

# Renal Health - A New Tool for Chronic Kidney Disease: *Application Development and a Proposal for Interventional Study*

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**Abstract:** The aim of this study was to create an application for smartphones for chronic kidney disease (CKD). The development of the application was conducted in three phases: data collection, conception and development of an application called "Renal Health". In the first phase, a literature review was conducted to ground the necessity of a tool to teach the general population about CKD and to give support to CKD patients in their treatment. Semi-structured interviews were then conducted with CKD patients (in hemodialysis or kidney transplant) and the general population to enhance out understanding of the main knowledge gaps about kidney disease. Individuals without CKD reported not knowing the disease (66.7%). Patients on hemodialysis reported difficulties with medication intake and diet (>50%). Transplanted patients had no problems with medication intake and showed to want more nutritional advices. After the development of the application, an usability test was done with CKD patients and specialists to evaluate its clarity and performance, and its acceptance was 89.6%. The use of Renal Health application can be an important tool for the general population, for knowledge acquisition, patients, health care workers, as well as patients' family and caregivers of elderly and children patients.

## 1 INTRODUCTION

Chronic kidney disease (CKD) is defined as the presence of abnormalities in structure or function of the kidneys for more than 3 months. Its classification is based on cause, glomerular filtration rate (GFR) and albuminuria (KDIGO, 2013). Its high incidence and prevalence puts CKD as a severe public health problem worldwide (Garcia-Garcia; Jha, 2015).

Access to renal replacement therapy (RRT), which includes hemodialysis (HD), peritoneal dialysis and kidney transplantation, is still unequal in the world. In countries such as Peru, for example, there is approximately 50% of the population without access to CKD treatment (Herrera-Anazco et al., 2015). In the Latin-American Dialysis and Transplantation Registry it is observed that HD is the treatment of choice in the region (75%) and the prevalence of RRT is related with the gross national product and the life expectancy (Pecoits-Filho, et al.,

2015). Regarding data from Brazil, according to the Brazilian Dialysis Census, the number of patients receiving dialytic treatment in 2015 was 111,303 (SBN, 2015) and according to the Brazilian Association for Organ Transplantation, a total of 5,556 renal transplantations were done in 2015, which is far from the real requirement in this country (ABTO, 2015).

RRT is recognized by the high demand of care, such as maintenance of specific diet for metabolic equilibrium, liquids consumption control, vascular access care, assiduity to the dialysis sessions and medical follow-up consultations, adhesion to drug therapy and comorbidities control (hypertension, diabetes and others). This complex context demands a high level of involvement by patients and parents for the self-administration of health care (Jain et al., 2016).

To decrease the incidence of CKD complications, one alternative is to put together the therapeutic options and technology. We believe that

patients with CKD need a better knowledge about their disease, having access to technological tools containing clear and secure information about the disease, such as etiology, risk factors, signs and symptoms, treatment and preventive measures.

The aim of this study was to build a health technology (mHealth) about CKD, incorporating information and services to help patients with CKD to manage their treatment and also give information to the general public, through an application for smartphones.

## 2 METHODS

The development of the application, which we called “Renal Health” was conducted in three phases: data collection, conception and development of a technological artifact (application for smartphones) and evaluation of the application. In the first phase, a literature review was conducted to ground the necessity of a tool to teach the general population about CKD and to give support to CKD patients in their treatment.

### 2.1 Data collection

Initially a literature review was done to investigate the necessity of the application. After this, semi-structured interviews were done with CKD patients (in hemodialysis and kidney transplanted patients) and the general population to know the main knowledge gaps about kidney disease. The sample size was defined by saturation, a method that stops new inclusions based on repetition of answers (FONTANELLA; RICAS; TURATO, 2008). The general population sample was randomly assigned in public places, and the patients were randomly chosen from different healthcare facilities.

### 2.2 Conception and design of the application

This was a laboratory phase, conducted at the Laboratory of Innovation in Information Technology, University of Fortaleza, Brazil, from July to October 2016, based on user’s centered interaction design (PREECE et al., 2013). This method is composed by four activities: identify the necessities and establish requirements, design and redesign of the artifact, building of an interactive

version (functional prototype) and evaluation (usability).

### 2.3 Evaluation of the application (test with specialists)

A test with specialists in Nephrology (Physicians, Nurses, Nutritionists and Psychologists) was conducted to assess their opinions about the applications and which changes they would advise to improve the application. Selection criteria were being a specialist and work in the area for more than 5 years. This test was done to evaluate the content and usability of the application.

