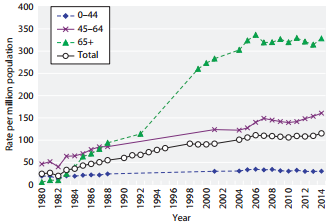
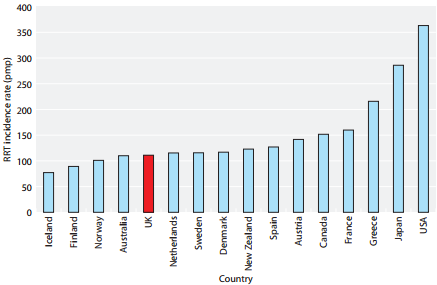
**Abstract -** Chronic kidney disease (CKD) is an important public health issue. It describes abnormal kidney function and/or structure. Despite many other diseases, it is usually asymptomatic until the late stages. In small but significant percentage of people, CKD can progress to End-stage kidney disease, which requires a lot of personal commitment in order to survive. This includes strict diet and regular appointments for Renal Replacement Therapy (RTT**) for the rest of the individual’s lfe.** In the majority of cases, RTT starts with receiving dialysis treatments, until the living kidney is transplanted. Since the process of receiving a transplant requires a three year waiting in average, it is particularly important to maintain individual’s health until the kidney is transplanted.

The aim of this nine-month project is to develop an **everyday mobile application(service?)** that fits the needs of renal dialysis patients. Market research shows that there are very few mobile **application(service)** available for people on dialysis. Through an agile-based approach, an application was developed to (1) remind patients about their appointments, (2) Check their health by scanning their blood test results, (3) react immediately if health check failed, (4) prepare them for their treatments and assist them during these treatments, (4) allow them an easy access to their personal details, clinical staff contact details and frequently asked questions, (5) offer them calendar of events with an option to add their own events in the system, (6) **Show graphs of how their blood test results changed during time.**

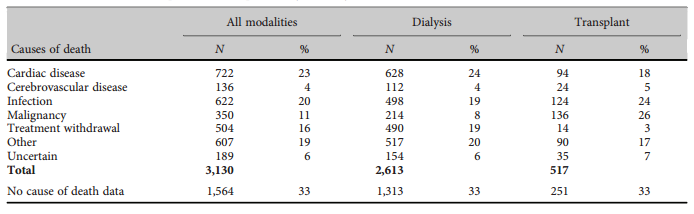
The final solution is an Android mobile application sitting on the top of a SQL database back-end. The **service** utilises a variety of powerfull, unique **frameworks(libraries?),** including Android-volley[**REFERENCE**], MPAndroidChart[**REFERENCE**]. A typical user of the service **can interact with an application every day: before, during and after treatments.** This report gives an in-depth breakdown of the process under which the project was developed.

**Keywords***Dialysis, Hemodialysis, Chronic Kidney Disease, mobile applications, Android*

**1 Introduction**According to UK Renal Registry 18th annual report [1.1], there were 7411 new RTT patients in the UK in 2014. Apart from that, between 1980 and 2014, RTT incidence rate increased by more than 2 times and chances of RTT incident increased with population ageing. (Figure 1) Across the UK, as a whole, the renal replacement therapy incidence rate for 2014 was higher than for 2013 and 2012. In the worldwide, UK statistical data is not showing the highest incidence rate, according to data supplied by United States Renal Data System (USRDS) (Figure 1.1). It is self-evident that there are strong reasons to consider Chronic Renal Disease as an important public health issue, since despite of only small amount of CRD cases, where disease progresses to the Kidney failure which requires RTT, the amount of incidents is growing each year. [2]   
  
***Figure 1****: RRT incidence rates between 1980 and 2014*



***Figure 1.1****: International comparison of RRT incidence rates in 2013(Data from USRDS)*[2.1]

In 2013, the total of 2613 RRT patients died for different reasons. Infection was the third most popular reason causing death in Dialysis patients. (Table 1)  


***Table******1****: Cause of death in prevalent RRT patients by modality, 2013*

Tayside Kidney Patients Association (T.K.P.A.) [2.2] is an association ran by volunteers. It aims to support Tayside Renal Patients by providing help and advice, when appropriate. Currently, T.K.P.A. **does not have any IT solutions apart** from the website. All the patients who joined T.K.P.A. are either running dialysis patients or those, who already received a kidney transplant. Unlike in many other associations, T.K.P.A. members are very close to each other, since they meet at least 3 times a week at the Renal Dialysis Unit in Ninewells Hospital. The most experienced patient in the association is receiving RRT for more than 30 years. T.K.P.A. is always here, when a CKD patients requires help or assistance.

