Hydriney: A Mobile Application to Help in the Control of Kidney Stones Disease

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***Abstract*— Nephrolithiasis disease requires the management and registration of the different values on a daily basis. These values include the monitoring of daily water consumption and the urinary pH, which should be registered in a mobile application. One of the authors of this paper had the disease and decided to design and develop the Hydriney application. This application meets the needs of people who want to manage all aspects of nephrolitiasis condition and keep it under control. The application tracks almost all aspects of the kidney stones treatment and provides detailed reports, charts, and statistics to share with the urologist. The user should set the daily goals and transcribe the medicine prescription to the mobile application. Then, the application will help him to automate the records for better decision-making in treatment of kidney stones disease. This paper shows that nephrolithiasis management is a health area where Hydriney can enhance the quality of life for people living with this condition.**

Keywords- mHealth; Hydriney; Nephrolithiasis; Water Consumption; Urinary pH; kidney Stones; Uralyt-U; Calcium oxalate; Calcium phosphate; Uric acid.

I. INTRODUCTION

One of the most common problems in the urology clinical area is the nephrolithiasis disease, popularly known as kidney stones (see Figure 1). Mobile devices (*e.g.,* smartphones, tablets, and other specific devices) may help in the control of the treatment of this disease [1].

Kidney stones are solid crystals formed from the salts in urine and affect up to 5% of the world population and the lifetime risk of passing a kidney stone is about 8-10% [2]. A kidney stone is caused by a disruption in the balance between solubility and precipitation of salts in the kidneys and the urinary tract.

Some metabolic disorders, genetic conditions, and dietary choices might contribute to their development. A stone forms when urine is in a "supersaturated" state with insoluble crystal-forming substances composed of calcium (Ca), calcium oxalate (CaOx), calcium phosphate (CaP) and uric acid, due to the dehydration or genetic predisposition to over-excrete these ions in the urine [4].

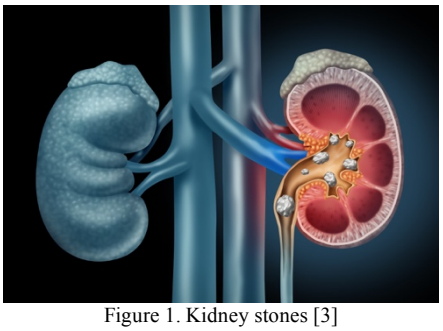

Figure 1. Kidney stones [3]

One of the most common reasons why people get kidney stones is the lack of sufficient water in the body. The body must produce at least 2 liters of urine to reduce risks of kidney stones to half [5]. People who live in warm climates and those who sweat a lot may be at higher risk than others.

Going to the doctor and taking medications are important, but not sufficient for optimal care. Individuals with kidney stones can reduce the short and long term impact of the disease by practicing self-management skills. Using mobile health technology makes it easier to control kidney stones disease. Regarding mobile applications for kidney stones, it has been found that most existing solutions are to a specific feature "food/diet". There is the mobile application named "StoneMD" [6] that was created by urologists and developers and that presents a list of foods (calcium, oxalate and citrates) classified and categorized according to the oxalate content/nutritional guidelines. If the patient has been diagnosed with an oxalate stone condition, there is the application named "oxaBrow" that can help him to manage his Oxalate Diet [7].

There are also several applications for medication like "Medisafe" [8] and water consumption control like "Waterlogged" [9]. "Medisafe" is one of the most popular medication management apps today working as a virtual pillbox on patient's smartphone. "Waterlogged" allows the user to set reminders for himself at scheduled intervals to drink some water. In order to have a complete and suitable app, the Hydriney application was developed.

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The rest of this paper is organized as follows. Section II describes the methods of diagnosis and the types of kidney stones. Section III presents the existent treatment methods. Section IV presents the mobile application developed. Finally, Section V presents the conclusions of this project.

II. Diagnosis and Types of Kidney Stones

The kidney stones diagnosis is suspected by the typical symptom of abdominal pain. Often, kidney stones are found on an X-Ray or ultrasound taken of someone who complains of blood in the urine. Imaging tests, including the X-Rays, are usually done to confirm the diagnosis (See Figure 2) [10].