## 3 RESULTS AND DISCUSSION

In the first phase, a total of 30 individuals without CKD and not on treatment were interviewed. The main characteristics of this sample are summarized in Table 1.

Table 1: Main characteristics of the interviewed individuals without chronic kidney disease (CKD), Fortaleza, Brazil, 2016.

Characteristics	Mean±SD or n (%)
Age	35.8±7.9
Gender	
Male	21 (70)
Female	9 (30)
Marital status	
Single	17 (56.7)
Married	10 (33.3)
Others	3 (10)
Religion	
Catholic	20 (66.7)
Evangelicalism	6 (20)
Others	4 (13.4)
Schooling	
Elementary school	3 (10)
High school	17 (56.7)
College	10 (33.3)

The majority of them (66.7%) reported not to know about CKD; 40% said not to know its risk factors and 53.3% associated CKD to the low water consumption. Regarding prevention, 53.3% reported not to know; 60% cited interest in knowing how to prevent CKD, and 43.3% wanted to know its causes.

Past studies evidences that knowledge by the general population about CKD is limited (Wang et

al., 2015; Stanifer et al., 2016; Roomizadeh et al, 2014), including people with its main risk factors – hypertension and diabetes (Oluyombo et al., 2016). These facts, along with the increasing CKD incidence, lead us to the reflection that giving more information to people and increasing “knowledge in health” (“health literacy”) can stimulate the adoption of preventive measures and capacitate people to take better decisions about life style and health care.

Among patients in HD, 73% were males, with mean age of 32.7 years. Mean time on dialysis was 6.3 years. Regarding medications, 53.8% reported difficulties in controlling its intake, half of them reported difficulty to adopt the prescribed diet and 56.7% said not to have problem in controlling water intake. Regarding information that they would like to receive about CKD and its treatment, half of the interviewed cited diet/feeding and 23% reported other treatment modalities, with emphasis in renal transplantation.

Due to the complexity of the ideal “renal diet”, a multidisciplinary work with General Physicians, Nephrologists and Nutritionists is essential to achieve an adequate care for people with CKD (Lu; Vakilzadeh; Teta, 2015; Martins, 2013).

A total of 7 renal transplant patients were interviewed, of whom 5 were females, with mean age of 41.1 years. Mean time of transplantation was 10.4 years. Regarding assiduity to post-transplant medical consultations, all interviewed said not to have problems, and the majority (4) reported not having difficulties to take medications. Regarding information they would like to have, the majority cited nutritional orientation.

In the second phase of the study, based on phase 1 results (expressed in Table 2), an application was developed, which was called “Renal Health”.

Table 2: Main doubts about chronic kidney disease (CKD) found among interviewed individuals (general population, patients in hemodialysis and renal transplantations), Fortaleza, Brazil, 2016.

Participants	Main doubts about CKD
Individuals without CKD	Preventive measures, Causes, Symptoms, Treatment
Patients with CKD in hemodialysis	Diet/feeding, Renal transplantation, Complications during dialysis sessions, Blood pressure control, Causes of disease Sports practice
Renal transplanted patients	Diet/feeding, Transplantation complications, Drugs that must be avoided, General advices

In the third phase of the study, with Nephrology specialist (2 Physicians, 2 Nurses, 1 Psychologists and 1 Nutritionist), the validation instrument was organized according to Likert scale, which is a technique with items expressing a point of view about an issue. In this method the items are expressed in a positive or negative way about an issue (Nascimento, 2012). In the evaluation questionnaire we have included 4 degrees of score were included to judge the application: 1= inadequate; 2= partially adequate; 3= adequate; 4= totally adequate. The evaluators have tested the application one single time, and they have answered questions regarding all the interfaces of the application and the contents displayed.

The application have acceptance of 89.6% according to specialists evaluation. This was a mean of the scores rated by specialists. The item with the lowest score was related to language adequation, and it was suggested to improve language and font size to a better understanding of users.

The main screens can be seen in Figure 1.

