

# **NATURAL LANGUAGE GENERATION IN E-HEALTHCARE: ABDOMINAL CANCERS SYMPTOMS DETECTION, MONITORING AND MANAGEMENT**

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**Declaration:**

No portion of the work contained in this document has been submitted in support of an application for a degree or qualification of this or any other university or other institution of learning. All verbatim extracts have been distinguished by quotation marks, and all sources of information have been specifically acknowledged.

**Signed:**

**Dated:**

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**Abstract:** Bridging the communication gap between doctors and patients while not compromising the quality information contained in textual format represents a challenge in the present day healthcare environment. When facing the challenge of constructing personalised reports from data gathered through monitoring of follow up cancer patients, the ideal text result have to take into consideration the professional requirements of the healthcare staff but also the stress perceived by patients reading the reports. Natural Language Generation systems can help process data and construct different personalised text reports aimed at the patient and professionals respectively. CARE eHealth is an NLG tool that provides colorectal and prostate cancer patients with personalised reports based on weekly evaluation forms. At its core the application helps develop text that is reassuring for the patients and avoid causing unwanted stress by avoiding complex medical terminology. The tool provides healthcare professionals with reports that highlight observed changes in patient symptoms from week to week basis but also tracks the evolution of the patient's symptoms. This paper presents the evaluation of the CARE eHealth tool based on user testing and discusses the results, making a case for why NLG systems could provide significant advantages in healthcare communication.

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# **Chapter 1 Introduction**

Colorectal cancer is one of the most common types of cancers, affecting more than 40.000 people in the UK every year (NHS 2016). A total of 134.490 cases of colorectal cancer are estimated for 2016 by the USA National Cancer Institute (2016). Projected numbers are even higher for prostate cancer, which is the third leading type of cancer with 180.890 new cases estimated for the year 2016. It is, therefore, critical that patients who have undergone cancer treatment in the past continue to monitor their health at regular intervals, in order to detect signs or patterns that could potentially indicate tumor recurrences or new primaries. However, the delivery of adequate follow-up programmes and arrangement of frequent visits and specialist appointments can prove to be a very difficult task, as a large number of patients live in remote or rural areas, far away from hospitals and medical facilities. Moreover, the number of patients who require follow-up support is constantly increasing and healthcare providers find it difficult to sustain the exceptional level of care provision.

This paper reports the development, testing and an initial evaluation of CARE (Cancer Aftercare Reporting Engine), an accessible eHealth application designed to assist patients and promote their active engagement in aftercare programmes through the weekly completion of digital self-assessments. The CARE tool aims to help people with a history of abdominal or pelvic cancers and their assigned health professionals, by monitoring weekly and overall patient progress, enabling remote communication between the two involved parties and providing automatically generated summary reports, which are adapted to the level of medical expertise of the reader. Such a system will bring numerous benefits over traditional procedures which are currently employed during follow-up programmes. CARE will allow for remote screening, early diagnosis and treatment of cancer remissions that occur between hospital visits. Simultaneously, it will be reducing a considerable amount of time spent on travelling and lowering expenses both for the patient and the healthcare provider. It is hoped that using this application as an enhancement to the current aftercare services will facilitate the detection of both recurrences and apparition of new primaries at a much earlier stage, when symptoms are not very advanced yet and treatment is still possible.

Chapter 1 of this report summarises the need, importance and motivation for using Natural Language Generation techniques in healthcare and outlines the primary and secondary objectives of this project. Chapter 2 will present the background on different cancers of the abdominal area, modern follow-up services and the role of eHealth applications and intelligent assistance in self-directed aftercare. Furthermore, this section of the report will describe and analyse related work in this field of Natural Language Processing. Chapter 3 discusses the project methodology, risk assessment and the different technologies used in the development of the system. Chapter 4 presents the user research and knowledge acquisition techniques used throughout the project and

the results obtained on account of these. The functional and non-functional requirements of the system are specified in Chapter 5 and the system design and implementation is described in Chapter 6. System testing is discussed in Chapter 7, while Chapter 8 shows the results of user testing. Chapter 9 reports on the findings of an initial human judgment based evaluation, highlighting the experiment design, evaluation process and the obtained results. These results are further discussed in Chapter 10 where other possible future work which would benefit this area of study is also presented, along with a summary and conclusion of this project.

## 1.1 Motivation

Natural Language Generation applications are used to automatically produce texts, reports and summaries in a given target language. Employing such systems in a medical domain is a challenging but rewarding task, as it brings several benefits to the multitude of parties involved in the overall structure of healthcare consumers and providers. This is an interesting research area as Natural Language Generation systems can be utilized in a diversity of contexts and settings with numerous reader populations benefiting from their textual outputs. In medical environments, such systems would be extremely useful as the constant flow of patient data and information overload are two universally known issues which inhibit data interpretation and decision making processes made by human experts. The need and demand for medical attention in the follow-up phase of the cancer continuum is increasing persistently and medical professionals need to filter through large volumes of data in order to detect meaningful patterns and make decisions on whether a patient's condition appears sufficiently aggravated to indicate signs of recurrence. Through the use of Natural Language Generation techniques and automatic production of summaries that detect these patterns and trends in patient development, the amount of information to be processed and the workload attributed to health specialists can be considerably reduced. This kind of intelligent technology has been previously used in home care for patients who suffered from conditions like diabetes, chronic heart failure, or asthma (Chumbler et al. 2005, Louis et al. 2003, Rasmussen et al. 2005), as well as cancer (Maguire et al. 2005). Reductions in the number of hospitalisations and associated costs have been reported (Louis et al. 2003), proving that digital interventions are effective and deliver excellent outcomes, improving the overall patient development (Kearney et al. 2008). The most apparent beneficiaries of a Natural Language Generation system in medicine include patients, healthcare professionals, nurses and administrators. However, an application such as the CARE eHealth software could also benefit people who do not suffer from any condition or have a precedent case of colorectal or prostate cancer. The application could potentially be used by any individual who would like to monitor their weekly health development, as, after all, anybody might be at risk of developing a cancerous tumor in the future, even without a previous history on their medical record. Moreover, computer generated reports in the medical environment have been shown to accomplish the information and emotional requirements of doctors and patients and be successful

additions to the traditional follow-up care services offered to cancer survivors, thus motivating this research in Natural Language Generation techniques for healthcare.

## **1.2 Project Objectives**

The main research interest in this project is focused on the applications of Natural Language Generation in the medical domain, with an emphasis on machine generated medical summary reports based on self-reported data by patients who have previously undergone surgery treatment for colorectal and prostate cancers. The project addresses a subtask of the greater challenge of offering intelligent support to medical staff and patients alike. The main project objectives are to develop, test and perform an initial evaluation of a smart prototype system that allows registered patients to submit weekly self-assessments and generates reports adapted to the level of medical knowledge, understanding and expertise of the reader. The goal of the CARE research project is, therefore, to enable patients to communicate with their health professionals and stand as a solution to the delivery of follow-up care through the automatic generation of reports, in remote and rural settings where healthcare providers and services are not easily accessible.

# **Chapter 2. Background and Related Work**

## **2.1 Modern Follow-up Care and Support Practices**

People who have suffered from colorectal and prostate cancer in the past are at high risk of tumor recurrences. It is very important that they detect signs of remission early and take part in follow-up programmes. Cancer survivors often experience a range of consequences after undergoing treatment and these include physical symptoms, psychological symptoms and social consequences (Jefford et al. 2008). However, issues encountered are different for each individual and they depend on a number of factors, such as the type of cancer, the administered treatment, the age of the subject, personality characteristics and the patient's social circumstances. Survivors might experience chronic pain, tiredness, sexual dysfunctions and ongoing psychological problems like depression and fear of recurrence (Howell et al. 2012). For this reason, different patients require different levels of aftercare, tailored to their own situation. For some cancer survivors, information about future risk of recurrence can lead to increased levels of depression and lack of control, while others might be highly interested in monitoring their health development in order to take preventive measures in a timely manner if a negative change is detected. At present, patients who are at low risk of remission are encouraged to take part in nurse supported self-management, while those at higher risk are offered more complex follow-up care services from medical specialists. Currently, aftercare lasts between 3 and 5 years and patient needs, both condition related and psychological wellbeing related, are addressed at

regular appointments. However, there is great inconsistency in the availability and quality of aftercare offered to colorectal and prostate cancer survivors.

## **2.2 Self-Directed Aftercare and eHealth Applications**

The number of patients who require aftercare services is constantly increasing and it is becoming more and more difficult for healthcare services providers to offer the same level of support to all cancer survivors. More recently, models for aftercare based on patient initiative and tailored to individual needs have proved to be equally helpful and effective (Brown et al. 2002). In order to promote such models, cancer survivors need to be provided with supporting tools and training to self-manage their conditions. It is important that patients are actively engaged in their follow-up phase of the cancer continuum and a large number of eHealth tools and applications have been developed to help and empower patients with a history of cancer do this. A recent study has shown that patients are interested in eHealth applications that remove the barriers they are currently experiencing in follow-up care (Duman-Lubberding et al. 2015) An example for recent work is constituted by DERMA/care (Karargyris et al. 2012), a mobile application used to monitor and detect skin cancer (melanomas). This proved to be highly effective as it can be used both by medical staff or any individual who owns a mobile device. Nowadays, more and more people are owning digital technologies and using electronic devices to search for health related information or communicate with medical specialists. A recent study has reported that 49% of households in the UK own at least a computer and mobile device (Webb et al. 2010). Hence, a shift towards patient empowerment and provision of supportive eHealth tools may soon become a fundamental element of cancer aftercare services.

