Towards a Model of Big Health Care Data Analytics in Panama: Chronic Kidney Disease

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doi: 10.5455/aim.2022.30.196-200
ACTA INFORM MED. 2022 SEP; 30(3): 196-200
Received: JUL 15, 2022
Accepted: AUG 12, 2022

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ABSTRACT

Background: A growing number of mobile applications have been designed for the chronic disease patient as the primary user. Mobile health applications for self-care have the potential to help patients living with chronic conditions such as kidney disease, and can be used to manage aspects such as the consumption of substances that are harmful to health. Chronic kidney disease causes significant morbidity throughout Panama, and is also responsible for an increase in cardiovascular disease. Objective: In this paper, we present a review of the applications offered by the Android store, based on a search and selection of the most efficient options that fulfill a set of criteria and functionalities. Methods: We evaluate a big health data model in terms of its usefulness for studies, research and projections of Panamanian patients with this chronic disease. Results and Discussion: We present a mobile application based on the most important standards and functionalities for the Panamanian population affected by this disease. Our analysis also highlights the importance of mobile applications for the self-care of chronic diseases and their usefulness to both patients and health care providers, since they can support better health habits and give good results in terms of following a diet, promoting a healthy lifestyle, and encouraging physical activity. The analysis presented here will form the basis for the development of an application that will be simple, user-friendly and powerful, in the sense that it will empower patients with the resources they need for self-care. Conclusion: Mobile applications are found to show promise for the self-care of chronic conditions, and can improve the quality of life of Panamanian patients. In addition, we intend to develop a data repository for scientific research within Central America.

Keywords: Chronic kidney disease, health, big health data, mobile applications, self-care of health.

1. BACKGROUND

Excess Today, the main causes of death in Panama are largely associated with chronic degenerative diseases: in order of prevalence, these are cancer, cardiovascular disease, diabetes and chronic kidney disease (CKD). According to the Pan-American Health Organization (PAHO), CKD, also called chronic kidney failure, involves the gradual loss of kidney function. The kidneys filter waste and excess fluid from the blood, which are then excreted in the urine (1). In a recent analysis, more than 60,000 deaths from kidney failure were identified in Central America between 1997 and 2013, of which 41% occurred in people under 60 years of age. Panama has experienced an increase in the number of patients with CKD. According to the National Institute of Statistics and Censuses of the Republic of Panama, in 2019 the total population of the country was 4,218,808. Between 2013 and 2019, there were 132,263 deaths, of which 5,286 were from "diseases of the genitourinary system" (2).

A healthy lifestyle can prevent diabetes, high blood pressure, and kidney disease, or can help to keep them under control (3, 4, 5). Periodic medical checkups, exercise, a healthy diet and self-care are vital strategies for coping with this disease and can enable the patient to have a good quality of life.
Self-management or self-care of this chronic disease is essential, and current technological devices seem to be useful for patients who are afflicted by it. Innovation in various areas of technology has led to the design and development of computer systems for health care, which have been implemented using devices such as tablets, mobile phones, the internet, wireless networks, wearables and other devices that offer comprehensive monitoring of various factors such as medication intake, blood pressure and blood glucose, among others (6).

Mobile applications can help in the practice of health-related activities such as the collection of clinical data. These applications can help professionals to monitor the health status of their patients, verify and share information, and perform diagnoses of various health problems (7). The more sensors a device contains, the larger the amounts of data that can be collected. These volumes of data are quickly becoming what is often called big data, a term that refers to large-scale sets of data that exceed the capacity of conventional software to capture, process and store within a reasonable time (8). Using big data, it is possible to analyze, process, monitor and predict hidden patterns that were previously inaccessible, and to create new services and businesses (9).

Through this proposal, we aim to be able to collect data from mobile applications and to use them to create models to support and help diabetic, hypertensive and hemodialysis patients in Panama to better manage their disease (10). Accurate data analysis has benefits in terms of early disease detection, the quality of patient care, and health services; however, the precision of the analysis is reduced when the quality of the medical data is low. The use of big data can enable quality data management and analysis. These solutions are necessary to reduce health care costs for patients in national hospitals and to improve traditional systems (11).