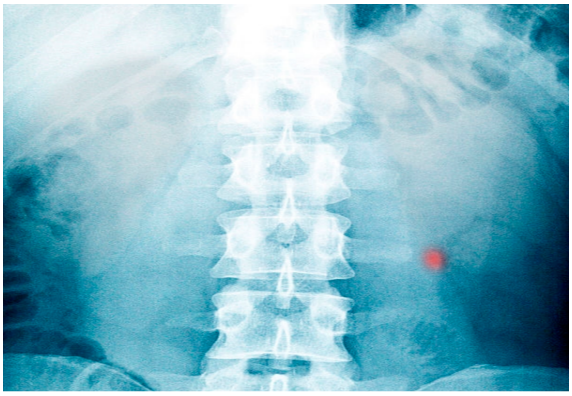

Figure 2. X-Ray with visibility of an opacity of calcic tonality, in red, suggesting the presence of a kidney stone at 1cm outside the left kidney [10]

Radiologists should measure the size of a kidney stone to help estimate the chance it will pass on its own. Stones measuring less than 4mm will pass on their own. Kidney stones develop when the urine cannot dilute all of the substances in it, like Calcium and Uric acid. As example, in Figure 3, a Calcium Oxalate stone dehydrate is presented.

Figure 3. Surface of a kidney stone with tetragonal crystals of Weddellite [11]

There are three major types of kidney stones, including: Calcium (Ca), Struvite and Acid Uric stones. These are:

- Calcium (Ca)
  - The most common type of kidney stones, that usually are in the form of Calcium Oxalate (CaOx);
  - Oxalate is a naturally occurring substance found in food and is also made daily by the liver [12];
  - Calcium stones may also occur in the form of Calcium Phosphate (CaP);
  - Calcium Phosphate (CaP) stones are much less common and typically develop in patients with metabolic or hormonal disorders [12];
  - Calcium stones form in an alkaline urine with a pH higher than 7.
- Struvite
  - Struvite stones form in response to an infection, such as a bacterial urinary tract infection;
  - These stones can grow quickly and become quite large and occur most commonly in women [12].
- Uric acid stones
  - These stones tend to form in patients with hyperuricosuria and gout diseases.
  - About 15-20% of patients with uric acid stones have a history of gout [13];
  - With an urinary pH of less than 5.5, uric acid is poorly soluble, but solubility increases with a pH greater than 6.5 [14];
  - These stones are not as visible on a plain X-ray.

III. Treatment of Kidney Stones

The treatment of kidney stones depends on the type. There are medications that the urologist doctor can prescribe to allow the stone to pass naturally. For stones with a size less than 2.5cm, there is the procedure lithotripsy that uses shock waves to break the stone into smaller pieces. Then, the pieces can be more easily expelled from the body. For most people with recurrent kidney stones, a combination of drinking enough fluids, avoiding urinary infections, and specific treatment with medications will significantly reduce or stop new stone formation.

Certain medicines, such as Acalka, reduce calcium excretion and decrease the chance of having another calcium stone. For people who have a high level of uric acid in their urine, or who make uric acid stones, the medicine Uralyt-U will usually stop the formation of new stones. This medicine re-dissolves any crystals that are already present in the urine. The administration method of Uralyt-U includes granules (1 g/dose), that should be taken, 3 times per day and dissolved in a glass of water and then drunk. Uralyt-U has a special indicator paper, which consists on yellow paper strips and a color scale within the range of 5.6 to 8 (See Figure 4). Lower numbers are more acidic and higher numbers are less acidic. The patient should bring the table every time he visits the doctor.

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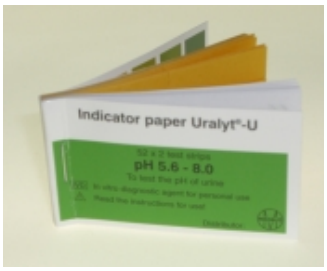

Figure 4. Test stripes of Uralyt-U medicine

At the main meals (every morning, midday and in the evening), before taking each dose, the patient should dip one paper strip into the fresh urine for a few seconds. The color of the strip will change and then it should be compared with the color scale. After matching the paper strip with the color scale, the user should register the urinary pH value measure in a traditional table.

IV. APPLICATION

The Hydriney application allows the patient to use it as a "personal schedule" of the kidney stones disease. Hydriney has innovative features to help improve life with kidney stones disease. There is a left side menu following the Google design pattern with the following features: Profile; Medication; Consumption of H2O; pH of Urine (See Figure 5).

A. Profile

When the application starts, the user is re-directed to the "Profile" module. This module, presented in Figure 6, focuses on individual parameters like height, weight, age and daily water goal, in liters (l). The user must register his weight and height for the automatic calculation of the Body Mass Index (BMI).