## **2.3 Natural Language Generation in Healthcare**

A substantial body of evidence exists in literature which shows that Natural Language Generation techniques can be used to help people in decision making, especially in environments such as medicine where there is constant inflow of information from patients. Natural Language Generation systems are software applications which automatically produce texts, reports or summaries in English and other human languages. (Reiter and Dale 2000, Reiter et al. 2003)

In medicine, research has focused on building summary reports from textual resources (Afantenosa et al. 2005) and generating patient reports for doctors or patients themselves (Reiter et al. 2003). Previous work that implements Natural Language Generation techniques in healthcare applications includes TraumaGen (Webber et al. 1998) that builds summaries and provides recommendations based on a medical expert system and MAGIC (McKeown et al. 1997, McKeown et al. 2000) which creates simple summaries containing the information of

patient records in order to aid the planning of care services after surgery. The latter system is comparable with the CARE eHealth tool developed for this project, both in terms of length of generated texts and type of input data. Another system that uses Natural Language Generation techniques is the BabyTalk project (Gatt et al. 2009, Portet et al. 2009) which creates different summary reports for nurses and parents of babies in Neonatal Intensive Care Units. Although similar to CARE, the main difference between these two systems is that the tool presented in this report describes the health status of patients at weekly intervals when a self-assessment is submitted and does not use or interpret sensor data. A different example of Natural Language Generation system in a healthcare domain is SemScribe (Varges et al., 2012), which generates letters presenting cardiological findings, by reading XML documents and using generated text to enhance them. The system uses a medical ontology and is inspired by SURGEN (Huske-Kraus 2003a, 2003b) and related to (Cawsey et al. 2000). The latter describes a system that tailors generated reports which explain diseases and treatment options to potential patients. Attempts have also been made to use Natural Language Generation in order to promote healthier lifestyles as well. (Reiter et al. 2001, Reiter et al. 2003) created a system which generated personalized letters, trying to persuade users to stop smoking.

There is a broad variety of systems which makes use of Natural Language Generation techniques in medicine, some of which present similar results as the ones described in this paper. It is hoped that the CARE eHealth application will provide useful contributions to this range of solutions and research area.

## Chapter 3. Analysis

The project methodology, development tools and technologies and project risk assessment are defined in this following chapter.

### 3.1 Methodology

An agile software development methodology was followed for this project, in order to develop the web application and report generation software. The activities are outlined below:

- Developing the plan for the project and understanding the research problem.
- Reviewing literature about related current research and existing systems.
- Comprehending related work (similar medical applications, natural language processing and generation, usability and accessibility of user interfaces etc.)
- Learning about relevant uses of new technologies, programming languages and tools.

- Conducting user research through surveys and interviews with academics with a professional medical background (as soon as ethical approval is received) and volunteer pretend patients.
- Creating the requirements specification document.
- Designing the system architecture and database.
- Implementing prototypes for each stage of the development process.
- Developing the system and implementing the functionalities to meet the requirements specification.
- Designing a responsive and accessible user interface.
- Evaluating, testing and debugging the system and the final deliverables of the project.
- Writing the documentation, report, user manual and maintenance manual.
- Adding extra features: additional functionalities, user interface enhancement etc.

### **3.2 Technologies and Development Tools**

The purpose of the CARE eHealth application prototype is to demonstrate the effectiveness of adopting Natural Language Generation techniques in a healthcare domain, as well as the feasibility of constructing a system that generates adaptive reports based on self-assessment input data received from patients. The system should be easily accessible from a wide range of devices, operating systems and browser and, therefore, it was decided to implement CARE as web application using the JRuby development language on the Rails web framework.

JRuby is an implementation of the Ruby programming language, written largely in Java upon the JVM. It has built-in support for Rails, RSpec, Rake and RubyGems and is very similar to Ruby. The primary difference between the two consists in the fact that JRuby can be called directly from Java programs and it can invoke classes of Java Platform.

Rails is popular framework developed in Ruby which can be used for building dynamic web applications. An alternative option was represented by implementing the application using PHP and the Code Igniter web framework which, similar to Rails, is based on a model-view-controller architectural pattern. Code Igniter is a cross-platform framework, renowned for its speed when it is compared with other PHP frameworks. Although these tools offered the same powerful and rapid development solutions, it was decided against using them, in favour of JRuby and Rails. The key reason for this decision was the availability of a JRuby gem that uses and includes version 4.4 of SimpleNLG. Although, the gem represents a partial implementation, it was providing sufficient functionality to convert input into actual text through the use of grammar rules. This was required during the surface realization phase of the natural language generation pipeline.

### 3.3 Risk Assessment

A risk assessment was carried out at the beginning of the project and it is outlined below. During the development of the project several time delays have occurred as initially predicted. These were caused by the lack of availability of third parties and illness. The project was also delayed by approximately three weeks as implementation and work on documentation was not possible due to a fractured arm accident.

**Table 1: Risk Assessment**

Risk	Mitigation	Level
<b>Time delays caused by workload/illness/unavailability of third parties to take part in knowledge acquisition and user research (e.g. medical staff) etc.</b>	<ul style="list-style-type: none"><li>• Following the project plan and working to schedule</li><li>• Dividing the project into several achievable milestones which can be worked towards incrementally using an agile development methodology</li><li>• Testing throughout the entire project to catch mistakes early and avoid extra workload</li></ul>	High
<b>Technology breakdown and security of assets caused by</b> Damage/Loss of physical and electronic copies of work and project information due to computer system failures, theft or unauthorized access to information	<ul style="list-style-type: none"><li>• Physically securing PCs, laptops and project information</li><li>• Allowing only authorized users to access data about the project</li><li>• Performing regular backups of the different versions and phases of the system</li><li>• Storing the information on multiple secure devices and locations</li></ul>	Low

## Chapter 4. User Research and Knowledge Acquisition

The knowledge acquisition and validation techniques used in this project are described in the following section, together with the description on two focus groups.

### 4.1 Knowledge Acquisition

Similarly to other artificial intelligence systems or expert systems, Natural Language Generation Applications require a substantial volume of knowledge. Kittredge, Korelsky, and Rambow, 1991 characterize three distinct types of knowledge that are needed by a successful Natural Language Generation system:

1. **Domain knowledge**, which is comparable to the knowledge required by domain expert systems.
2. **Communication knowledge** which is comparable to the knowledge required by natural language processing systems.
3. **Domain Communication knowledge** which refers to the ways information in the given domain is generally communicated in written or verbal form.

In the context of the current research, the natural language generation components of the CARE e-health application will be significantly influenced by medical knowledge and specific terminology used in healthcare. The most important knowledge that was required for this project was:

1. What content should be selected for generation of patient reports where the intended recipient is the patient?
2. What content should be selected for generation of medical reports where the intended recipient is the health professional?
3. What changes in the patient's various health parameters are relevant and how is this information classified in terms of levels of importance (i.e. what are the underpinning medical concepts and notions required for data interpretation)?
4. How should the information be presented to the health professionals?
5. How should the information be presented to patients?

Reiter et al. (2003) discusses that it is challenging to acquire correct knowledge due to the difficulty and novelty of some attempted tasks. The problem is also worsened because human authors have very different writing styles. This was indeed one of the issues encountered during the development of this project, as building a sizable text corpora with examples of texts written in a consistent fashion proved to be extremely troublesome. Another problem described is that structured expert oriented KA approaches are also affected, since domain experts often disagree and not enough information is collected from the interviews. Reiter et al. (2003) suggests that a combination of knowledge acquisition techniques is used, as they all have their own strengths and weaknesses. Analogous to Reiter et al. (2003) the CARE eHealth system is attempting a writing task that is complex, requiring large volumes of information and it is considered novel as human experts do not currently write medical and patient summary reports of patient self-assessments.

Knowledge acquisition for the CARE system was gathered using a variety of techniques ranging from directly asking experts, to structured interviews with experts and manual corpus analysis. Overall the domain, communication and domain communication knowledge necessary to build summary reports was acquired from two academics with a professional background in medicine. The experts were knowledgeable about colorectal and prostate cancer and the modern aftercare service offered to patients.

In the initial stages of the project knowledge was acquired by directly asking the experts on how data interpretation should be performed and what the information should be structured like in the output report. Later in the development process, a structured expert oriented interview was organised with one of the medical experts to revise the knowledge acquired until that stage and to discuss issues that have surfaced from the two focus groups described in more detail in the following section. A non-expert revision of the system was performed after the implementation of the CARE application prototype in order to receive feedback on the ease of use of the system and revision of generated texts in order to improve their fluency and naturalness. The results of this revision are presented in a later Chapter 8.

