

A Mobile Health Application to Assist Health Professionals: A Case Study in a Portuguese Nursing Home

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Keywords: Health Information and Communication Technology, Mobile Health, Health Professionals, Elders, Nursing Home, Ethical Issues in Medicine.

Abstract: The rapidly aging population has been a matter of concern over years since this problematic has been posing several challenges to healthcare systems worldwide. In Portugal, which is one of the countries with the largest aging population, nursing homes have been getting a higher demand, and health professionals are overloaded with work. Furthermore, the fact that few nursing homes use health information and communication technology (ICT) resorting to paper to record information and clinically manage their residents is a tremendous problem, since this method is more prone to errors and time-consuming. Thus, this paper proposes the design and development of a mobile application for health professionals working in a Portuguese nursing home with the intention of assisting them at the point-of-care, by recording and providing all the necessary information, and helping them to schedule, perform, and digitally record their tasks. This solution will help health professionals to provide better care, by reducing time-waste and errors, and, consequently, to improve elders' quality of life. A mobile solution was chosen since a hand-held device, which can be used anywhere and anytime, is able to give access and store all the needed information at the point-of-care.


1 INTRODUCTION


Over the last few years, the rapidly aging population has been a matter of concern, namely because of the challenges this situation is posing to healthcare systems in many countries all over the world (Kuo *et al.* 2016, Mostaghel 2016). In fact, the statistics regarding the aging population are alarming: comparatively to the growth of the whole population, it is estimated the elderly population is growing twice as fast (Mostaghel 2016). Consequently, this demographic change leads to several problems, namely to the increase in the costs of elderly care (Mostaghel 2016) and of the number of elders in nursing homes.


In Portugal, which is one of the countries with the largest aging population in the world (UN DESA 2015), the increasing number of elders in nursing homes has been one of the major challenges caused by the aging population (Pereira 2018, RTP 2019). In


fact, finding a place in a nursing home in Portugal has been a tremendous challenge for several elders since the demand is higher, and the vacancies are filling up quickly (Pereira 2018, RTP 2019). On the other hand, health professionals are overloaded with work since the number of elderly people is high compared to the number of health professionals (Borja-Santos 2015, DN/Lusa 2018), which can lead to the decrease of the quality of the nursing care delivered, and, more than not, nursing homes use rudimentary methods, i.e. paper, to record information and clinically manage residents, which can be time-consuming (Alexander and Wakefield 2009, Broughton *et al.* 2013).

Therefore, there is an urgent need to face these challenges and improve elders' quality of life and the care delivered in nursing homes. Thus, with these problems in mind, this project emerged and consists in designing and developing a mobile application for health professionals, i.e. nurses and doctors, working in a Portuguese nursing home that can assist them at

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the point-of-care and help them to schedule, perform, and digitally record their tasks.

In order to have a better understanding of the relevance of this project, it is essential to present the main challenges faced by the nursing home for which this project is being developed. Firstly, there is no electronic health records to clinically manage the residents, whereby all the information is gathered in papers which make the record and the access to this information a lot more time-consuming, especially at the point-of-care, since the professionals constantly need to go back to the nursing station in order to retrieve or record information. This situation makes the risk of misplacing, losing, or forgetting information much higher.

Moreover, there are few health professionals comparatively to the high amount of elderly people. Lastly, due to the lack of time and the overload of work experienced by the health professionals, some clinical information is not properly or not at all recorded. Thus, in order to solve these problems, there is a need to design and develop a solution that can help these health professionals at the point-of-care and, subsequently, enhance the care delivered and the elders' quality of life.

Therefore, the proposed solution consists of a mobile application that would allow health professionals to:

- Have access and manage the personal and clinical information of the residents at the point-of-care as well as add and disable residents when necessary;
- Create clinical and nursing notes, and consult the clinical and nursing notes' history of each resident;
- Schedule nursing interventions, e.g. wound care, nasogastric tube and urinary catheters replacement, periodic evaluations, and tracheostomy care, among others, and confirm their execution;
- Record the evaluations made by them, and consult the history of these evaluations for each resident;
- Record new wounds and their treatment and evolution via images and observations, and consult the wound history of each resident;
- Consult the history of the medical records of each resident, and add new medical records;
- Have a simplified plan of the nursing home to identify which resident is in each room and bed.

