saúde na atenção primária: desenvolvimento e validação.* Rev Esc Enferm USP. 2015; 49(Esp 2): 25-34.[9]

The researchers defined the number of workers that each observer could observe sequentially, and established four observers and one field supervisor for each FHU.[5,9]

Data collection with the application took place from March to October 2013, when professionals from the 27 units were observed. They agreed with the study and signed an informed consent form, approved by the Research Ethics Committee of the Nursing School at the Universidade de São Paulo, under protocol n° 170278.

The observations collected using the application followed the principles of the work sampling technique. The intervals between the observations were set, and each observer recorded the interventions/activities performed by the health professionals every 10 minutes during the FHU hours, on five days of a typical work week.

In this case, the field observer had to present some skills, such as accurate perception, attention and concentration on the aspects of their focus, and skills that were developed during the theoretical-practical training.[14,15] In addition, the observer had to show an attitude of impartiality to observe only the selected aspects, honesty in presenting data that were actually observed without omissions, discretion so that confidential data were not disclosed inadequately, and prudence to avoid inference and premature speculation.[14,15]

The reliability test was conducted daily for one hour by each observer during data collection at all 27 FHUs. Simultaneous observations obtained an agreement of 80% on average, which is considered satisfactory according to the literature.[16,17]

Results

The validated content from the instrument to measure the workload of health professionals in primary care, consisting of 39 interventions/activities, was coded according to chart 2 and adapted to an electronic form for mobile devices.

The application tests were conducted in two situations. The first test was performed by the supervisor and an observer in a three-hour observation session at one FHU. The registration of workers, the records, data entry, proper storage of observed interventions, and proper data transmission were considered satisfactory by both.

The second application test was conducted during the theoretical-practical training for data collection with all 16 field observers, at three FHUs. The registration of workers, the records, data entry, proper storage of observed interventions, and proper data transmission were considered satisfactory by everyone participating. The skills to use a data collection tool, find workers by observers, and record the interventions/activities every 10 min were also analyzed. In this context, each observer was able to observe six workers sequentially.

Also in this step, the reliability test was conducted between each of the observers and the field supervisor. For one hour, the supervisor simultane-

ously watched the observer and each of them recorded the observed intervention code on his/her tablet; then the supervisor interpreted it if the record was correct. A 90.4% agreement rate was obtained between the observers and the supervisor in the identification of interventions using the application in parallel observations.

Application use in data collection

The tablets were numbered, and configured with their own directory in which the files and folders were stored with their respective identifications; files were stored in subdirectories with their corresponding numbering.

Each observer was responsible for a tablet, as shown in figure 1. To access the application, the observer had to log in to the system. The observer entered his/her ID on the first screen, linking the observed information saved in the folders of the directories with the person in charge of the observation.

The observer then registered a professional by his/her nickname for easier identification process during data collection; then, the professional category was selected, according to Figure 2.

The observations were performed at fixed intervals of 10 minutes during the FHU hours for five days of a typical work week. For interventions outside of the FHU, such as a home visit, observers recorded the time the professional was out of the unit on a home visit.

The content related to the interventions/activities was distributed in different tabs to select the observed interventions and insert records (Figure 2). The application screen described in this figure refers directly to the collection of time information used in the activities and interventions through the sampling technique, such as the frequency set for the observation of activities and coding of interventions during data collection. The observer recorded the observed interventions on this screen, and such information remained stored for an hour. and then was recorded and a new screen was displayed.

After daily observations were recorded, it was possible to locally store the data synchronized with the external server, because both were organized with the same hierarchy of directories, files, and
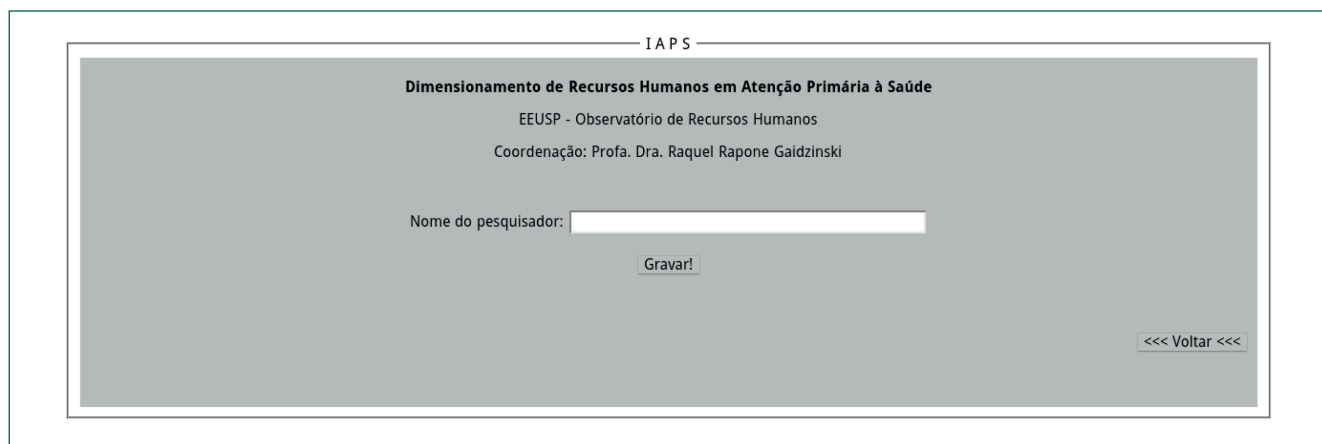
Figure 1. Initial screen of the data collection application