## 4.2 User Research

In addition to the knowledge requirements described in the previous section of this report, further knowledge about potential patients and their expectations regarding the system is necessary for the virtual healthcare application to meet its objectives. While it is possible to acquire such knowledge by interviewing health specialists or professionals with a medical background on what they consider to be useful or appropriate features for their patients, a more effective solution is to directly collaborate with non-expert end users to identify their needs. Previous work (Moncur et al. 2009) showed that this kind of approach is helpful at discovering otherwise unanticipated information and improving user satisfaction. This is mainly due to the fact that potential patients do not have the same medical proficiency or understanding of medical terminology as domain experts in this field. Very often it is possible that patients will misinterpret medical information when it is not revised and adjusted in advance to their degree of expertise. (Alpay, Toussaint et al. 2004). Another important distinction between non-experts and specialists is the level of emotional impact that a virtual healthcare system like CARE could make them experience. As a consequence of this, machine produced output must be reassuring, sensitive and carefully constructed, since patients should not be caused any additional or unnecessary distress by poorly delivered information.

Based on the above considerations two focus groups were organised with the purpose of learning more about non-expert user requirements and to establish the following:

1. Would patients find the eHealth application useful when participating in colorectal or prostate cancer aftercare programmes and would they consider it to be a more convenient self-assessment alternative to the currently existing paper formats?
2. Would patients find the adaptive machine generated summary reports useful?
3. What kind of generated textual output (in terms of content and style) would patients expect to receive after submitting a digital self-assessment?
4. What represents appropriate vocabulary to be used in the generated summary reports they will have access to and the patient's view of the system?

5. What features of the application would patients like or dislike the most?
6. Would patients find a stool diary feature useful and would they use it on a regular basis?
7. What other additional features would patients like to see included?
8. What would make the entire process more comfortable for the patients?
9. Would patients like to be able to attach stool images to their self-assessment submissions?
10. What kind of device are patients most likely to use for accessing the application?

Full ethical approval for the user research was sought from the University Of Aberdeen College Of Physical Sciences and granted on 24 February 2016. A total of 8 non-expert participants with native or fluent English language skills were recruited for the two focus groups. The subjects were all final year students enrolled in higher education or recent graduates with no professional medical background, but with an interest in healthcare and medicine. Participants were presented the motivation and context of the project and shown an early proof of concept of the CARE application, after which a discussion took place around the topics listed above. The volunteers agreed that the application and automatic generation of reports would prove to be very helpful to both patients and medical staff. They liked the notion that potential patients could self-manage their own symptoms and progress and emphasized the importance of the numerous benefits introduced by the application, including the reduced costs and travel times for follow-up visits. They also liked the idea that health professionals would be monitoring their progress on a weekly basis, as this would make them feel more relaxed and supported.

Before the end of the sessions, participants were asked to write examples of summary reports that they would like the system to generate based on predefined input data. For this exercise, a sample patient model was built around a fictional 40 year old male with a medical history of colorectal cancer and no colostomy. Two self-assessments were simulated for this model, each corresponding to one of two consecutive weeks. Focus group subjects were shown the input self-assessment data for the first week and asked to write a medical report based on this data with the intended recipient or reader being a health professional or doctor. Afterwards, participants were provided with the data from the second week and asked to repeat the previous task, whilst taking into consideration the changes which were introduced over the seven days period. Finally, they were all asked to write an example summary based on the input data from both weeks with the intended recipient or reader being the fictional patient model created at the beginning of the exercise. A set of 8 example medical reports for the first week and 8 example medical reports for the second week was collected and used to form an initial corpus of summaries addressed to health specialists. A second corpus constituting of summaries addressed to healthcare consumers was built using the 8 example patient reports which reflected the changes occurring since the first week and the data inputted during the second week. Corpora had to be constructed artificially because humans do not routinely write patient summary reports and there were no preexisting specimens available to analyse. The limited size of the corpora was principally due to the time constraints imposed by the project and the substantial amount of time needed to create a

single sample, but also influenced by the fact that the belonging texts were intended for manual corpus study, rather than automatic analysis performed using methods like machine learning.

## Chapter 5. Requirements Specification

The system functional and non-functional requirements are presented in the following section.

### 5.1 Functional Requirements

The functional requirements were formulated based on the collaboration with medical experts and the outcomes of the two focus groups. In this section the following actors are referred to:

**A: Administrator.** Any member of staff who is granted administrator privileges.

**HP: Health Professional.** Any member of staff in a Medical Centre.

**P: Patient.** Any individual with a history of colorectal or prostate cancer.

**S: System.** The CARE eHealth application itself.

**Table 2: Functional Requirements**

No	Actor	Description	Priority
1.0	Sys	Will be maintaining a constant pool of all health professional and patient user records with their access and authorization levels.	High
1.1	Sys	Will be authorizing access if correct credentials are entered on login.	High
1.2	Sys	Will be loading profile details and display the content to the user.	High
1.3	Sys	Will be automatically generating patient adapted summary reports.	High

1.4	Sys	Will be automatically generating medical adapted summary reports.	High
1.5	Sys	Will be loading and displaying the correct generated summary to the patient users and to the health professional.	High
1.6	Sys	Will be loading the form details and display the content to the user.	High
1.7	Sys	Will be comparing submitted form information with information from previous submissions.	High
1.8	Sys	Will be highlighting any important changes in the health status evolution of the patient users to them and to their assigned health professionals.	High
1.9	Sys	Will be adapting the self-assessment form based on the type of cancer, gender, other present conditions, and previous responses.	High
2.0	A	Will be able to enter email address and password to login into the system.	High
2.1	A	Will be able to view their own profile.	Low
2.1.1	A	Will be able to edit their own details in their profile.	Low
2.2.1	A	Will be able to view a list of all the patient records in the system.	Medium
2.2.2	A	Will be able to view a list of all the health professional records in the system.	High
2.3.1	A	Will be able to select a specific record in the system to view its details.	Medium
2.3.2	A	Will be able to apply changes to the details of a specific record in the system.	Low
2.4	A	Will be able to allow system administration access to other users.	Low
2.5.1	A	Will be able to create a new patient record.	High
2.5.2	A	Will be able to create a new health professional record.	High

2.5.3	A	Will be able to delete a specific record from the system.	Low
3.0	HP	Will be able to enter email address and password to login into the system.	High
3.1	HP	Will be able to view their own profile and edit their own personal details.	Low
3.2	HP	Will be able to view a list of all their associated patient records.	Medium
3.3.1	HP	Will be able to view the form submissions of their associated patients.	High
3.3.2	HP	Will be able to view the medical generated reports that show the health status evolution of their associated patients.	High
4.0	P	Will be able to enter email address and password to login into the system.	High
4.1	P	Will be able to view their own profile and edit their lifestyle and contact details: address, email, phone number.	Low
4.2	P	Will be able to start a new form submission.	High
4.3.1	P	Will be able to review their form after submission and make any necessary edits.	Low
4.3.2	P	Will be able to read a patient adapted summary that shows their health status evolution after submission.	High
4.4.1	P	Will be able to indicate their current level of functioning on the ECOG Performance Status Scale.	High
4.4.2	P	Will be able to indicate how often have they felt nervous, anxious, or on edge during the past week on a scale from 1 (not at all) to 5 (nearly every day).	High
4.4.3	P	Will be able to indicate how often have they have not been able to stop or control worrying during the past week on a scale from 1 (not at all) to 5 (nearly every day).	High
4.4.4	P	Will be able to indicate how often have they have had little interest or pleasure in doing anything during the past week on a scale from 1 (not at all) to 5 (nearly every day).	High

4.4.5	P	Will be able to indicate how often they have felt down, depressed or helpless during the past week on a scale from 1 (not at all) to 5 (nearly every day).	High
4.4.6	P	Will be able to indicate how well they have been managing their physical symptoms (pain, fatigue, nausea) during the past week on a scale from 1 (having major difficulties in this area) to 10 (managing very well).	High
4.4.7	P	Will be able to indicate how well they have been managing their relationships and support (e.g. family, friends) during the past week on a scale from 1 (having major difficulties in this area) to 10 (managing very well).	High
4.4.8	P	Will be able to indicate how well they have been managing their activities and interests (e.g. work, home and leisure) during the past week on a scale from 1 (having major difficulties in this area) to 10 (managing very well).	High
4.4.9	P	Will be able to indicate their overall sense of wellbeing during the past week on a scale from 1 (having major difficulties in this area) to 10 (managing very well).	High
4.5.1	P	Will be able to enter their current weight in kilograms.	High
4.5.2	P	Will be able to indicate whether they have received the results from their last medical scan.	High
4.5.3	P	Will be able to indicate whether they have been prescribed any medication since their last check.	High
4.5.4	P	Will be able to indicate what medication they have been prescribed.	High
4.5.5	P	Will be able to indicate the disease for which they were prescribed this medication.	High
4.5.6	P	Will be able to indicate whether they are still following treatment with this medication.	High
4.6.1	P	Will be able to indicate whether they are suffering from any abdominal pain.	High
4.6.2	P	Will be able to indicate whether they are suffering from High	High