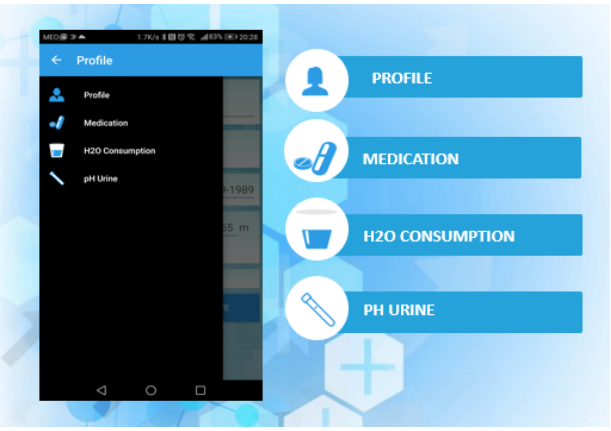

Figure 5. Main screen of Hydriney application

B. Water

Goals and reminders really help throughout the day. Hydriney reminds the user to drink according to the progress which is filled with the volumes consumed.

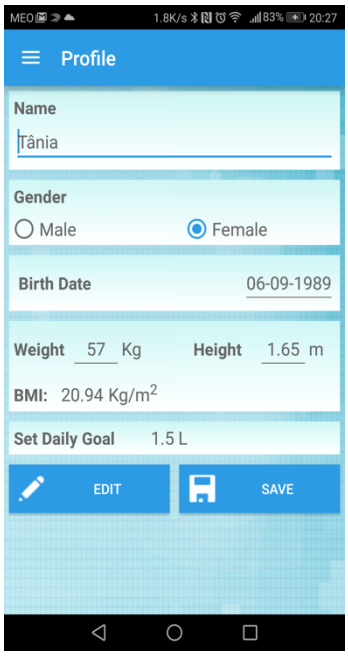

Figure 6. Profile screen of Hydriney application

Increasing water intake is important to ensure an urinary volume of approximately 2.5 liters per day that is associated with the reduced urinary supersaturation with CaOx and a significant reduction in stone recurrence [15]. H2O Consumption's feature (See Figure 7) allows the registration of water intake with notifications about the need to drink water. The screen is divided into two tabs: "Today" and "History". The "Today" tab allows the user to record, throughout the day, the water consumption. The user must press the bottle (s) corresponding to the water volume that he has just to drink. There are 5 bottle standard sizes: 1.5L, 1L, 0.5L, 0.33L, and 0.10L.

As the user registers what he drinks, the progress chart updates, in real time, the percentage of drinking water in relation to the daily goal (see Figure 6). There are also automatic notifications to remember the user to drink water, helping him to drink more water. After entering the values, the application shows in the "History" tab the detailed history chart of water consumption related to today, latest month and last year.

C. Medication

It is not always easy to keep the right time in memory taking a medicine or administering of dosage required during the treatment. The Hydriney application allows the user to detail the schedule of medicines, the dosage options (pills, boxes, and others) and medication intervals. This module development was inspired by the format of pill boxes with dividers (See Figure 8).

The screen has four divisions/boxes grouped by shift - morning, afternoon, evening and dawn. Adding the medications to the med cabinet, the user can see any interactions between them.

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Each box displays the name of the medicine to take, the time to take and the flag whether it has already been taken or not.

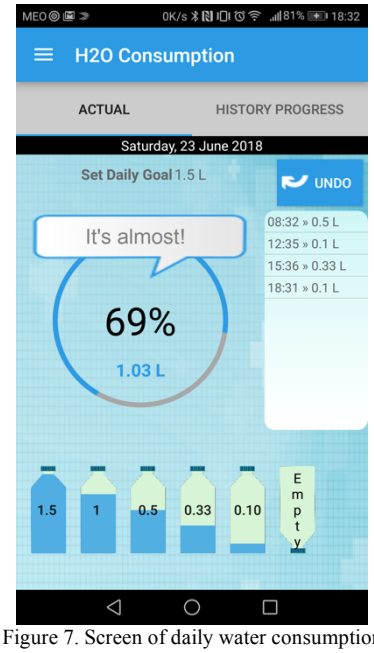

Figure 7. Screen of daily water consumption

D. pH Measurement

A metabolic evaluation starts with a 24-h urinary pH profile, because pH is used to measure urine acidity [16]. A lower urinary pH level increases the risk of the presence of different types of kidney stones, promoting the formation of calcium oxalate (CaOx) and uric acid stones (UA) [16]. The alkalization of the urine is important for the treatment of uric acid stones [16].