folders. Observers used the tablet in an area with Internet access (Wi-Fi) and sent the information to the online database.

Data transmission and extraction were conducted daily, through file storage and synchronization in Dropbox®, which could be accessed from any computer, protected by passwords, ensuring safe access to the information and only by authorized persons.

Data recording was performed every hour. After this interval it making changes to data was not allowed, so when there was incorrect data transmission, the field observers informed the supervisor and the project coordinator, who made the required changes in the database.

Before starting to check the codes of the interventions/activities in the corresponding fields, the observer was instructed to select the code of the FHU where the research was conducted and the observation order of the professionals. This process guaranteed the same sequence of professionals during the observation day, increasing the effectiveness of the work sampling technique.

On the screen to record the observed interventions/activities, a field was developed for remarks, as required, about the intervention registered for every observed professional (Figure 2). In the cell for the intervention/activity code, an entry was created that allowed up to two numbers and one letter to record the following situations: identify interventions/activities that were in progress between one observation and another, with the same user used (letter U

was used in this case); and when the observed professional was performing the intervention/activity in the presence of students (letter E).

The electronic data collection application was used during the observations of 418 FHU health professionals. Of these, 48 were physicians, 34 dental surgeons, 37 dental technicians or assistants, 48 nurses, 94 nursing technicians or assistants, and 147 community health agents, totaling 85,398 observations registered at 27 FHUs.

Discussion

With the mobile application for data collection, proper records of the observations of interventions/activities performed by health professionals were obtained. This process was optimized with the use of a system to record and store the collected information and send it to the database for subsequent analysis.

Applications for tablets, smartphones, and other mobile devices have been used as the new generators of sources of information because they offer good performance, as well as easy transport and storage.[18,19]

The main characteristics of mobile applications are related to enhanced mobility, because they can go with the user wherever he/she is. There is also the personal identity the equipment ensures to its users, considering that it serves as a personal device, as the user is used to it.[18,19]
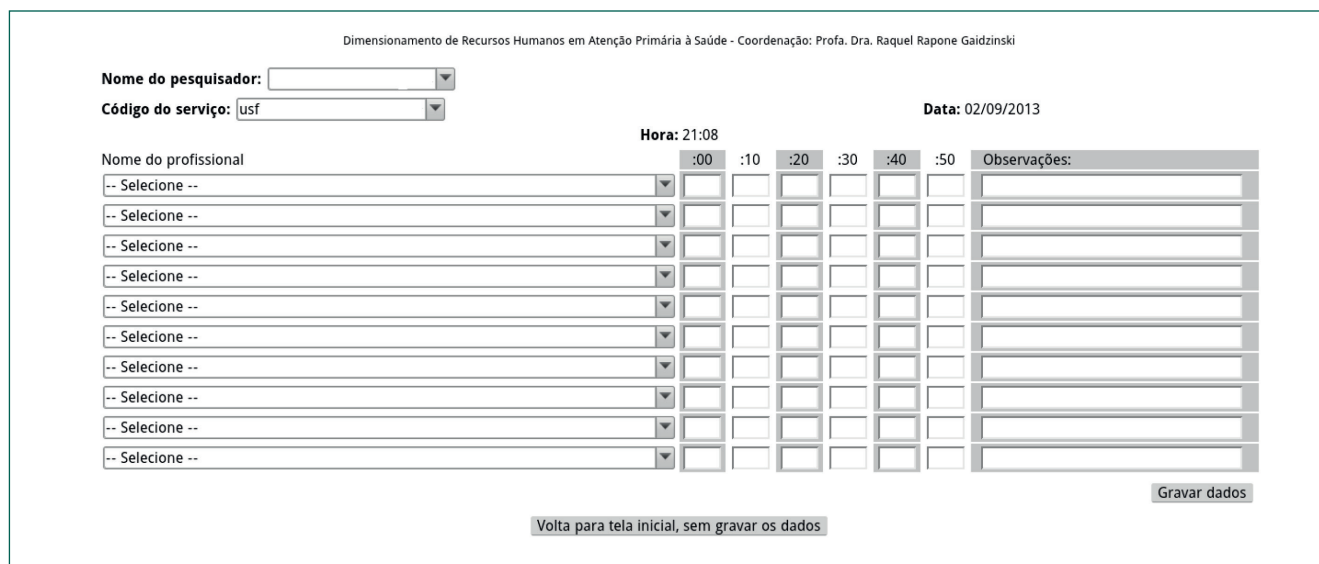
Figure 2. The screen to record the observations of the interventions performed by the workers using the data collection application