		abdominal bloating.
4.6.3	P	Will be able to indicate whether they are suffering from High diarrhea.
4.6.4	P	Will be able to indicate whether they are suffering from High constipation.
4.6.5	P	Will be able to indicate whether they are suffering from rectal High bleeding.
4.6.6	P	Will be able to indicate whether they are suffering from blood in High the urine.
4.6.7	P	Will be able to indicate whether they are suffering from frequent High urination.
4.6.8	P	Will be able to indicate whether they are suffering from High incontinence.
4.6.9	P	Will be able to indicate whether they are suffering from any High difficulties in initiating urination.
4.7.1	P	Will be able to indicate whether they are feeling any pain whilst High passing urine.
4.7.2	P	Will be able to indicate whether they are suffering from bladder High spasms.
4.7.3	P	Will be able to indicate whether they are suffering from High heartburn or indigestion.
4.7.4	P	Will be able to indicate whether they are feeling sick. High
4.7.5	P	Will be able to indicate whether they have been vomiting. High
4.7.6	P	Will be able to indicate whether they have been suffering from High tiredness and fatigue or feeling weak.
4.7.7	P	Will be able to indicate whether they have been suffering from High hot flushes.
4.7.8	P	Will be able to indicate whether they have been suffering from High loss of appetite.
4.7.9	P	Will be able to indicate whether they are suffering from any High

		sexual problems.
4.8.1	P	Will be able to indicate whether they are suffering from High jaundice.
4.8.2	P	Will be able to enter information about the selected symptoms High or any other symptoms that have not been listed in the form.
5.1.1	P	Will be able to indicate their stool frequency on an average day High in the past week.
5.1.2	P	Will be able to indicate their stool consistency on an average day High in the past week.
5.2.1	P	Will be able to indicate whether their stoma function is High satisfactory or unsatisfactory if the patient has a stoma.
5.2.2	P	Will be able to indicate whether there have been any stoma complications over the past weeks if patient has stoma.
5.2.3	P	Will be able to indicate how the complication has been dealt with.
5.3	P	Will be able to enter any other information they would like to send to their health professional.
5.4	P	Will be able to request to be contacted by a health professional by phone or email.
6.1	P	Will be able to view a history of their previous form submissions.
6.2	P	Will be able to view a history of the previous adapted summaries provided by the system.

## 5.2 Non-Functional Requirements

The non-functional requirements can be split into five main sections: Hardware and Software Requirements, Usability, Reliability, Performance and Supportability.

### Hardware and Software Requirements

The following hardware and software requirements must be met in order to provide excellent user experience to the health professionals and the patients:

- The CARE e-health application must be accessible across all major operating systems, internet browsers and devices, including tablets and other mobile devices.
- The CARE e-health application must not run exclusively on high-end performant computers or mobile devices and should be accessible to as many people as possible.

### **Usability**

The CARE e-health application must be easy to use and all interfaces and menus must be simple and intuitive. No action will require more than four clicks to achieve a goal. A user manual will be provided to instruct users on how to access and navigate within the application.

### **Reliability**

The CARE e-health application will be very reliable and rarely encounter any bugs. It will be tested thoroughly and it will be partially implemented using Test Driven Development to ensure that there are no major bugs that could affect the data integrity or confidentiality. Any errors detected after deployment will be patched promptly without inadvertently causing any more errors. The application must be able to rigorously validate and handle any type of input received from the user without encountering errors.

### **Performance**

The CARE e-health application will perform well on wide variety of systems and hardware. Load times must be fast even on slow internet connections, as a large proportion of users will be trying to access it from remote or rural areas.

### **Supportability**

The CARE e-health application will be frequently updated after deployment and there will need to be easy, quick ways for users to report problems. A method for contacting the support team at the medical centre must be provided to the users and be easily accessible and visible to them.

### **Availability**

The amount of time for which the application is up and running correctly should be maximised by increasing the average time to failure and reducing the average time to repair it and resume operation after a failure has been encountered.

### **Security**

The application should resist any unauthorized access attempts and continue to be available for use to the legitimate users. To login into the system users have to identify using a username and an encrypted password. The system has been configured to use Secure Sockets Layer (SSL) in

order to encrypt all information which leaves the local browser. This configuration prevents sensitive information, such as patient data, to be sent over the network, thus being immune to intercept and critical session hijacking vulnerabilities.

### **Maintainability**

The application should accommodate changes or future additions quickly without having other components failing as a result of these modifications. We plan to improve the system over time and correct any bugs to ensure a high standard.

### **Portability**

The application will be built to run on a multitude of platforms, including Windows, Linux, Apple MacOS, and even various mobile devices.

### **Learnability**

The system should have an intuitive GUI and reduce the learning process times. It should enable new users to adapt to the interface style easily through the use of tutorial bubbles. A user manual and a maintenance manual are also provided to the users.

### **Modularity**

The system should be built using interchangeable components in order to increase cohesion and reduce coupling.

### **Testability**

The system should allow thorough testing before, during and after the production stage, in order to be able to identify bugs on time and prevent the apparition of future errors.

## **Chapter 6. Design and Implementation**

This chapter discusses various elements related with the design of the system, expanding on how the main features were implemented.

### **6.1 Development Process**

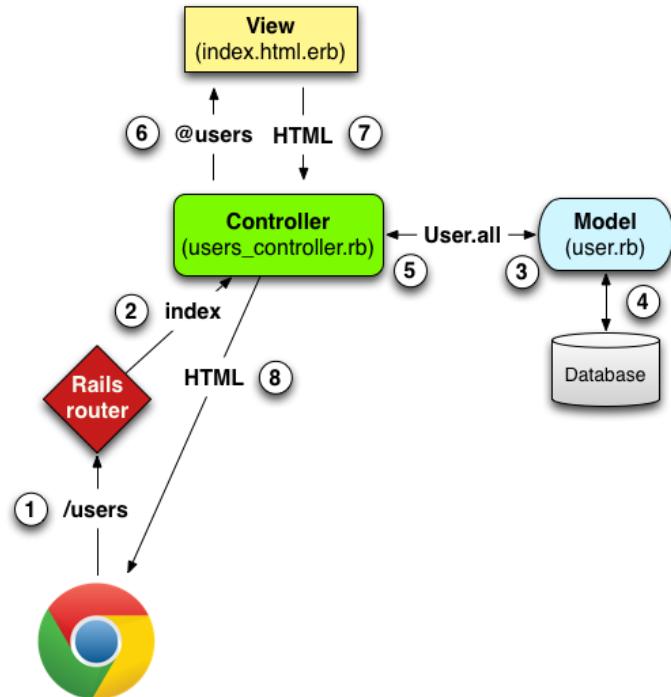
The results from the user research and knowledge acquisition stage of the project were used together with observations from the interviews throughout the entire design and development process of the CARE software. The Care eHealth application was implemented using agile development methodology techniques. The application source code was placed under version control using Git in order to allow the tracking of modifications made to the code and prevent any potential errors. The repository was pushed to Bitbucket, so that a complete system backup of the code is stored securely. The final prototype accomplishes all the specified functional and non-functional requirements listed in Chapter 5 of this report.

## 6.2 System Architecture, Design and Implementation

This following section of this report will discuss the combination two architectural patterns followed in the design and implementation of the CARE e-health software: the Model-View-Controller and the NLG architectural pipeline.

### Model View Controller

The CARE application is implemented using jRuby on Rails, an open source web development framework, and thus follows a model-view-controller (MVC) architectural pattern. The model layer includes processing, validations and associations, carrying the rules required to manipulate the application data. This component of the application implements the business logic and is in control of retrieving stored data and changing it into accessible concepts within the application. For the CARE e-health tool, the domain logic consists of data models for: health professionals, patients, sessions and self-assessments. The view layer is responsible for rendering visual presentations through the use of available information about the modeled data. This component of the architectural pattern is associated with the graphical user interface (GUI) and is represented by a series of views, HTML files that have embedded JRuby code used to display the data. The controller layer is managing the requests received from the users and renders a response through its interaction with the model and view layers. This component is responsible for delegating resources, verifying validity, allocating data fetching and processing to the model layer, as well as selecting the correct presentational information which is allocated to the view layer. In the example shown in Figure 2 user attempts to interact with the application and the browser sends a request to the web server which passes it to the controller via the defined routes. The action in the controller request the User model to fetch all user records from the database. Afterwards, the User model returns a list of all the user records in the database to the controller, which captures the information in a variable and communicates it to the index view. Finally, the view renders the HTML page, which is passed back to the browser by the controller.



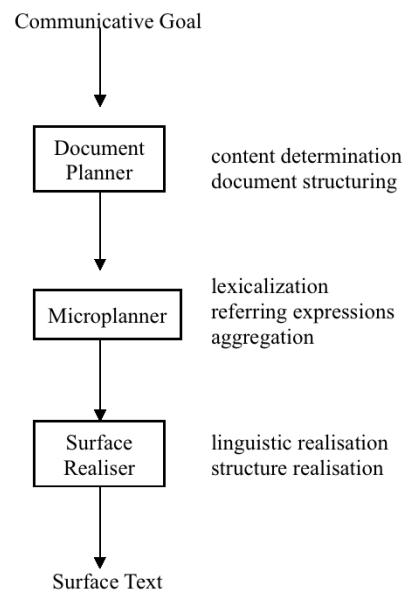
### Natural Language Generation Architectural Pipeline

The natural language generation architectural pipeline employed for the CARE system is based on that described by Reiter (1994), Reiter and Dale (2000), and Reiter (2007). and has three stages: data analysis and interpretation, document planning and microplanning and surface realization.