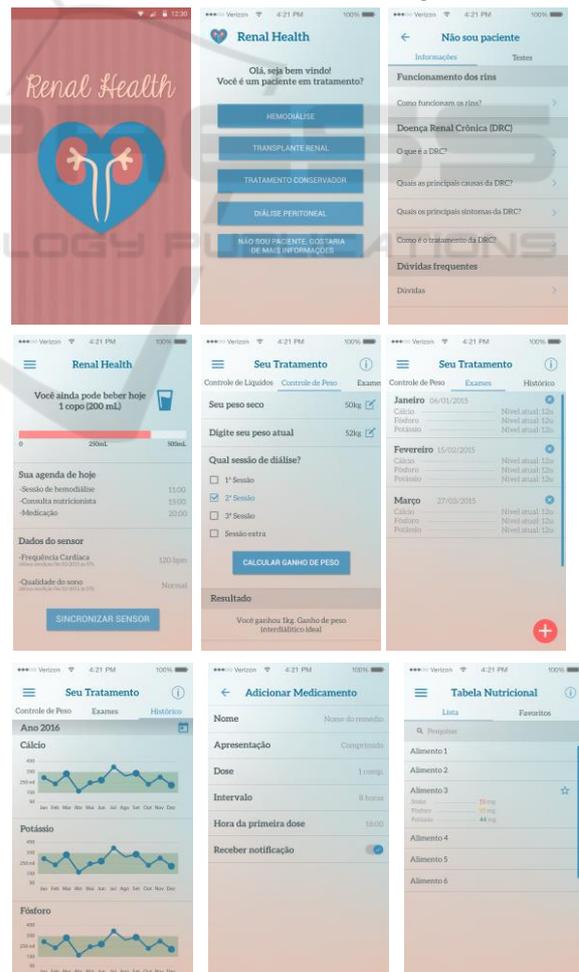


Figure 1. Renal Health application's screenplays samples.

In the first interface the user have the options for connecting as “hemodialysis patient”, “transplanted patient”, “conservative treatment” (people with CKD not yet on dialysis) or “general population” (just to get information about CKD and access laboratory data regarding renal function). It is worth mentioning that the interface for the general population will inform the users if they need a medical consultation. When laboratory tests point to any abnormality, the application will advice for a medical consultation. In the dialysis interface, the user can access a tool for liquids intake, which is illustrated by a glass of water, informing when the limit is achieved. This is important because people on dialysis should have a strict control on liquids intake in order to prevent fluid overload. Regarding medication intake, it will be available for both dialysis and transplant users. Patients can insert the names and the time of medication intake. The application will remember when it is time to take teh medications through alarms and it will also give information about the medications (its actions, side effects and other information for patients). Other interfaces include laboratory tests information, displaying graphics illustrating the evolution of each test. It is important because both dialysis and transplanted patients need to have laboratory tests every month, and this tool will help to evaluate and interpret each test.

The application is also intended to interact with the users, by displaying alarms on medications and medical consultations, for example. It will also be connected with some devices to improve adherence to medication. One of de devices that will be developed is the “medication smart box”, which will be connected to the application by Bluetooth. The aim of this medication box is to detect every time the patients take the medications, so that it will be possible to exactly measure medication's adherence. The prototype of this box can be seen in Figure 2.



Figure 2. Prototype of the medication smart box to be connected with Renal health application.

The Renal Health application will be adjusted, based on patients and health professionals advices and will be tested in a large number of patients in the settings of hemodialysis and kidney transplant. The next phases of this study consists in the improvement of the application, with the initial version developed in Portuguese (in Brazil) and an administrative tool on the web using JAVA platform. Further translation to English and Spanish will be done, and new tests will be conducted in other countries. The data are entered manually in the application by the patients, automatically, through the application synchronization to the network of laboratories responsible for analyzing the monthly tests, as well as being continuously recorded by biosensors (blood pressure, heart rate, arrhythmia detection, weight, percentage of body fat and water). For people without CKD the application focus on preventive measures and tools to help interpret diagnostic tests for kidney function, basically serum creatinine, glomerular filtration rate and urinalysis.

## 4 CONCLUSION

There are many gaps in the knowledge about CKD for both the general population and patients with CKD, which difficult disease prevention and treatment. We believe that the use of “Renal Health” application can be an important tool for the general population for the acquisition of knowledge about CKD, as well as for patients, health care workers, family and caregivers. A prospective longitudinal study is being proposed to investigate if the application has a positive impact in clinical outcomes among patients in dialysis and after kidney transplantation. We suppose that the use of this application can decrease CKD complications and possibly also decrease mortality.

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