This project is devoted to development and evaluation of Android application that would work as an everyday mobile application for RRT patients. The application is aimed to check patient’s health and help with patient’s preparation to the treatment, through the treatment and in their aftercare. The aim of the project is to produce a mobile application to support daily RRT patient’s needs.

This report describes the agile-oriented procedure the author took to develop a mobile **solution** for T.K.P.A.

**The remainder of this document presents background research providing context for the project (Section 2), the project proposal resulting from client discussions (Section 3), individual project handling techniques (Section 4), the design, implementation and testing process for each phase of development (Sections 5-7), a functionality and testing overview of the final product (Section 8), and a conclusive discussion including student reflection and notions for future work (Section 9).**

**2 Background**

**2.1 Kidneys**The kidneys are two beam-shaped organs, the size of the fist, located on either side of the body, just beneath the ribcage. The main role of the kidneys is to filter waste products from the blood before converting them into urine. Apart from that, the kidneys help to maintain blood pressure and the correct level of chemicals in the body which, in turn, helps heart and muscles to function properly. The kidneys also produce the active form of vitamin D that keeps bones healthy, and simulate production of red blood cells by producing erythropoietin. [1]  
**2.2 Chronic kidney disease**Chronic Kidney disease (CKD) is an important public health issue. It can be defined as the reduced ability of the kidney to carry out its tasks. In spite of it being common, with its popularity increasing with age, chronic kidney disease is an independent risk factor for other diseases, particularly cardiovascular disease. It often coexists with other cardiovascular conditions meaning that it needs to be managed alongside other diseases and risk factors such as diabetes and hypertension as well as the social needs that come with frailty and multiple conditions. In a small, but significant percentage of cases, chronic kidney disease progresses to end stage renal disease, which may require renal replacement therapy. This progression and the risks of other vascular events, such as stroke and heart failure can be reduced if chronic kidney disease is identified and managed, early diagnosis is therefore essential. There are five known stages of CKD. These stages are mainly based on measured or estimated GFR (Glomerular Filtration Rate) (Table 1.1) [2]

|  |  |  |
| --- | --- | --- |
| Stagea | GFR (ml/min/1.73 m 2 ) | Description |
| 1 | ≥ 90 | Normal or increased GFR, with other evidence of kidney damage |
| 2 | 60–89 | Slight decrease in GFR, with other evidence of kidney damage |
| 3A | 45–59 | Moderate decrease in GFR, with or without other evidence of kidney damage |
| 3B | 30–44 |
| 4 | 15–29 | Severe decrease in GFR, with or without other evidence of kidney damage |
| 5 | < 15 | Established renal failure |
| a Use the suffix (p) to denote the presence of proteinuria when staging CKD. | | |

***Table 1.1****: Stages of chronic kidney disease* [3]

**2.2.1 Causes of chronic kidney disease**A number of conditions can cause permanent damage to the kidneys and/or affect their function and lead to CKD. According to [4], diabetes, high blood pressure and ageing kidneys are the three most popular causes of CKD.