After matching the paper strip with the color scale, the patient should insert the value measured in the "pH Urine" module (See Figure 9).

As it was previously mentioned, patients taking Uralyt-U need to measure and record the urinary pH 3 times per day: before breakfast, before lunch and before dinner.

This feature makes it easier to record the urinary pH, replacing the traditional paper table. Thus, it is easier not only to register in itself but also the grouping and organization by phases of the day. When entering pH measurements, there is also a "History" tab that shows a chart with the evolution of the urinary pH. Figure 10 shows a scatter chart with the evolution of urinary pH for one month.

The charts improve the understanding of data oscillations registered and promote the better disease's self-monitoring, improving the apprehension of the patient's condition by the doctor.

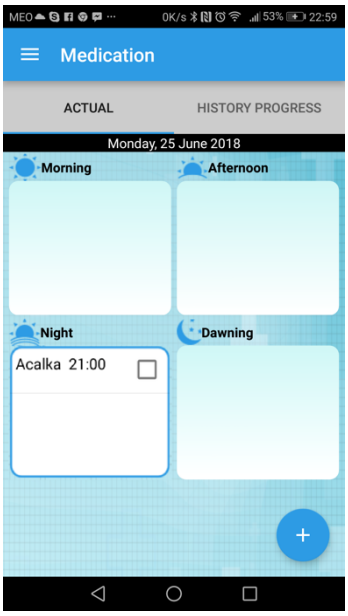

Figure 8. Screen of daily medication reminders

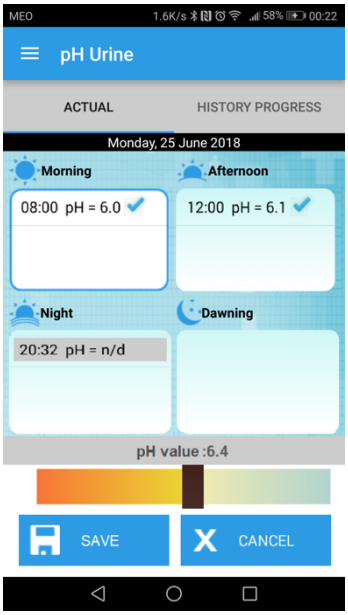

Figure 9. Screen of daily pH measurements

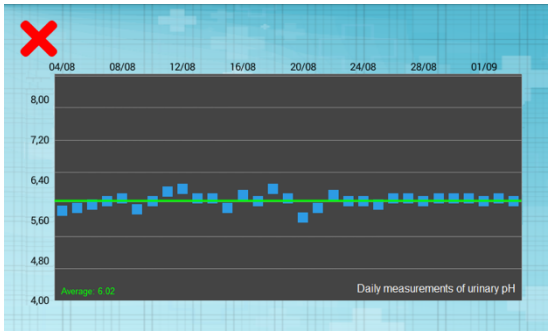

Figure 10. Chart of daily urinary pH measurements

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V. DISCUSSION AND CONCLUSIONS

In this paper we have presented Hydriney, an application tailored for patients with nephrolithiasis. It can effectively help patients with their daily tasks. The Hydriney application will not replace the patient's doctor, but will greatly facilitate the care of the patient and will help reduce the risk of a possible stone recurrence.

If patients track different parameters relevant to kidney stones self-management, they might start noticing different correlations, for example, between their pH Urine and water intake.

This mobile application promises to bring benefits and opportunities to the treatment and prevention of kidney stones disease for a better quality of life. Using this app the user can then take readings, store results, set up timed interval logging, or schedule reminders for particular logs he need to complete. The mobile application tracks almost all aspects of the disease treatment and provides detailed reports, charts and statistics.

By looking for patterns or trends in patients results, the doctor could make changes on the disease treatment plan of patients.

Hardware and software tools are now making it easier for patients to take greater control. As future work, we intend to develop a pH probe using the Arduino platform to interface the Hydriney application. The sensor will be immersed in the urine sample to read the pH variation. After reading it, the data will be transmitted to the microcontroller present in the Arduino platform. Then, the Bluetooth integration will connect the data to the Hydriney application that will allow the user to keep track accurately his urinary pH. The pH sensor will transmit live readings and captures data in real-time.

ACKNOWLEDGMENTS

This work was supported by FCT project UID/EEA/50008/2013. The authors would also like to acknowledge the contribution of the COST Actions IC1303 – AAPELE – Architectures, Algorithms and Protocols for Enhanced Living Environments, and CA16226 – Indoor living space improvement: Smart Habitat for the Elderly.

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