2. OBJECTIVES

The primary contribution of this work is the development of a mobile application for self-care by Panamanian patients with CKD, to improve their quality of life. In this paper, we carry out an in-depth analysis of the most important characteristics of existing mobile applications for CKD offered by a mobile application store. We also put forward a design for a new mobile application that has the characteristics that are essential for self-care. As a secondary contribution, we create a repository of real, reliable data on Panamanian patients with CKD; this information can be used as a source for the creation of big data models that can help doctors make decisions about patients with CKD (12).

3. MATERIAL AND METHODS

Our study is divided into two phases. First, we present a mobile application that can help Panamanian CKD patients achieve better control of their disease through self-care and thus improve their quality of life. Following this, we develop a big healthcare data model that can help in research in this area and the development of health strategies.

The methodology used in this research involved the following tasks:

3.1. Search strategy

In January 2021, we conducted a search of online stores for Android mobile applications, We used CKD-related search terms to identify applications, such as kidney disease, kidney failure, dialysis, and glomerular filtration rate (GFR), among others (13).

3.2. Classification of applications

We classified existing applications based on their specific objectives within the management of CKD:

- Self-care, drug databases, knowledge of CKD, requests for physicians and blogs.

3.3. Selected applications

In this section, we present a comparative analysis of mobile applications for the control and management of CKD. The most popular applications were called "Calculator GFR", "NefroConsultor", "Calculator GFR Renal Function" and "CKD-EPI and MDRD", and had more than 10,000 downloads. The applications with the highest scores were "Mosa: Glomerular Filtration Rate" and "CKD-EPI and MDRD", both of which had ratings of 4.9. Based on the classification criteria described above, we performed an analysis of the functionalities of the selected applications in more detail.

Table 1 gives a summary of each application (14).

| Functionality     | Description                                                                 |
|------------------|-----------------------------------------------------------------------------|
| 1. Store and Process Data | It allows the user to store their data.                                      |
| 2. Degree of kidney disease | Allows knowing the degree of chronic kidney disease in the patient.       |
| 3. GFR            | Estimates the GFR according to the Cockroft-Gault, MDRD, CKD-EPI and Mayo Quadratic equations. |
| 4. Dashboard CKD  | Allows you to graphically observe the values of the elements related to CKD failure. |
| 5. GFR for kids   | Calculate Primary GFR in children (Schwartz).                              |
| 6. Data Security  | Allow the security of patient data and that these data can be protected.   |
| 7. Access to educational materials | Access to medical journals or information material on kidney diseases. |
| 8. Social networks| A connection to social networks is established for patients with CKD.       |
| 9. Patient follow-up recommendations | Make recommendations for the follow-up that should be carried out on the patient. |
| 10. Diet for patients with CKD | Provides information on the amount of sodium, phosphorus, potassium, water in food. |

Table 1. Functionalities of each application

4. RESULTS

4.4. Analysis of functionalities

We reviewed the features and functionalities provided by the most popular applications in the Google Play store for managing CKD. We summarize the main advantages of each in Table 2, and present the results of our analysis of the functionalities of each selected application.

The application which offered the widest range of functionalities was "Calculator GFR", followed by "Nefroconsultor".

3.5. Proposed system

The analysis carried out here allowed us to determine the characteristics and functionalities of each application. It also served as a basis for the development of a new application for self-care by patients with CKD, which included the processes and functions that are important in this regard. Figure 1 illustrates the proposed system. Below we detail each part of the proposal.
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Patient data

There are several sources of data input to the system, among them we have the data that the patient provides to the mobile application, data such as: age, sex, weight, height, serotinin levels, blood sugar, blood pressure, creatinine and albuminuria among others. We also extract data from social networks, through questionnaires given to patients, to collect any additional data necessary for decision-making. It should be noted that to obtain significant volumes of data, the sending must be daily for a long period of time to obtain reliable and measurable statistics. CKD patient data is received by the mobile application and stored in its database. With these data, several important processes can be carried out and GFR can be calculated using at least four formulas, such as CKD-EPI, Cockcroft-Gault, Mayo Quadratic, and Modification of Diet in Renal Disease (MDRD). Another source of data is the EHR from which everything related to diagnoses, medical procedures, tests performed, prescribed medications will be obtained (15, 16, 17).