The novelty of this project lies in the fact that few nursing homes use health ICT, which consists in any form of electronic solution that allows to retrieve, store, manage, manipulate, and transmit digital

information in a healthcare setting, despite their great potential and well-known advantages (Alexander and Wakefield 2009, Broughton *et al.* 2013, Ko *et al.* 2018, Wei and Courtney 2018). In fact, they can enhance the quality of care, reduce time-waste, e.g. by accessing and recording the information at the point-of-care, and improve the sharing of information, e.g. by making the information more accessible and legible (Alexander and Wakefield 2009, Rouleau *et al.* 2015). Moreover, the lack of literature and of an integrated body of knowledge on the use of ICT in nursing homes show that there is still much work that needs to be done in this area.

Concerning the structure of this paper, the state of the art related to this project is presented in Section 2. Subsequently, Section 3 discusses the research strategies selected to design and develop this project. Thereafter, in Section 4, a brief description of the case study, i.e. of the Portuguese nursing home for which the proposed solution is being developed, is presented with the intention of having a better understanding of the main challenges encountered in the institution and, thus, affirm and validate the relevance of this project. Then, in Section 5, the results achieved are presented. Finally, to conclude this paper, a discussion of the results attained is presented in Section 6, and, lastly, in Section 7, the main conclusions of the project are explained, and future work is suggested.

2 STATE OF THE ART

2.1 Mobile Health

Over the last few years, the implementation and rapid expansion of mobile technology, which refers to all the technology that can be used "on-the-move", have been impacting several industries, and the healthcare industry is not an exception (Aungst 2013, Ventola 2014). In fact, the use of mobile health (mHealth), i.e. of mobile devices and applications in a health and clinical context (Nouri *et al.* 2018), to help health professionals to execute their daily tasks, namely to manage and monitor patients, to access and manage health records and other types of data, and to enhance the decision-making process, among others, has been transforming several aspects of the health industry (Prgomet *et al.* 2009, Ventola 2014, O' Connor and O' Reilly 2018).

In this context, the use of mobile devices in healthcare settings has been rapidly growing and, consequently, the development of mobile applications for these devices, thus leading to the

rapid integration of mobile devices in healthcare settings (Ventola 2014, O' Connor and O' Reilly 2018). Furthermore, the adoption of mobile technology by health professionals can be explained by the need to have a better and easier communication and access to the information at the point-of-care since a single device, which is portable, light, and small, can gather and give access to all the needed information anywhere and anytime (Prgomet *et al.* 2009, Ventola 2014, O' Connor and O' Reilly 2018).

In fact, mHealth has been proving to be quite promising and to offer several benefits, such as (Prgomet *et al.* 2009, West 2012, Ventola 2014):

- Faster accessibility and better management of the data since all the data is gathered in a single source, which can be used anywhere and at the time of need, making the access to information much more convenient;
- Faster and better decision-making process, since it provides access to information at the point-of-care where the decisions are being made, thus leading to a lower error rate;
- And, consequently, an enhancement of the quality of the care delivered and of the elders' life, among other advantages.

In some cases mobile applications are developed without truly understanding, assessing, and meeting the needs of health professionals, thus resulting in their under-utilization (Nouri *et al.* 2018, O' Connor and O' Reilly 2018). Therefore, a better evaluation of the needs of health professionals should be done before developing these applications. Nevertheless, the benefits of mHealth are undeniable and a higher investment should be done in this area since it can improve the quality of the care delivered and of the patients' quality of life.

2.2 Ethical Issues in Medicine

Without a doubt, the use of health ICT and mHealth in healthcare settings provides many benefits to the clinical practice having the potential to enhance the care delivered, as mentioned previously. However, despite the advantages offered by these technologies, challenges and issues may arise from the use of solutions based on them. In fact, one of the main challenges associated with the introduction of any form of technology in healthcare settings are ethical issues.

In this context, one of the problems that can be pointed is the fear and distrust that the confidentiality and privacy of the electronic health records and data of the patients are compromised and not guaranteed, since, comparatively to the traditional paper-based

method, technological advancements made access to data and the break of the privacy of health information easier (Wallace 2015, Nouri *et al.* 2018).

Additionally, despite the many advantages and benefits provided by mHealth, some health professionals still remain hesitant regarding its use, since mHealth applications are currently being used without having a complete understanding about their effectiveness, accuracy, quality, and associated risks (Ventola 2014, Nouri *et al.* 2018).

Therefore, during the design, development, and implementation of mHealth applications, a set of best-practice standards should be thoughtfully followed in order to ensure their quality, accuracy, and safety (Misra *et al.* 2013, Ventola 2014, Nouri *et al.* 2018). Moreover, after their development, these applications should be subjected to a proper and rigorous set of validation and evaluation methods as a way to guarantee their quality, accuracy, correct use, safety, and importance in a healthcare setting (Misra *et al.* 2013, Ventola 2014, Nouri *et al.* 2018).

