

# Kidney Transplant aftercare with IOT Medical Wearables

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## ABSTRACT

Kidney disease has been a growing concern in Sri Lankan healthcare system. Many patients are undergoing transplantation day by day. Physicians must be equipped and knowledgeable to treat this growing unique patient count. Not just doctors, patients too have to do their part to ensure their own safety. This means frequent visits to the doctor's office which can cost a lot. In this current economy in Sri Lanka most patients are not able to pay the consultation fees and it's a major hassle to go to the government hospitals every day to check your blood pressure, body temperature etc. We live in the era of Internet of Things and Wearable devices are becoming extremely popular, not just for sports utilized necessities but also for self-health monitoring. This research paper summarizes the attempt made by the Safe Plant [1] development team in finding the feasibility of having a medical wearable to help and support kidney transplant patients in their aftercare process.

**Index Terms** – Assistive mobile application; Cloud Platform; MIIOT; Kidney Transplant Aftercare.

## I. INTRODUCTION

Sri Lanka has been battling with Kidney Disease for more than 20 years. It all started in the rural areas of the country but now it is prevalent across the island. More than 20,000 deaths have been recorded in the Anuradhapura District itself since the first diagnosis of the disease back in 1991. 400,000+ people were sickened during the past 2 decades and nearly 1100 patients are hospitalized every month. [2]

The exact reason for this outbreak is yet to be confirmed, but the majority believes that it is Water that causes the disease. Harsh Agrochemicals are widely used in the fields and as a result they somehow get leaked in to the adjacent water bodies making them toxic. Consumption of this chemical heavy water will cause the kidneys to fail eventually. And the sufferers will have difficulties even drinking 100% pure water as their kidneys will no longer function normally.

Unfortunately, there's no cure for Chronic Kidney Disease (CKD). But there's a possibility of relieving the symptoms by doing treatments. Following are few major treatment methods and the exact treatment will depend on the stage of the individual's CKD.

1. Change in Lifestyle – Early Stages
2. Medication
3. Dialysis
4. Kidney Transplant

Dialysis (The process of doing the function of a Kidney artificially) cannot be done for more than 5 years and if the patient doesn't get better over time transplantation is recommended. [3]

Finding a donor to match your blood type is comparatively easier than the whole aftercare process that follows transplantation. Many consider it to be a total nightmare. Following are some key factors to be vigilant after you are done with your surgery.

- Medication must be taken on time and in the proper dose
- Infections has to be checked (In the operated area)
- Vaccines must be taken
- Regular checkups for diabetes, High Blood Pressure, Cholesterol
- Must prevent from smoking, drinking etc.
- Must keep track of the body Weight

Once the transplant is done, patients are prone to various conditions. In order to overcome these situations constant health monitoring has been made mandatory by the doctors. Patients must always be vigilant about the heart rate, blood pressure, body temperature etc. Only a handful of patients are able to measure these vitals by themselves as the process is a bit complicated. Visiting a physician daily will cost a lot of money and going to the general hospitals every day is also unrealistic.

The Internet of Things (IoT) is a new phenomenon that has received every techie's attention. Many believe that it will explode by the year 2020. With this amazing technology, wearable technology has marked itself prominent during the past few years making healthcare monitoring using wearable technology possible. With this technology, vitals can be measured by attaching sensors to the human without interrupting the user. The wearable health monitoring industry has taken a huge leap forward and new devices are introduced to the consumers daily.

To integrate IoT in a wearable device to help transplant patients, we have to dig deep in to the whole aftercare process. In order to gain a better understanding of the problem, a literature review was carried out by the development team.

## II. LITERATURE REVIEW

### *What is Kidney Disease and What causes it?*

There are a number of biological processes happening inside a living being and in order for any organism to function properly, these processes should work at their optimum. Excretion is one of the most important mechanisms which lets out the bi products of the reactions that produces energy. Therefore, a healthy pair of Kidneys are a must for a disease free life. But when the Kidneys are damaged and doesn't function as they should, all the waste matter gets clogged up causing harmful side effects. Leading causes of kidney failure are diabetes & high blood pressure.[4]

Not only diabetes and high blood pressure, urinary tract infections can also cause damage to the kidneys as they leave scars once they are healed. Obstructions in the urinary tract also causes kidney disease. Some people tend to overuse medications such as pain killers which might permanently damage the kidneys. There are number of reasons for kidney disease but it is also inherited. Polycyclic kidney disease is the most common type of inherited kidney disease. [5]

### *What to expect after a transplant?*

From the moment you wake up in the ER, until you die you have to take a good care of the organ. Success of the surgery solely depend on the patient's behavior. All the time and effort should be allocated in taking care of the new kidney.