The first stage in the generation pipeline is represented by data collection. In the CARE e-health application data is manually inputted by patients at weekly intervals when they are performing their digital self-assessments. The type of data received by the system can be classified into three categories:

1. Numeric data, which includes information such as the patient's current weight or ratings provided by the user on the scale-type input fields of the self-assessment form.
2. Symbolic data which is used to store information about events that occurred during the week such as the apparition of new symptoms or stoma complications, as well as information related to patient's average stool frequency or stool consistency.
3. Free text data which can be entered by the patient to support the selected choices on a range of questions. Patients can include observation and justification notes to explain their symptoms further, to describe newly detected problems and inform about new medicine prescribed to them by their general practitioner.

The document planning uses a fixed structure and performs the sub-task of choosing the data and content which must be included in the generated report. The document planner focuses on identifying patterns that suggest either a high risk of cancer remission, good overall progress of the patient's health status or a change in the weekly trends for the various dimensions and parameters measured in patient self-assessments. Content selection processing is based on chained rules that control which information is included in the final output summary. This is primarily determined by the degree of importance attributed to each specific sub-section of the report. For example, the apparition of a new symptom is considered to be an event of high importance that will instantly trigger the threshold. Therefore, this type of event will always become part of the final output. Similarly, the content selector will acknowledge improvements, neutral trends and aggravations in all aspects reported by the patient and associate them with corresponding categories that have been established around the different degrees of variance



**Figure 2:** A typical NLG system architecture. From Reiter and Dale p.60.

from one submission to another. However, other different sections are initialized with lower importance values and they will only be acknowledged if another certain event takes place before or a connected parameter becomes associated with a particular encoded value. One such example is the patient's last scan, as the threshold for this sub-section is only triggered if the patient consecutively answers "No" to the "Have you received the results of your last scan?" question in the self-assessment for more than four weeks. Because the data in the project corpus was sparse, a number of content selection rules had to be inferred to cover for cases which were not mentioned in the human-written examples or in the outcomes of the interviews. Each main event or action selected to be included in the final output could also have other events explicitly connected to them. These events are dependent and would be incorporated in the text together with the main event. After the content has been selected, it is then serialized into the correct fixed sequence. The medical report will always begin with a short description of the patient's overall sense of wellbeing. This is followed by events classified as being of high importance: new symptoms, ongoing symptoms and any free text notes that the users have left regarding their symptoms. This is followed by any newly prescribed or current medication taken by the patient. However, these two sub-sections are only stated if their corresponding events have been triggered. Next, information about patient's weight and bowel information is presented and compared with values from previous submissions. These units are automatically selected during the document planning phase for inclusion in the final output, no matter what values are attributed to them. The summary is followed by a comparison of the different aspects of the patient's general wellbeing, such as ECOG performance or anxiety and depression levels. The last section of the summary is conditional and it concerns information about the patient's last scan, contact preference or other free text entered notes. Finally, the document planner also manages the content organization through the use of linking words and discourse markers (such as "then", "again" or "however") that have the role of reporting the information in a manner that is as fluent and as natural as possible.

The microplanning is responsible for mapping the events selected during the document planning phase to semantic representations. The lexicalization process is rule based and endeavors to construct output in forms of sentences and phrases that resemble the language and terminology used in the project corpora. The principal task performed is that of matching events against templets and building relations between clauses. A second important sub-task of the lexicalization process is choosing the most suitable words to express changes in a patient's wellbeing and health status. For example an average stool frequency that is lower than two stools per day or between three and four stools per day would be lexicalized as "normal". Reiter and Sripana (2002) argue that choosing lexemes to efficiently communicate information can be a difficult challenge as different people usually disagree on exact definitions of words, thus increasing the risk that the reader would not interpret them as intended by the e-healthcare system. This represents a major problem in the medical field, as misinterpreted information can lead to severe complications or preventable stress. Jucks and Bromme (2007) have analysed communication between doctors and their patients and showed that patients use technical words

to refer to different meanings than doctors do on a regular basis. An example is the word “migraine” which patients use to label any type of headache. This is different from the medical term which should be used to describe a specific kind of recurring headache that is caused by a range of biological mechanisms. In order to avoid such issues, the words used in phrases generated by the system are carefully selected, although it is expected that over time a richer vocabulary can be used, as soon as users become accustomed to the system. Hard constraints were created for the microplanner as a result of analyzing the example texts from the project corpus. This has the purpose of maintaining the generated output within its writing style and genre. For instance, most of the examples in the project corpus contained the verbs “improve” and “recover”, but none of them used the verb “ameliorate”. While, initially the system used any of these verbs to express a positive development of the patient’s condition, after performing user testing it was revealed that the verb “ameliorate” is not very commonly used by native English speakers, although it is frequently encountered in other languages that originate from Latin roots, such as French, Spanish or Romanian. Therefore, a hard constraint was created so that the verb is not included in sentences generated by the system and only words with higher frequencies are used. However, frequencies are not necessarily accurate indicators as they may simply show the writing style of an individual author if contributions are not equally distributed. In the context of this project, each corpus author contributed in equal amounts to its construction so it is an appropriate approach. The handling of named entities differs from that described in Portet et al. (2009), as technical abbreviations in the medical generated output are introduced directly in the text from the initial occurrence without being complemented by their definition or descriptive phrase. McKinley (2010) observed this difference between human generated texts and system generated texts and argues that the latter might cause irritation to the reader (in this case the health professional) as it would be including redundant details and be interpreted as patronizing. The surface realization phase is responsible for generating the actual text output using the rules and decisions made in earlier phases. In this stage, the realizer ensures that the text is grammatically correct in the target language. The CARE e-health application uses a jRuby gem partial implementation of the SimpleNLG package to carry out realization. The SimpleNLG engine is described in Gatt and Reiter (2009).

## **Overall Report Generation**

In addition to the weekly generated summaries, a secondary report showing all time progress is generated for each patient. This follows a fixed structure reporting on the patient’s cancer history, overall progress and wellbeing. The resulting text is accompanied by a set of graphical data visualization. Law && et al 11 has showed that health professionals are more prone to make the right decision regarding treatment when presented with a human-summary of data than when they are provided with graphs and other visual presentations, as the latter place the burden of pattern discovery and interpretation of the viewer. Nonetheless, medical specialists expressed a confident preference for the graphical modality and the discrepancies between their true performance and their preference reflects the research outcomes of Elting et al. (1991).

However, in the context of the CARE eHealth application, it was decided to include these visualization techniques as an enhancement to the textual output.

### **Affective Techniques**

In the case of the patient generated texts, the system adapts the information to the reader by also considering their emotional state and stress levels. This approach is motivated by the fact that patients who have had a history of colorectal or prostate cancers are coping with high levels of stress and the information presented to them could have a significant impact on their emotions if it is vague or concerning. In natural language generation, suitable affective tone must be used in order to positively stimulate the mood of the readers. The challenge faced by the CARE eHealth system is to present information in an appropriate style and structure to non-expert users. This idea has been discussed in previous research work 80 and 91 and Williams 127. Inspired by Gatt et al. (2009), and Mahamood Reiter (2011) the current application uses empathy and affective information types in the final outputs:

1. Explanatory justifications which aim to provide further details and explanations for patients on why they are experiencing some symptoms in order to prevent them from feeling worried or anxious. For example if the patient is experiencing constipation and his average stool consistency is Type 1 or Type 2 on the Bristol Stool chart, then system will tell the patient this change in bowel behavior is normal from time to time, especially if there is a lack of dietary fibre.
2. Positive trend descriptions are used to inform the patient about good progress in any of the aspects regarding his health. The system uses discretion and only reports changes that end in an improvement or positive final value. For example if the ECOG performance improves from Grade 1 to Grade 0, the system will report this as “a slight improvement” and follow by mentioning that this is “excellent performance”. Even if a negative trend occurs, but the final value is positive this is still reported without mentioning that the condition has aggravated. In the case that there is no positive trend to be reported, the facts are simply stated to the patient, without mentioning the value or type of change.
3. Reassurance statements are used when multiple negative absolute values and trends are encountered. This strategy helps the patient feel like he is understood and listened to by the system and enables him to cope with the continuous pressure felt when their condition is worsening. An example includes telling the patient that their assigned health professional will be made aware of the apparition of a new symptom.

Mahamood and Reiter (2011) have shown that affective texts are preferred over non-affective texts which are considered to contain too many technical terms. As such, a model of patient stress levels was not implemented and all generated texts intended for patients employ the affective techniques.

## **Chapter 7. System Testing**

Test driven development was used to write model validations and implement the main features of the application in order to confirm that implementation was performed correctly. This software development process involves writing an initially failing automated test case and then writing the minimum necessary amount of code that makes the test pass. Finally, the code is refactored to achieve acceptable standards.

On the creation of models and controllers in Rails, skeleton text code is automatically added to the application. Fixtures were set up to populate the separate database in the test environment. Unit tests were written in order to validate the models in the application through the use of available assertions. Functional tests were also created to test controllers for actions such as receiving a successful web request, being redirected to the correct page on log in, successfully authenticating a user or displaying correct messages in the rendered views. Integration tests were used to verify the interaction between the different controllers in the application, as this type of tests enables the simulation of a user performing action and interacting with the system inside a web browser. The most important work flows in the CARE eHealth application were tested using integration testing, including the use user login, the creation of new patient and health professional records in the database and editing an existing record. A total of 141 tests and 197 assertion have been written and tested against.