3 RESEARCH STRATEGIES

In order to have well-defined standards and an organized path to follow, this project is being sustained by a set of methods with the intention of ensuring its success. Firstly, extensive research was made with the aim of identifying a broad range of options. Then, after analysing the available options, a choice was made based on the method that was the most effective to meet the established objectives and adequate according to the scope of this project.

Therefore, the main research strategy that is being followed during the course of this project is design science research (DSR). DSR was chosen since it is suitable for ICT research projects, which is the case of this study (Hevner *et al.* 2004, Peffers *et al.* 2007). The main purpose of the DSR strategy is to create and evaluate objects know as artefacts, i.e. solutions, in order to solve organizational problems (Hevner *et al.* 2004). Thus, in a simplified way, DSR corresponds to a rigorous science research method that offers a set of techniques, principles, and procedures that must be followed in order to design and develop successful solutions (Peffers *et al.* 2007).

The DSR methodology can be divided into the steps shown in Figure 1.

In order to perform the first three steps – “Problem Identification and Motivation”, “Definition of the Solution's Objectives”, and “Design and Development of the Solution” – focus groups, semi-structured interviews, and questionnaires were made

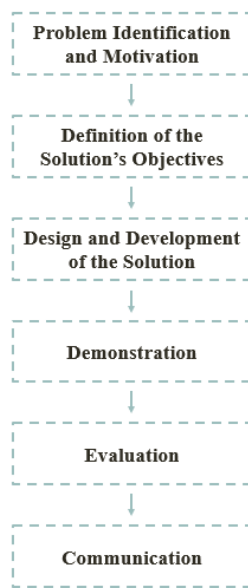


Figure 1: Schematic representation of the steps composing the design science research strategy.

with the health professionals working in the nursing home for which this project is being developed. The information given by these professionals was fundamental and valuable since it allowed to identify and understand the main challenges encountered by them. Thus, it was then possible to identify and motivate the problems that needed to be solved, to define the objectives and benefits of the proposed solution, and, finally, to design the architecture of the solution, which is currently being developed. Additionally, observation of the case study was also necessary since it allowed to have a better understanding of the conditions of the nursing home.

The fourth and fifth steps – “Demonstration” and “Evaluation”, respectively – are currently being executed: the design of the proposed solution was demonstrated to the target audience, i.e. the health professionals, and as the solution is being developed, the professionals are being consulted to assess if the established objectives are being met and if changes need to be done. It must be mentioned that in order to evaluate the usefulness and accuracy of the proposed solution, a proof of concept (PoC) was made.

Finally, the last step of the DSR methodology – “Communication” – is currently being performed. This step consists of diffusing the importance of the problem and the novelty of the proposed solution, which is the aim of this paper.

It must be mentioned that during all stages of the design and development of this project, ethical issues are being taken into account and safeguarded to

guarantee the quality, accuracy, and safety of the solution and that confidentiality issues do not arise.

4 CASE STUDY

The case study for which the proposed solution is being developed corresponds to a Portuguese nursing home, which is being managed by a Portuguese hospital. Thus, in this section, a brief description of the case study will be presented in order to identify the main issues of the nursing home and the challenges faced by the health professionals.

As mentioned before, focus groups, semi-structured interviews, and questionnaires were performed with the health professionals in order to identify their needs and the main challenges faced by them. Additionally, the case study was subjected to observation to assess the conditions of the nursing home. Thus, it is possible to identify a set of challenges and issues that need to be solved:

- The nursing home does not use health ICT or any other form of technological progress. There is only one computer in the nursing station, and it is not being used to record or document clinical information. Additionally, there are not electronic health records or any other form of digital information to clinically manage the residents. Therefore, the professionals use handwritten charts and medical records, and all the information is stored and recorded in papers. This situation makes the access and record of information a lot more time-consuming, especially at the point-the-care, since the professionals constantly need to go back to the nursing station in order to retrieve or document information. On the other hand, this situation makes the risk of losing, misplacing, forgetting, and documenting the information in the wrong place higher;
- All the tasks performed by the health professionals are scheduled and documented in handwritten charts or boards, which can lead to errors since its more confusing and less organized than to digitally schedule and document tasks;
- There is no wireless internet connection in the nursing home. The only internet connection available is in the nursing station where the computer is located. This situation makes it a lot more difficult to implement any kind of mHealth solution since the nursing home does not have the necessary needs;

- There are few health professionals comparatively to the high amount of elderly people. Thus, at times, the health professionals are overloaded with work. This situation combined with the fact that all the information is documented through papers poses the risk of some clinical information not being properly or at all recorded.