**2.3 End-stage kidney disease**End-stage kidney disease (also called end-stage renal disease (ESRD) or established renal failure (ERF) is the last stage of chronic kidney disease. It is caused by inability of kidneys to support patient’s body needs. Since the kidneys are performing one of the leading roles in the body, it is essential to maintain their functionality, which requires renal replacement therapy (RTT). RTT can take a number of forms; kidney transplantation, hemodialysis or peritoneal dialysis. Receiving a kidney transplant can be a very challenging process. According to [5]:

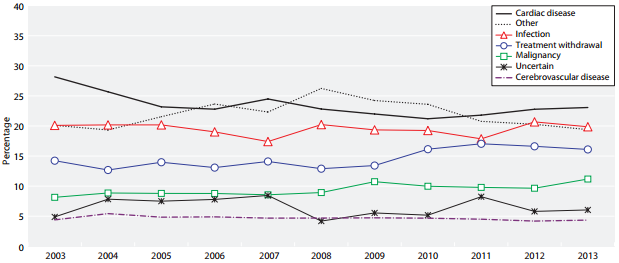
* Only around one in three people with kidney failure is suitable for a transplant.
* Not all kidney transplants are accepted by body.
* Ideally, kidneys will come from a close relative because of the likelihood of sharing the same blood group and tissue type.
* An individual who needs a kidney transplant, but don’t have a suitable living donor, will have to wait until suitable deceased donor kidney becomes available. On average, the waiting time is two to three years, but if the individual has a least common blood group or tissue type, the waiting time increases.
* From April 2014 to April 2015, around 3,000 kidney transplants were carried out in the UK, but there were still more than 5,000 people on the waiting list for a kidney by the end of this period.

Since the chances of obtaining a kidney transplant straight away after diagnosis are small, usually individual is offered a dialysis treatment, while waiting for a transplant.

**2.4 Hemodialysis**Dialysis is a procedure that is a substitute for many of the normal functions of the kidneys. Hemodialysis uses a dialysis machine with a special type of filter to remove excess waste products and water from the blood. There are multiple ways to connect a patient to the dialysis machine. One of them is known as “Cimino fistula”, which is a direct connection between an artery and vein in the arm. Hemodialysis can allow individuals to live productive and useful lives, even though their kidneys no longer work adequately.

**2.4.1 Causes of death during hemodialysis**Over the last years the quality of hemodialysis treatment within NHS Tayside improved with the help of modern medical technologies, but death rate within dialysis patients is still high. According UK Renal Registry [6], infection is one of the leading causes of death within dialysis patients (Figure 2). It is very easy to catch an infection, since fistula is the place, which is used as a link between the patient and dialysis machine. In order to decrease a death rate of Dialysis Patients, infections should be prevented at earliest stages.

***Figure 2****: Cause of death in RRT patients by year*



**2.5 Important aspects of CKD patients’ life**Since their kidneys are not working properly, there is a number of life-changing guidelines which should be followed by people, diagnosed with CKD need to follow in order to improve their health. First of all, CKD patients follow special diet, which restricts their fluid intake and avoids potassium, phosphorus, salt, protein rich foods. Then, if the patient is undertaking RRT, attending hemodialysis appointments three times a week, 3 to 5 hours per treatment is essential. For new patients, following this strict schedule is of the most challenging adjustments needing to be made. [7] Apart from that, maintaining a hand hygiene is very important for people, who are undertaking their treatment through the fistula, since it is a very vulnerable place.

**2.6 Access to health check results for CKD patients/NHS medical staff**Currently, it is possible to access health check results from desktop computer using Patient View system [8], where registered patients can access their health check results and view them in a grid or table format. NHS medical staff are using eMed system to input results in the system.

**2.7 Market Research**The amount of mobile applications available on the market is very limited. According to National Kidney Foundation [9], there is a total of 4 applications available for the CKD patients. Most of them are pocket guides to nutrition assessment. Currently there are no applications available that offer RRT patient to view their blood test results explained on a mobile device. Apart from that, there are no applications that offer assistance during dialysis. On the other hand, there is a Patient View website available, it is mobile friendly and it allows patients to communicate with their doctor using messaging, but the blood test results shown there are very hard to understand due to abbreviations and medical terms being widely used. Moreover, instead of offering explanations for different blood tests using “on click popup”, in Patient View these explanations are only accessible from third-party websites. Summing up, there is no such a system that would offer RRT patients to access nutritional information, their personal details, essential clinical staff contacts, prepare them for their treatments, guide them through their treatments and review their blood test results in one mobile application.