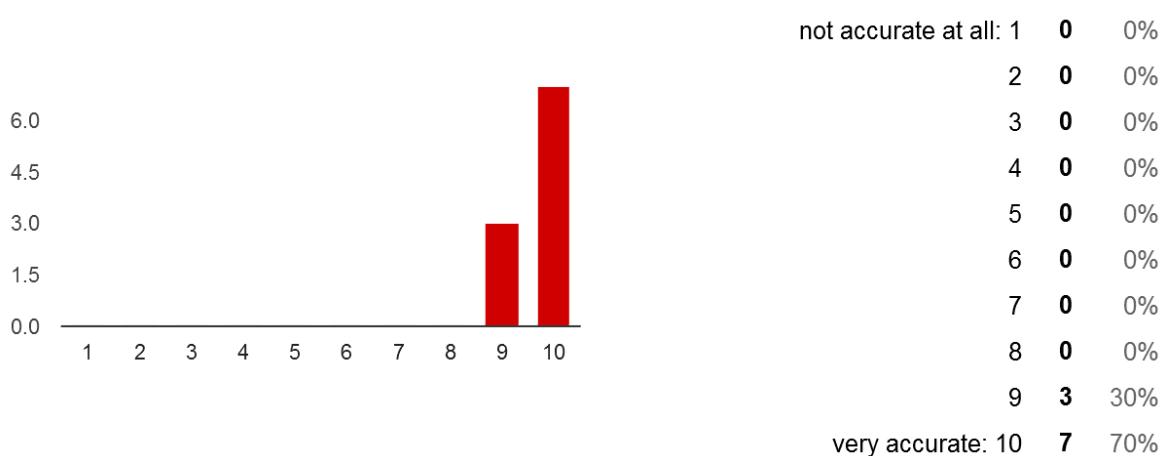
## **Chapter 8. User Testing**

Data about the CARE software was collected during an experiment in which human subjects were asked to make judgments about the general accessibility and usability of the tool, as well as the accuracy of generated reports and their linguistic fluency, naturalness and appropriateness for the intended reader. Survey results were collected during user testing from 10 participants. The questions focused on determining the perceived attributes of the CARE eHealth tool as well as rating on a scale, where higher values represent better performance, several aspects of the generate reports from the perspective of both the professional and the patient.

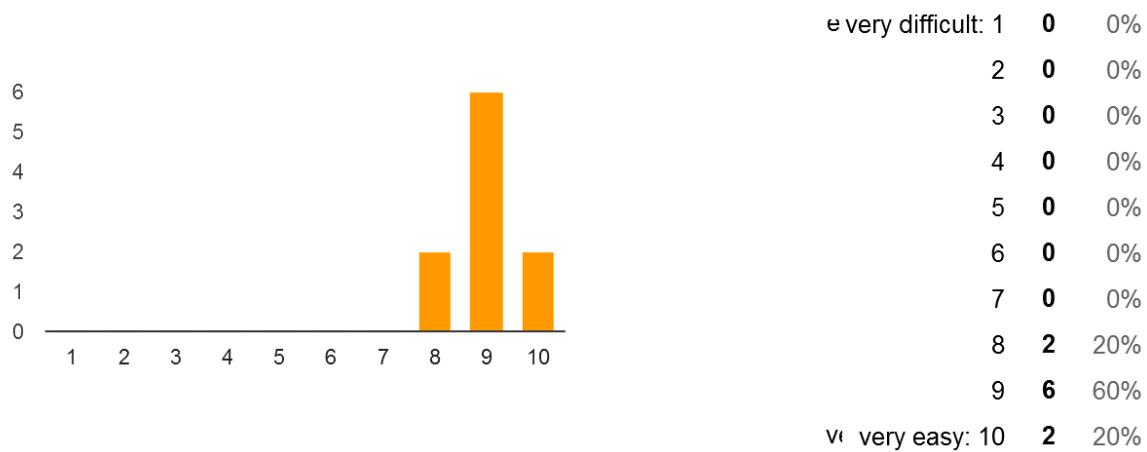
Strengths and weaknesses of the software were highlighted and constructive feedback on ways that could improve the application was provided by the participants. The application received mostly positive responses from all participants. Out of the 12 rating questions, 2 concerned the general ease of use and efficiency of the tool, while the other 10 focused on 5 aspects of the

generated reports for both the doctors and the patients. In general, the data indicates that the application is considered very easy to use and efficient. There is observable variation in the concerning the doctor and patient reports. Generally the patient report received lower scores than the doctor report, for example the overall quality of the patient report has values from 7 to 10 with 60% rating it 9 and only 10% rating it 10 while the doctor report has a range from only 8 to 10 with 40% rating it 9 and with 50% rating it 10. Similar trends are observed in the rest of the section, with the accuracy of the patients reports 60% at 9 points compared to the doctor report with 70% at 10 points. The lowest ratings were given for both reports in the naturalness section, the patient reports failing to receive any 10 point rating and having 30% at 7 points while the doctor report receiving 7 points for 10% of the responses but 30% giving the report 10 points. The content of the reports was considered appropriate for the patient and the professions with both receiving points between 9 and 10. The users were also asked if they consider that the contents of the patient reports contain possible stressful information, all participants indicated that this is not the case. From the feedback received the ease of use, design and the comforting approach it uses to deliver information to the patient were considered as strengths of the application. Some minor negative remarks were also made, for example that doctors and patients might benefit from the option to structure their reports in different way such as bullet points over paragraphs. Proposed features for future development were also received from users, such as the option to download forms or print them from the application and also the option to customise the layout and colour options of the application. Overall the results of the CARE eHealth tool survey indicate that the application is considered by the majority of users as being very easy to use and also efficient. Minor differences were observed between the patient and doctor reports, the first receiving lower points for naturalness. Both type of reports were perceived as being of high quality and portraying accurately the data. Results obtained are shown below:

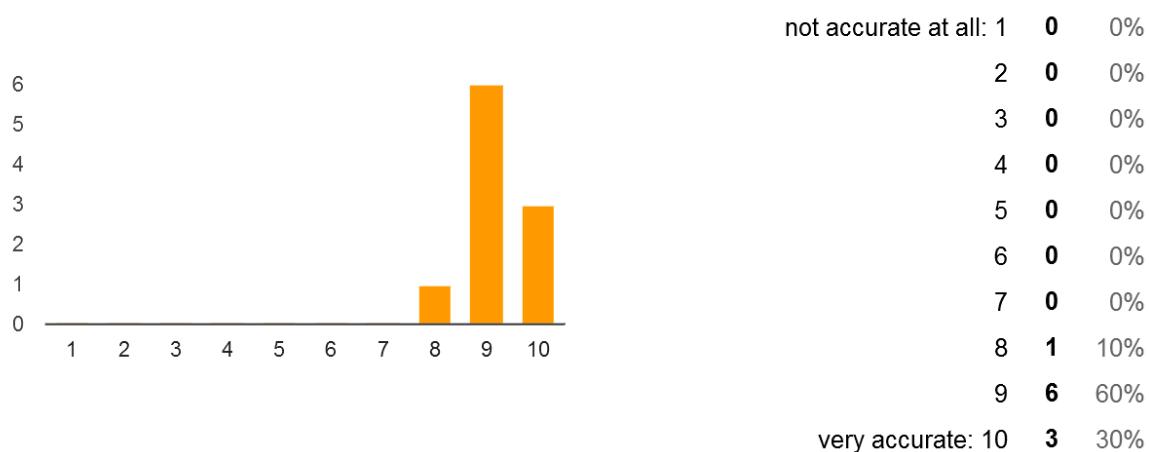
**How would you rate the accuracy of the medical report from a doctor's perspective?**



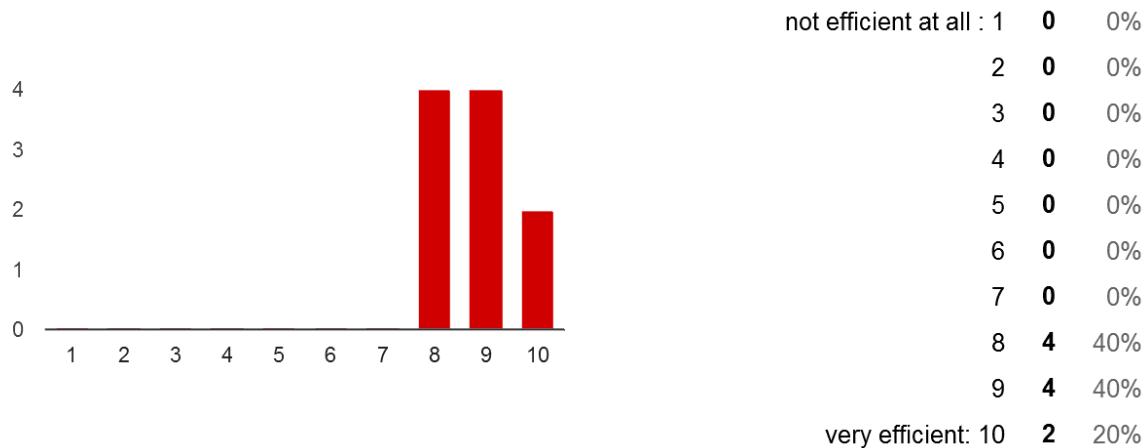
**How easy was it for you to use the CARE eHealth tool?**