During the realization of these interviews and focus groups, it was also mentioned that the nursing home tried to implement a web application but without success. This web application had the intent of converting all the information recorded in papers to the digital form, allowing the health professionals to schedule tasks, document them, and record clinical information. However, this application was abandoned because it was time-consuming and not user-friendly: the health professionals constantly needed to return to the nursing station, where the computer was, to use the application, thus spending too much time with it, e.g. scheduling tasks and documenting information.

Moreover, the health professionals manifested their wish of needing a mobile application that would allow them to be anywhere in the nursing and still have access to information and schedule and document their daily tasks. Therefore, there is a need to design and develop a mobile solution, i.e. a mHealth application, that would help these health professionals at the point-of-care by allowing them to have access, document, consult, and manipulate information anywhere in the nursing home and, subsequently, enhance the care delivered and the elders' quality of life.

5 RESULTS

As mentioned previously, the nursing home for which this project is being developed does not have any form of technological progress and, naturally, any database implemented. Therefore, before designing the architecture of the mHealth application, a database had to be defined to support it and to allow the storage of the necessary data.

Thus, a MySQL database, which is a highly secure, reliable, and scalable relational database, was designed and created. Thereafter, once the database created, it had to be deployed and implemented in the server of the Portuguese hospital that is managing the nursing home. A MySQL database was chosen because the server was already configured for this type of database. Additionally, it must be mentioned that although the database has been successfully

implemented in the server, it remains to be populated with real data, i.e. residents' and health professionals' information.

On the other hand, the proposed solution is being developed using React Native, which is a JavaScript framework that allows the development of native mobile applications (Facebook Inc. 2019). React Native was chosen since the same code can deploy on both iOS and Android, thus saving a lot of time in the development process. Moreover, React Native has an optimal performance for mobile environments.

Additionally, a REST API written in PHP with SQL queries is being developed in order to allow the sharing of data between the frontend, i.e. the mobile application, and the backend, i.e. the database. PHP was chosen since the server in which the database was implemented is only configured for this programming language.

In Figure 2, a schematic representation of the interactions between the different elements of the proposed solution is presented.

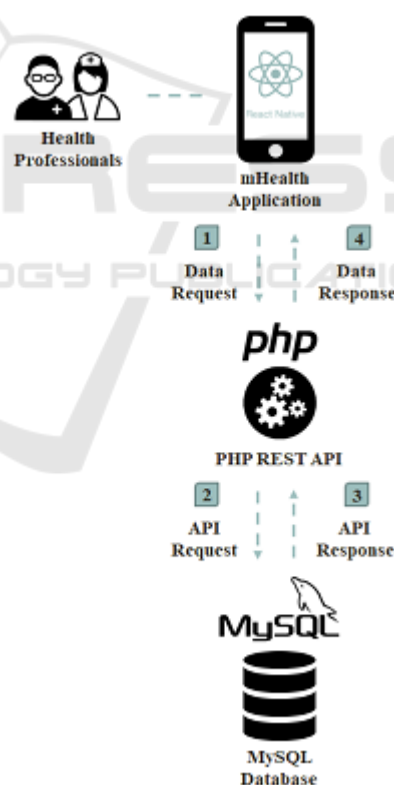


Figure 2: Schematic representation of the interactions between the different elements of the proposed solution.

Firstly, the user, i.e. the health professional, needs to sign up for an account in the mobile application. Then, all the data provided by the user, i.e. his login credentials and his personal data, is stored into the

database. Alternatively, if the user already has an account, he needs to sign in into the mobile application with his login credentials.

Once the user is successfully registered into the application, the following features are provided to him:

- Profile: the user can have access and edit his personal data;
- Management of the residents: the user can view and edit the personal data of each resident. Additionally, the user can add new residents when needed or deactivate a given resident. Moreover, it is also possible to view and edit the contacts of each resident as well as add and remove contacts;
- Clinical notes: if the user is a doctor, he can create new clinical notes and consult the clinical notes' history of each resident. However, if he is a nurse, the user is only able to consult the clinical notes' history;
- Nursing notes: if the user is a nurse, he can create new nursing notes and consult the nursing notes' history of each resident. However, if he is a doctor, the user is only able to consult the nursing notes' history;
- Management of the clinical information of the residents: the user can consult and edit the clinical information of each resident;
- Management of wounds: the user can record new wounds as well as consult and document their evolution for each resident. Additionally, the user can consult the wounds' history of each resident;
- Periodic evaluations: the user can add a new periodic evaluation and consult the periodic evaluations' history of each resident;
- Periodic evaluations of the capillary blood glucose: the user can add new periodic evaluations of the capillary blood glucose for residents with diabetes. Moreover, it is also possible to consult the history of the periodic evaluations of the capillary blood glucose of each resident with diabetes;
- Medical records: the user can add new medical records or consult the medical records' history of each resident;
- Planning: the user can schedule nursing interventions for each resident;
- Plan of the nursing home: the user can consult which resident is in each room and bed;
- Calendar: the user has a calendar in which he can consult the nursing interventions scheduled as well as cancel a nursing intervention or confirm its execution;