**2.8 Client – T.K.P.A. (Tayside Kidney Patient Association)**Tayside Kidney Patient Association (hereafter referred as “the client” is an association ran by volunteers. Following a meeting with T.K.P.A., the student consulted with the Head of association, Audrey McHugh and **came to an agreement over the Honours Project proposal**. The client’s aim is to help new and ongoing patients with CKD. The client is currently missing a mobile application that could offer both renal specific features and a part of existing functionality of the Patient View system.

**3 Specifications   
3.1 Project Selection**Before having initial meeting with a client, the project required ethical approval. Since RRT patients are considered disabled under Equality Act 2010, primarily the student was advised to apply for NHS ethical approval [10] and Caldicott Guardian ethical approval [11]. Initially there were many reasons for selecting advanced ethics. First of all, such an approval would allow to visit Renal Unit and speak to RRT patients on NHS grounds. Then, easy recruiting of patients for design evaluation would be possible. Finally, Caldicott Guardian ethical approval allows to request a real medical data that could improve the precision of application when performing a health check. Unfortunately, due to the fact that getting NHS ethics is a very long process, there existed a possibility that it will not be possible to get ethics approved in time, allocated for the project. Instead of getting NHS ethics, the student decided to find a patient association that is not directly connected to NHS and use a standard **Dundee University School of Computing Ethical Committee approval.** This solution significantly decreased time spent on ethics approval. On the other hand, it restricted the student from speaking to patients on NHS grounds, which made a patient recruitment more challenging. While ethics were awaiting approval, the student created a first version of project proposal and made an attempt to contact a client for the first time. Unfortunately, the only way to contact the client was by using a form on their website, which was not working properly. Later, when calling Renal Dialysis Unit, charge nurse transferred student to the client. Once the ethical approval was granted, an initial meeting with a client was set up on 18/11/2015. During this meeting first version of project proposal document was reviewed and updated. The student was not given any specific technical implementation guidelines, the client asked to consider an average age of the patients (50-55 years old) when developing an application. It was agreed, that design workshop will take place due to clients interest in considering patients’ age in application development. The client was asked to find a group of volunteering patients from association who would be interested to participate in a **study**.

* **Background**
* Initial Client Proposal
* Materials to be provided by the client
* Primary functionalities expected from the system:
* Secondary functionalities possible for the system:
* Further Discussion

Project Management

* Agile – agile definition + description of how applied
* Risk assessment – standards + description
* Requirements definition – international standards + description
* Use cases – international standards + description
* Pivotal tracker (backlog) definition + description
* Design – Anna, sketches
* Github(vcs definition, commits etc)
* Github issues section
* Project timetable
* Weekly meetings
* Logbook
* Figure 1: Expected system architecture including project phase breakdown [9]
* Phases
  + Phase0
  + Phase1
  + Phase2
  + Projected system overview

Phase 0

* Design
  + DB design

References:

[1.1] https://www.renalreg.org/wp-content/uploads/2015/01/web\_book\_07-04-16.pdf

[1] http://www.nhs.uk/conditions/Kidney-disease-chronic/Pages/Introduction.aspx

[2] <http://www.healthcheck.nhs.uk/document.php?o=81>

[2.1] Saran R, Li Y, Robinson B, et al. US Renal Data System 2015 Annual Data Report: Epidemiology of Kidney Disease in the United States. Am J Kidney Dis, in press

[2.2] http://www.tkpa.org.uk/

[3] <https://www.nice.org.uk/guidance/cg182/chapter/1-recommendations>

[4] <http://patient.info/health/chronic-kidney-disease-leaflet>

[5] <http://www.nhs.uk/Conditions/Kidney-transplant/Pages/Introduction.aspx>

[6] <https://www.renalreg.org/wp-content/uploads/2014/09/Chapter_5.pdf>

[7] <http://www.niddk.nih.gov/health-information/health-topics/kidney-disease/hemodialysis/Pages/facts.aspx>

[8] <https://www.patientview.org/#/>

[9] https://www.kidney.org/apps

[10] NHS ethics committee

[11] http://www.tasc-research.org.uk/images/cmsimages/pdf/Caldicott%20Approval%20Procedure.pdf

[12]

[13]

[14]