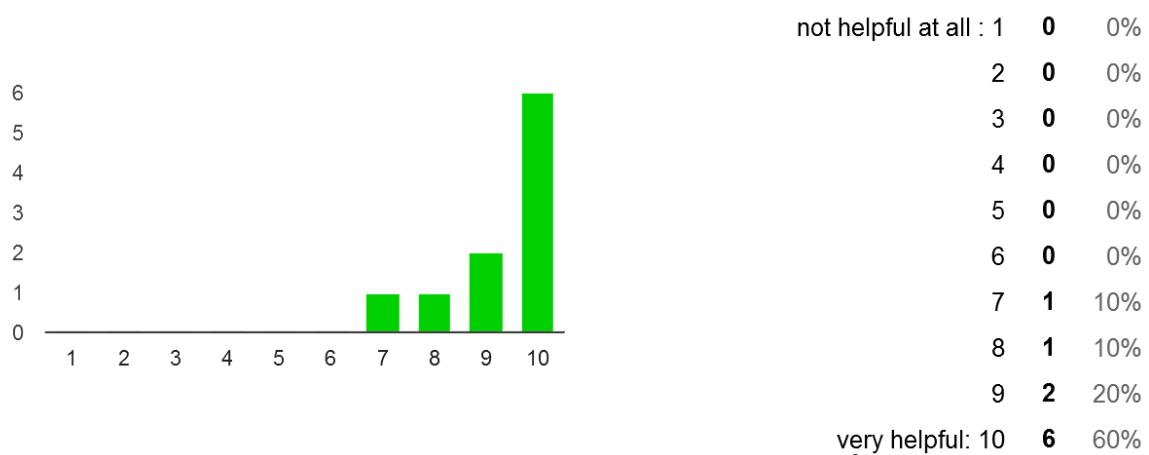
**How would you rate the accuracy of the patient report from a patient's perspective?**



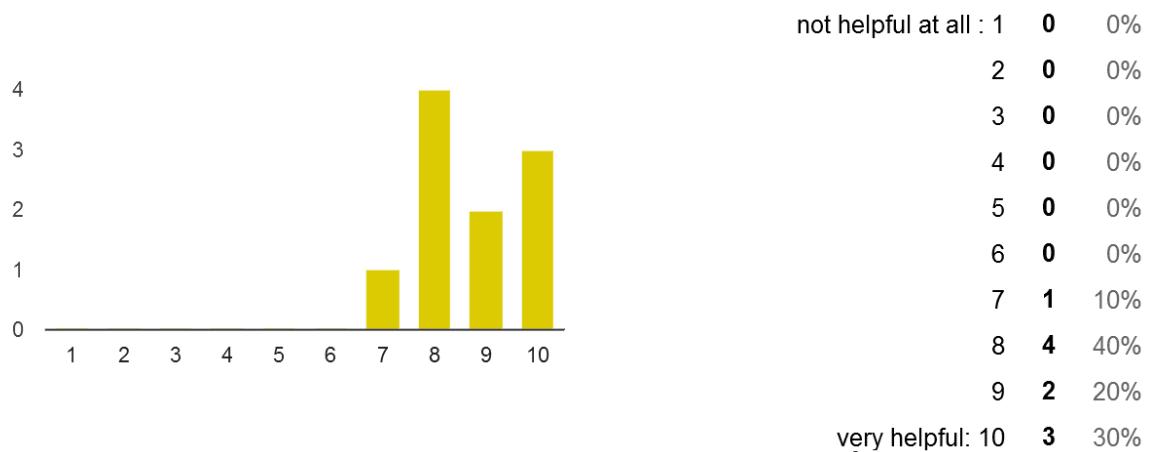
### How efficient is the CARE eHealth tool?



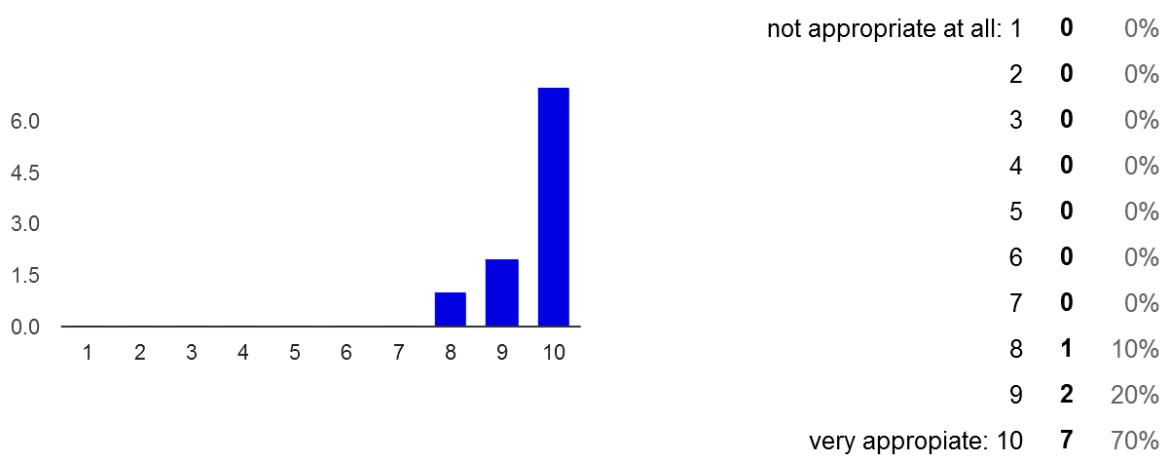
### How helpful is the CARE eHealth tool from a doctor's perspective?



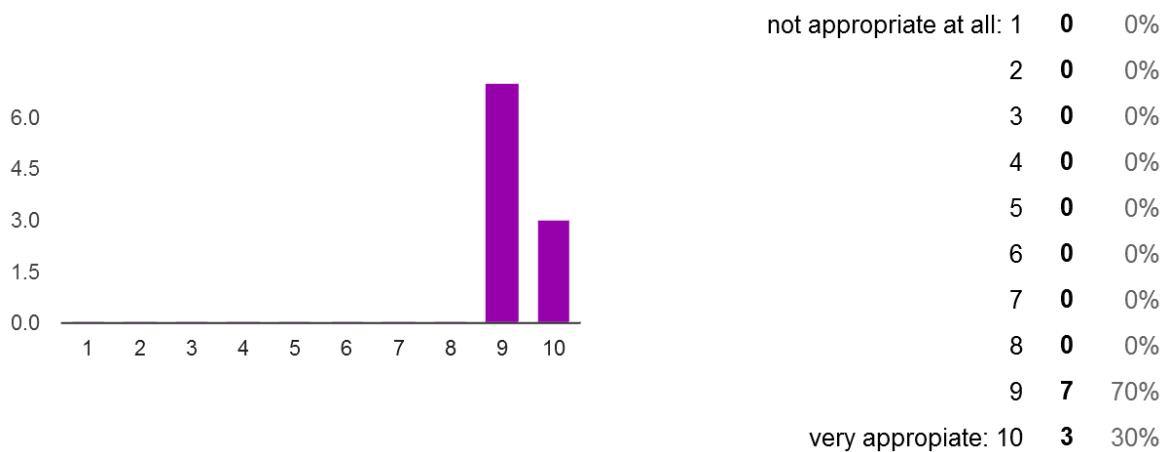
**How helpful is the CARE eHealth tool from a patient's perspective?**



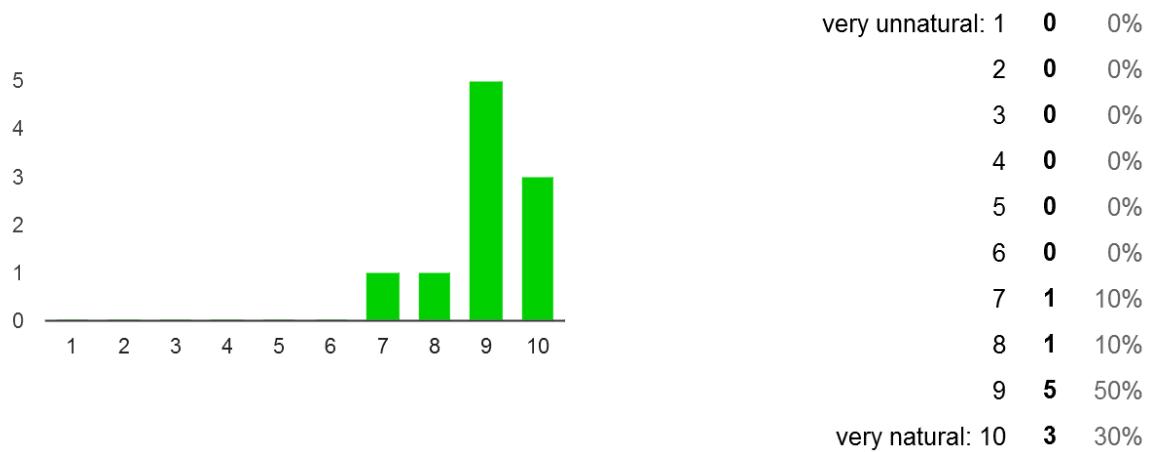
**How appropriate is the information in the medical report from a doctor's perspective?  
(assuming high level of expertise in the medical domain)**