Transplant patients should always:

- Consult the assigned physicians on a regular basis and follow their advice at all times.
- Take anti-rejection medications daily in the proper dose and at the right time, as directed by the transplant team, to keep the body from rejecting the new kidney.
- Follow the recommended schedule for lab tests and clinic visits to make sure that your kidney is functioning properly.
- Follow a healthy lifestyle including a proper healthy diet, exercise etc.
- Take regular blood sugar and blood pressure checkups.
- Refrain from alcohol, smoking and other drug use.
- Take necessary vaccinations to avoid any vulnerabilities. [6]

## III. WEARABLE HEALTH MONITORS

Despite the extreme popularity of wearable technology, its usage in healthcare is still a bit skeptical. With the help of sensors, wearable devices are able to track almost everything ranging from body temperature to UV exposure. These devices are known to be extremely versatile, compact and programmable. These awesome features attract the consumers automatically as the use of these devices will cut down personal visits and allows doctors to check in on their patients remotely.

Unlike fitness enthusiasts, patients are hesitant to purchase medical wearables. This is the most significant downfall in the medical wearable industry. Product developers are doubting whether to take the risk of production as the target market is niche. As a result, providers tend to target the four most common chronic diseases. (ex. heart failure, diabetes, hypertension and chronic obstructive pulmonary disease). Diseases like Kidney Disease is often overlooked. There's an empty slot in the current smart wearable market for an accurate glucose monitor and for a blood pressure monitor. [7]

Not just monitoring, some of these devices are capable of issuing early warnings to patients which enables them to act fast to prevent the disease. This reduces possible hospital stays which can cost a lot of money.

### *A Medical IoT device for Kidney Transplant aftercare.*

Most of the health monitors in the market are targeted towards heart patients. And they often include ECG or EEG sensors along with few others. But a multi-tasking health monitor is very rare to find and the size of those devices tend to be large. So there's still a space and necessity in the market for a multi-tasking compact wearable health monitor.

What if there's a wearable for Kidney Transplant patients that could help them in their aftercare process. In simpler terms, if there's a device that could take all the vital health readings and if it could analyze the data and warn the user of any issues it would be excellent.

## IV. SAFE PLANT – SMART WRISTBAND FOR KIDNEY TRANSPLANT PATIENTS

### *What is Safe Plant?*

#### **DEVICE**

“Safe Plant” is a smart wrist band which is made to help Kidney Transplant patients in their aftercare process.

As we all know, the aftercare process is a nightmare for patients and the Sri Lankan economy makes it even difficult for them to keep up with their treatments. A visit to the doctor will cost you around Rs.500 just for a regular check-up. With Safe Plant the aftercare process will become much easier, efficient and economic.

Safe Plant will keep track of your vitals at all times. And it'll beep and will notify you if there're any abnormalities. Kidney Transplant patients are prone to diseases like High Blood pressure, Heart Attacks, Weight gain etc. So patients have to be vigilant about their health.

The band will constantly monitor

1. Heart Rate
2. Body Temperature
3. Blood Pressure
4. Activity (number of steps taken, calories burnt, distance travelled with in the day)

With all these readings “Safe Plant” will calculate if there’s any risks and will notify the user to take immediate action.

It consists of a simple user interface which will help older patients as they might not be tech savvy. And it even has a “Panic Button” which the user can program manually and it will send a SMS to a mobile number, if the patient clicks the button in case of an emergency.

## ANDROID APP

The Android Mobile application will receive all the data from the wrist band when it is connected and it’ll will act as a secondary display as well. You’ll be able to customize the app according to your preferences. But the device is not dependent on the Mobile App.

The app has an interface where you can schedule your important doctor’s appointments, medicine intakes, vaccination dates etc. And it will have a feature to seek medical advice from our community of doctors as well. Plus, you will get some extra features such as daily tips and tricks and an option to donate to the presidential fund if you are using a Dialog GSM sim card on your phone.