Data Integration

As it is data extracted from various sources, data integration is a set of processes used to retrieve and combine data from different sources into meaningful and valuable information. The integration processes are: capture, alignment according to the established structure, the linking of the records is carried out and then the data is merged. Data integration is a sophisticated process that seeks to standardize the organization of data between each source and then store it in a repository or health cloud for later analysis.

Health Cloud

This will be the repository where the data will end up stored after the integration is done.

Big Data Analytics for health care

The central reason and main contribution of our work is the proposal of this big data analytics for health care. Data analytics allows inferring a layer of intelligence, which leads to the creation and application of predictive models that help anticipate health needs and offer more effective medical care in the country. Among other things, data analysis can provide us with new opportunities to improve health care processes and thus achieve disease prevention. In addition to offering personalized medical attention since the behavior of patients and their needs can be studied. In our proposal we want to apply our own data analysis techniques (machine learning or deep learning) that allow us to optimize both the administration to use health resources more efficiently and treatment and patient care, providing, among other services, alerts, prediction of needs and generation of recommendations. Without neglecting what has to do with the security of patient data.

Mobile App

The app offers basic nutritional advice and a search engine

Table 2. Functionalities of each application

| Apps                              | Functionality |
|-----------------------------------|---------------|
|                                  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
| Calculator GFR                   | x  | x  | x  | x  | x  |    |    |    |    |    |
| NefroConsultor                   | x  | x  | x  | x  | x  | x  | x  |    |    |    |
| Renal diet and diabetes          | x  |    |    |    |    |    |    |    |    |    |
| Renal Insufficiency              |    | x  | x  | x  | x  | x  | x  |    |    |    |
| Easy Dialysis                    | x  |    |    |    |    |    |    |    |    |    |
| Mosa: Glomerular Filtration Rate | x  | x  | x  | x  | x  |    |    |    |    |    |
| Nefrodiet                        |    |    |    |    |    |    |    |    |    |    |
| eGFR                             | x  | x  | x  | x  |    |    |    |    |    |    |
| Calculator GFRe (ANHAES)         | x  | x  | x  |    |    |    |    |    |    |    |
| Calculator GFRe Renal Function   |    | x  |    |    |    |    |    |    |    |    |
| CKD-EPI & MDRD                   | x  | x  |    |    |    |    |    |    |    |    |

Figure 1. Proposed system for CKD patients

Figure 2. Main screen of the application
for articles written by people with real experience of the disease, meaning that it is also an educational-grade application. In addition, it provides statistics and graphs, which allow the patient to gain an overview of their condition (18).

**Analysis and design**

We designed a solution by evaluating the best alternatives for development and the functionalities indicated above; the technical and social aspects and the overall user-friendliness were also taken into account. We used a traditional design called model, view and controller (MVC), a software architecture pattern in which the business logic of the user interface is separated into three distinct components (19).

**Development**

Coding of the application will take into account the characteristics identified in the previous stages. The Android Studio (20) environment was chosen, as this is an official integrated development environment for the Android platform. We are currently developing a prototype of our application, called RenalApp, and Figure 2 shows the main screen of our application.

**Tests**

Our application will be verified for different scenarios; for example, we will use different devices and emulate various models of mobile devices, cell phones, and tablets to explore all the utilities and functions of the application, and will enter a range of different data. We applied a usability test to the prototype, based on the parameters of Jakob Nielsen’s usability heuristics; the application was tested by a total of eight patients with kidney disease, aged between 30 and 60, who interacted with the prototype and left their comments on its visibility, control, error prevention, flexibility and efficiency of use (21).

**Distribution**

When testing and debugging of the application are complete and we have ensured that all the requirements have been met, it will be released. We intend to launch our app via the Google Play store, since the application was designed for this environment.