The advantages of using mobile applications are: they are affordable; easy to use; multi-tasking; and handheld. In terms of versatility, a mobile device offers web tools for interactivity, collaboration, and access to applications especially developed for these devices.[19]

Mobile computing can be applied to several areas in health including remote monitoring, support to diagnosis, and support for decision making.[7,18-21]

In Brazil, studies on mobile applications developed for health show that it is a new and growing field as a result of the popularization of smartphones and tablets.[22,23]

The development of applications for patients was highlighted as a gap to be explored, as it represents an important support for patient adherence to attitudinal and/or drug treatment.[22,23]

In the international literature, health applications were classified according to the application categories for health professionals focused on supporting medical diagnosis, drug reference, literature research, clinical communication, medical and nursing training, and application to patients focused on the management of chronic diseases, as well as application to medicine and nursing students.[24]

This study showed that the use of mobile applications on a tablet improved the performance of the observer, who was able to observe six workers se-

quentially and enhance the data collection process. It optimized the transmission and extraction of data synchronized with Dropbox®, which were conducted once a day, allowing an easy transfer to the server that was accessed through a user ID and password. Then, data were ready to be checked, and organized in such a way to identify duplicate records; so adjustments were required.

This application is considered a good alternative in studies whose time for field research and resources are limited.

Among its functionalities it acts as a communication channel between the data generated and the database for easy exchange of information between the two systems.

Considering the high number of observations (85,398) collected in this study, using the application promoted fast, organized, and convenient data collection, with no need to fill out printed forms and subsequently enter data in the database, thus reducing errors.

Information about the observed interventions was stored and processed electronically, enabling data recording, retrieval, and handling. Data from the frequency distribution and the time spent on the interventions for the analysis of working time were obtained with the use of this electronic instrument.

The development of mobile applications for scientific research is important, because the content tends to be analyzed and tested by professionals who know the real needs of end users. Recognizing the needs of these users is essential for the planning and implementation of new technologies in a coherent and appropriate manner, according to specific demands that are tested in the study and implemented in real life.

The application developed in this study allowed the collected information to become available quickly, for easier evaluation of data saturation, still during data collection-that is, when data are repeated and new information no longer appears in the records. This instrument proved to be satisfactory and fast, suggesting that the application can be used for data collection in other studies that employ the sampling technique of observation, intended to improve the management of data generated in observations.

With the development of this application, this study is expected to raise interest in the development of new applications for data collection. Nursing should enjoy the advantages offered by mobile technologies and their applications, enabling researchers, professors, and students to successfully incorporate and use new technologies in health. This field still needs further studies, exchange of experiences, and innovative practices.

Conclusion

The contribution of this article consists in the description of a methodology for the development and use of a mobile application for data collection in time and movement studies with health teams, using the sampling technique. The development and use of this application, containing interventions/activities of the instrument that measures the workload of health professionals, supported the collection and management of research data. It proved to be safe in terms of recording, storing, and sending information, with dynamic, fast, safe data collection, and integrity when sharing collected data

and information. A limitation related to the use of this type of tool is the cell phone reception oscillation using 3G and Wi-Fi technology or its unavailability in several Brazilian regions, considering that the telephone service, used with this application, is still poor or limited to a certain mobile operator.

Collaborations
Pereira IM, Bonfim D, Peres HHC, Góes RF, and Gaidzinski RR collaborated in article development, data analysis and interpretation, article writing, revision of its intellectual content, and approval of the version to be published.

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