## WEB PLATFORM

All the data gathered will be sent to Microsoft Azure cloud services for processing and the data is accessible through our web platform. (safeplant.apareciumlabs.com). We will invite renowned urologists in the country to volunteer with us and they will be given access to the patients questions and their health readings. If a particular patient has asked a question one of these volunteers can look at their vital readings and give feedback to them.



Figure 1: Main components of safe plant

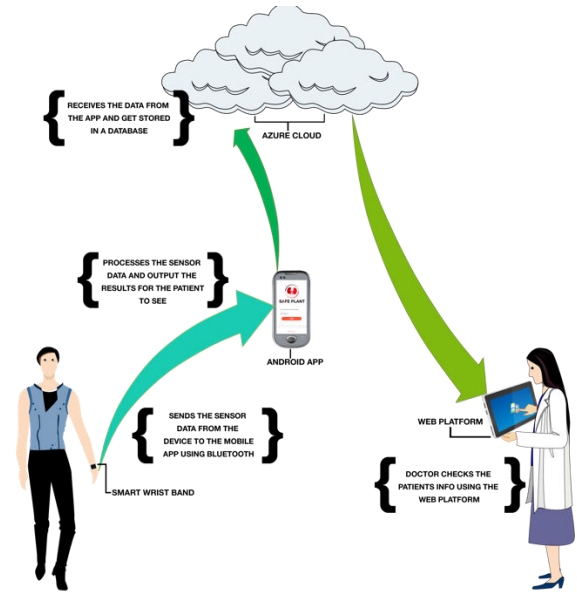


Figure 2: Rich Picture diagram for the system

## V. EXPECTED COMPETITION AND CHALLENGES

### Competition

The current market was flooded by fitness trackers during the past couple of years. Most famous devices being Fitbit and Mi Band by Xiaomi. Even a company in Sri Lanka had come up with their own fitness tracker called “GOYO”. These devices are specifically marketed for sports enthusiasts. So the competition with our device (Safe Plant) won’t be direct. But we went ahead and carried out a comparison between the devices and following chart represents a summary of it.

| FITBIT                                                                              | SAFE PLANT                                                                            | MI BAND- Xiaomi                                                                       |
|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  |  |  |
| Fitness Oriented                                                                    | Medical Wearable                                                                      | Fitness Oriented                                                                      |
| Interactive Screen on some                                                          | Interactive Screen                                                                    | No Interactive Screen                                                                 |
| Body Temperature                                                                    | Body Temperature                                                                      | No Body Temperature                                                                   |
| Heart Rate                                                                          | Heart Rate                                                                            | Heart Rate                                                                            |
| No Blood Pressure                                                                   | Blood Pressure                                                                        | No Blood Pressure                                                                     |

Figure 3: Comparison between Safe Plant, Fitbit and Mi Band.

### Challenges

The main challenge that we came up when designing the device was that the blood pressure sensor was taking up a fairly large space on the prototype. Many attempts were made to minimize the form factor of the sensor but it all failed eventually. So we had to settle just for the Blood pressure status. The device won’t be able to display the exact blood pressure as a number (ex. 80 mmHg) but it’ll display if the

pressure is normal, high or low. Following are the series of equations that were used in estimating the status of the blood pressure. [8]

## EQUATIONS

$$\text{Cardiac Output} = \text{Stroke Volume} \times \text{Heart Rate}$$

and

$$\text{Stroke Volume} = \text{End Diastolic Volume} - \text{End Systolic Volume}$$

so

$$\text{Cardiac Output} = (\text{End Diastolic Volume} - \text{End Systolic Volume}) \times \text{Heart Rate}$$

$$\text{Blood Pressure} = \text{Cardiac Output} \times \text{Resistance}$$

and

## VI. CONCLUSION

In this project, the we identified there is a problem in these fields, then we examined the problem domain and started gather requirements by reading research papers, articles, survey etc. After gathered those requirements team move to designed and implementation part. The entire product was done under prototype methodology. The project gave us lots of learning experience to us connect with new ideas, concepts, methodologies like stuff. Also this is an opportunity for us to use in the real world and implement those concepts what we learnt in the university.

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