In Panama, a personal data protection law known as Law 81 was introduced in March 2019, which establishes principles, obligations and procedures for data processing in the country, in order to ensure protection of the right to privacy and identify the conditions that must be met by companies or individuals who manage user databases (22). Our proposal must comply with Law 81 to guarantee the rights and freedoms of patients regarding the processing of their personal data.

**5. DISCUSSION**

With the advent of COVID-19 (23), hospitals in Panama have become cautious, since they can act as sources of infection for this virus (24). We therefore believe that it is important to develop strategies for the creation of new regulatory policies and innovative methodologies in terms of mobile technologies for CKD patients, to allow for self-care. Our proposed m-health application, RenalApp, will offer a comprehensive solution to this problem, and will ensure greater effectiveness in the treatment of CKD (25).

RenalApp is intended for daily use. The application is appropriate for patients of any age, and it will be particularly suitable for the management of elderly patients due to the simplicity of its development and that they feel committed and well connected. In Panama, the use of m-health tools is still uncommon; it is therefore essential that our app is straightforward enough to be used by the elderly patients and older adults who fill the waiting rooms of health institutions, sometimes just to ask how a drug should be taken. We therefore believe that our application will make a significant contribution to the treatment and the control of CKD.

The process of collecting these data gave rise to a very important observation. The onset of the pandemic has shown that patient data are not sufficient to make projections for health strategies; since we do not have data on each patient before and after the onset of disease, we have not been able to adequately take advantage of these data to make decisions. The data that are stored are not suitable for making projections, for example, in analyses based on the region, sex, or age of the patient. The collection of data from different sources such as wearables or social networks is essential. A revolution is under way in terms of the amounts and variety of health data that are now being generated, and access to georeferenced data will be necessary in order to obtain good results from analyses.

Our analysis also highlights the importance of mobile applications for the self-care of chronic diseases and their usefulness to both patients and health care providers, since they can support better health habits and give good results in terms of following a diet, promoting a healthy lifestyle, and encouraging physical activity. The analysis presented here will form the basis for the development of an application that will be simple, user-friendly and powerful, in the sense that it will empower patients with the resources they need for self-care. In addition, we intend to develop a data repository for scientific research within Central America.

6. CONCLUSION

Although the Central American region has advanced slowly in terms of technological development, it now has a significant technology and communications infrastructure that will allow for the development of innovative solutions for the Panamanian population and the wider region, as the country provides technological services to these areas.

In Panama, there is a high demand for public health services, and the number of patients under various forms of hospital care is growing rapidly. This is particularly true in the current pandemic and for patients with chronic diseases. The use of electronic health and mobile health technologies can play an important role in the country’s health strategies. Plans should therefore be established for the regulation and development of suitable methodologies for the use of technologies to promote the health of Panamanian citizens, in which the privacy of the patient is taken into account.

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**Acknowledgments:** We would like to thank the National Secretariat of Science, Technology and Innovation of Panama (SENACYT, SNI) for the support given in the development of this research. Also, GISES-CIDITI-C-UTP and the CRPO-UTP.

**Author’s contribution:** All authors were included in all phases of preparation of this article, analyzing results and final proof reading.