- Sign out: the user can sign out of his account.

6 DISCUSSION

In order to demonstrate the potential, quality, utility, and practicality of the proposed solution, a PoC was made. Therefore, in this section, a SWOT analysis is performed to identify the main strengths and weaknesses, which are internal factors, and opportunities and threats, which are external factors, of the proposed solution.

The main strengths of the proposed solution are as follow:

- Reduces time-waste since health professionals can have access and record information at the point-of-care;
- Reduces errors since it decreases the risk of misplacing, losing, or forgetting information;
- Enhances the nursing care delivered and the elders' quality of life since less errors are being made and health professionals have more time to perform their tasks;
- Makes the scheduling of tasks less confusing and more organized;
- Reduces the amount of paper that is being generated with hand-written charts;
- Has high usability due to its user-friendly design with well-defined paths and decision points and organized information;
- Has high adaptability since the proposed solution was designed to allow its easy implementation in other nursing homes;
- Has high scalability since new features can be easily added.

However, some weaknesses can be pointed to the proposed solution:

- Need of a wireless internet connection, which is not currently available in the nursing home;
- Need of mobile devices such as mobile phones and tablets to use the solution;
- Need to populate the database with real data, i.e. residents' and health professionals' information, which will require time resources;
- Need to train the health professionals to use the solution.

On the other hand, the opportunities of the proposed solution are as follow:

- Technological improvement of the nursing home, which can lead to the demand for improving other processes;
- Elimination of the paper-based method used by the nursing home, which is rudimentary and more prone to errors, having clinical data

stored in databases. This data could be used to complement the mobile application with business intelligence (BI) clinical indicators, which can enhance the decision-making process and the care delivered;

- Implementation of the mobile application in other nursing homes.

Lastly, the following threats can be highlighted for the proposed solution:

- Potential issues may arise if the necessary needs are not provided to the nursing home, namely if the wireless internet connectivity is not reliable and if there are not any mobile device. In these cases, the health professionals would not be able to use mobile application.

7 CONCLUSION AND FUTURE WORK

In conclusion, this paper shows that, in Portugal, nursing homes need several improvements, more specifically, technological improvements, in order to solve some of the problems faced by them, e.g. the overload of work faced by health professionals. Thus, in this context, this project emerged and consists in designing and developing a mobile solution that would help and assist the health professionals of a Portuguese nursing home at the point-of-care.

As mentioned throughout this paper, with this solution, it is intended to allow these professionals to have access, document, consult, and manipulate information anywhere in the nursing home. Therefore, this solution will help to reduce time-waste and errors made by health professionals and, subsequently, enhance the nursing care delivered and the elders' quality of life.

In this paper, the architecture and the features of the proposed solution were presented. However, as future work, it is intended to continue the development of the mobile application since, currently, certain features remain to be implemented. Thereafter, it is envisioned to populate the database with real data, i.e. residents' and health professionals' information.

On the other hand, it is also planned to provide the nursing home with the necessary needs, namely a reliable wireless internet connection and mobile devices such as tablets or mobile phones, for health professionals to be able to use the mobile application. Moreover, it is foreseen to test the application with the health professionals to assess if the objectives are being met and if changes need to be done.

Finally, in the future, when enough data will be gathered throughout the use of this application, it is hoped to complement it with BI clinical indicators related to both the residents and the health professionals. These indicators would help to obtain useful knowledge to support the decision-making process improving its outcomes, which can be proven by previous and current work by the research team (Esteves, Miranda, and Abelha 2018, Esteves, Miranda, Machado, *et al.* 2018, Neves *et al.* 2018, Esteves *et al.* 2019). Additionally, if the mobile solution proves to be of quality, it is envisioned to implement it in more nursing homes. This will be possible since the mobile application was designed to allow its adaptability according to the needs of similar institutions.

ACKNOWLEDGEMENTS

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope: UID/CEC/00319/2019.

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