**Conflict of interest:** There are no conflicts of interest.

**Financial support and sponsorship:** None.
REFERENCES

1. Panama Ministry of Health. Indicadores de Salud Básicos. Indicadores de Salud Básicos, Panama. 2014; 1-26.
2. Lozier M, Turcius-ruiz RM, Noonan G, Orduney P. Chronic kidney disease of nontraditional etiology in Central America: a provisional epidemiologic case definition for surveillance and epidemiologic studies. 2016; 40(5): 294–300.
3. Bramlage P, Lanzinger S, Hess E, Fahrner S, Heyer CHJ, Fribe M, et al. Renal function deterioration in adult patients with type-2 diabetes. BMC Nephrol. 2020; 21(1): 1-10.
4. Kovesdy CP. Epidemiology of chronic kidney disease: an update 2022. Kidney Int Suppl [Internet]. 2022; 12(1): 7–11. Available from: https://doi.org/10.1016/j.kisu.2021.11.003
5. Maritati F, Provenzano M, Lerario S, Corradetti V, Bini C, Busutti M, et al. Kidney transplantation in systemic sclerosis: Advances in graft, disease, and patient outcome. 2022 July; 1–10.
6. Galetsi P, Katsaliaki K. A review of the literature on big data analytics in healthcare. J Oper Res Soc. 2020; 71(10): 1511–1529.
7. Cedeno-Moreno D, Vargas-Lombardo M. Mobile Applications for Diabetes Self-Care and Approach to Machine Learning. Int J online Biomed Eng. 2020; 16(8): 25–38.
8. S S, C V Joe. Big Data Business Analytics As a Strategic Asset for Health Care Industry. J ISMAC. 2019; 01(02): 12–20.
9. E. Youssif A. A Framework for Secure Healthcare Systems Based on Big Data Analytics in Mobile Cloud Computing Environments. Int J Ambient Syst Appl. 2014; 2(2): 1-11.
10. Cai L, Zhu Y. The challenges of data quality and data quality assessment in the big data era. Data Sci J. 2015; 14: 1–10.
11. Data B, Zhou M, States U, Grimmer J, King G, Science QS. The Age of Big Data. 2012; 1–5.
12. Islam MM, Razzaque MA, Hassan MM, Ismail WN, Song B. Mobile Cloud-Based Big Healthcare Data Processing in Smart Cities. IEEE Access. 2017; 5:11887–99.
13. García MAM, Rosales MSF, Domínguez EL, Velázquez YH, Lsidro SD. Telemonitoring system for patients with chronic kidney disease undergoing peritoneal dialysis: Usability assessment based on a case study. PLoS One. 2018; 13(11): 1–14.
14. Rzayeva L, Matyukhin I, Ritter O, Patschan S, Patschan D. Health Care Quality in CKD Subjects: A Cross-Sectional In-Hospital Evaluation. Int J Nephrol. 2022; 2022: 1–9.
15. Harerimana G, Jang B, Kim JW, Park HK. Health big data analytics: A technology survey. IEEE Access. 2018; 6: 65661–78.
16. Calderon-Gomez H, Mendoza-Pitti L, Vargas-Lombardo M, Gomez-Pulido JM, Castillo-Sequera JL, Sanz-Moreno J, et al. Telemonitoring System for Infectious Disease Prediction in Elderly People Based on a Novel Microservice Architecture. IEEE Access. 2020; 8: 118340–54.
17. Mendoza-pitti L, Gomez-pulido JM, Vargas-lombardo M, Member S. Machine-Learning Model to Predict the Intradialytic Hypotension Based on Clinical-Analytical Data. 2022;10(June): 72065–79.
18. Srivastav A, Khadayat S, Samuel A. Mobile-based health apps to promote physical activity during COVID-19 lockdowns. J Rehabil Med – Clin Commun. 2021; 4(1):  jrmcc00051.
19. Principe M, Yoon D. A web application using mvc framework. Int Conf e-Learning, e-Business, Enterp Inf Syst e-Government. 2015; 15.
20. Choudhary R, Batra R. Android based Result Checker App for GGSIPU. 2018; 730–735.
21. Labrie A, Cheng J. Adapting Usability Heuristics to the Context of Mobile Augmented Reality. UIST 2020 - Adjun Publ 33rd Annu ACM Symp User Interface Softw Technol. 2020; 4–6.
22. Knoppers BM, Thorogood AM. Ethics and big data in health. Curr Opin Syst Biol. 2017; 4: 53–57.
23. Velavan TP, Meyer CG. The COVID-19 epidemic. Trop Med Int Heal. 2020; 25(3): 278–280.
24. Yang L, Liu S, Liu J, Zhang Z, Wan X, Huang B, et al. COVID-19: immunopathogenesis and Immunotherapeutics. Signal Transduct Target Ther. 2020; 5(1): 1–8.
25. Gansevoort RT, Hilbrands LB. CKD is a key risk factor for COVID-19 mortality. Nat Rev Nephrol. 2020; 16(12): 705–706.