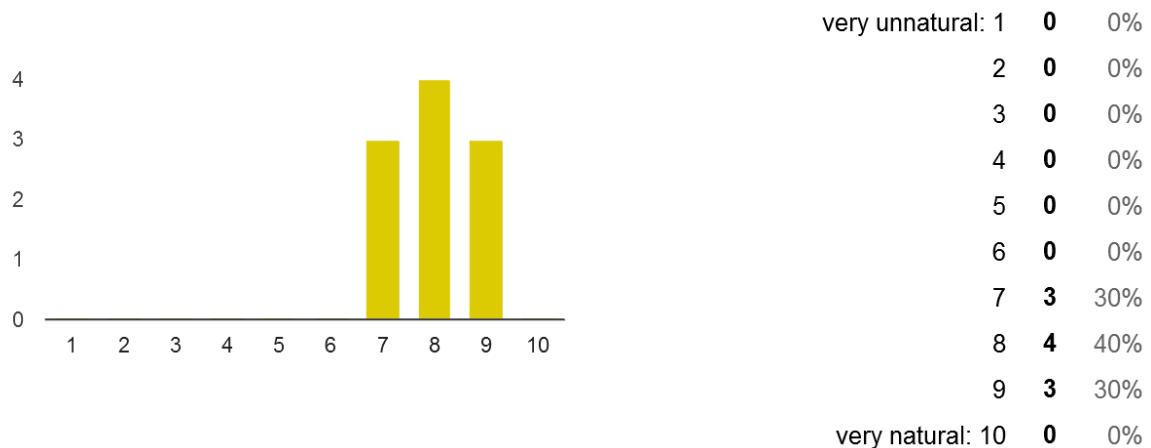
**How appropriate is the adapted information in the patient report from a patient's perspective? (assuming no expertise in the medical domain)**



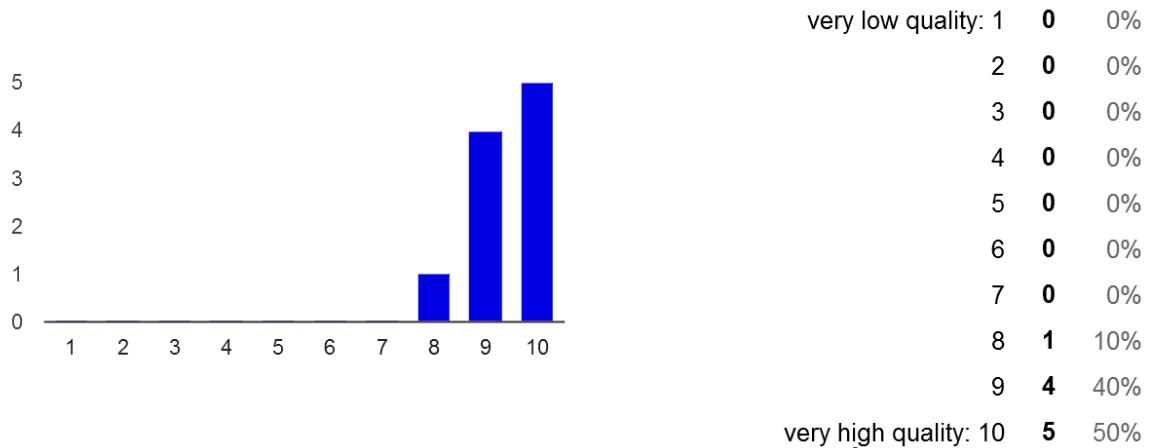
**How would you rate the naturalness of the text within the medical report from a doctor's perspective?**



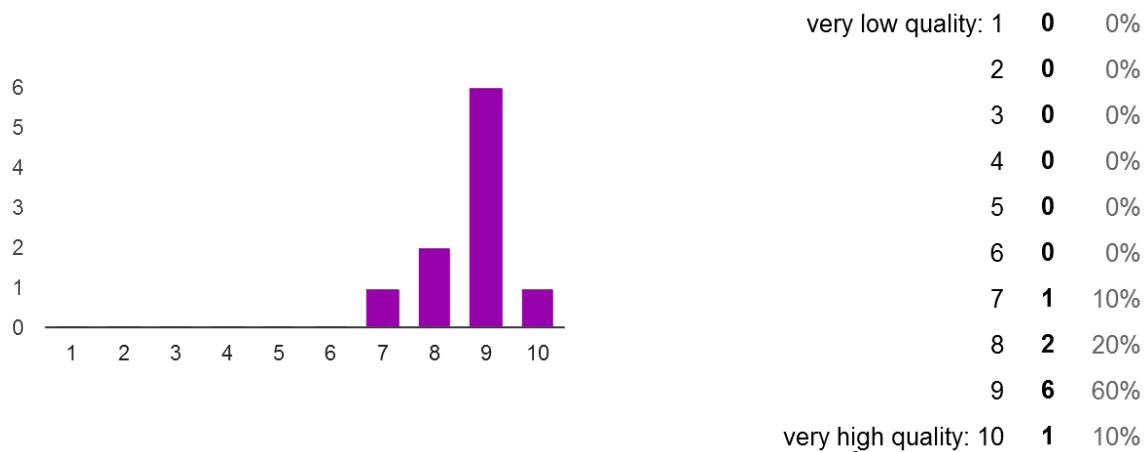
**How would you rate the naturalness of the text within the patient report from a patient's perspective?**



**How would you rate the overall quality of the medical report from the doctor's perspective?**



**How would you rate the overall quality of the patient report from the patient's perspective?**



**Do you consider that the content within patient report will cause unnecessary stress to potential patients?**



## **9. Evaluation**

As described in (Reiter and Belz 2009), the most common approaches to evaluating systems such as the CARE application can be classified into three categories:

1. Evaluations using automatic metrics, such as BLEU or ROUGE, which calculate average n-gram intersections between machine generated and human-written summary reports.
2. Task-based evaluations which measure the level of impact that the texts have on the end reader through the means of controlled psychological experiments or clinical trials.
3. Human judgment evaluations which involve interviewing human experts and end users, as well as asking them to rate various properties of the machine generated texts and compare them with versions from the human-written corpora.

Currently, there is increasing interest in the use of automatic evaluation metrics, as these offer a less expensive alternative to the human based evaluations. (Reiter and Belz 2009) However, such a comparative assessment would require a gold standard corpus to be available and in the present context of this project, only a very small number of human written texts were produced as a result of the user focus groups. Although these texts have been used during the design and implementation of the system, the limited dimensions of the corpora could significantly decrease the consistency and reliability of the outcomes produced by an automatic metrics evaluation. Additionally, health specialists or nurses do not usually write summaries based on patient self-assessments, so there were no preexisting specimens available for analysis or report examples built on real patient data. The summaries we collected were written by academic students with interest in health and medicine, but who do not necessarily have a professional level of medical expertise. Because of this, the collection does not meet the requirements to be considered a gold standard corpus and there is no guarantee that it would reflect the approaches which a health specialist would take in writing such a report or that it would make use of a comprehensive spectrum of specific domain terms and expressions in order to be categorized as accurate or ideal by the majority. Moreover, previous related work in the field indicates that there is an insubstantial connection between automatic metrics results and human based evaluations results. (Reiter and Belz 2009, Gatt and Belz 2010)

The second type of evaluation would be very effective in determining the actual impact of automatically generated texts on real users. Performing a clinical trial with patients currently involved in aftercare programmes would enable the acquisition of informative results which are not influenced in any manner by artificial factors. (Reiter and Belz 2009) However, due to time and ethical constraints, the feasibility of conducting such an assessment was extremely low. This type of evaluation would be expensive to run and it would be highly dependent on the availability of medical domain experts who often have very busy schedules.

For this reason, the impact and effectiveness of the system was measured using a third type human judgment based evaluation, in which participants were recruited and asked to rate the overall quality, followed by a series of 5 other properties for a sequence of human-written and machine generated texts. The methodology was first used in Natural Language Generation by Lester and Porter (1997) and it is similar to that described in Hunter et al. (2012), with the main difference being that the participants in the present evaluation were non-experts, but rather undergraduate and postgraduate students in higher education who were given a scenario and requested to answer accordingly to the best of their knowledge. This is presented in further detail in the following section.

## **9.1 Experiment Design and Evaluation Process**

The research question proposed for this evaluation is what impact does the natural language generation of medical and patient reports in the CARE eHealth software have on the end reader and how useful is it for different categories of users (patients and health professionals)?

In order to answer the proposed research question, an experiment was conducted in which human subjects were asked to “blindly” rate a series of machine generated medical reports (labelled as MG), as well as a subset of human reports written by distinct individuals (labelled as HW1, HW2, HW3 and HW4) that had been randomly selected from the project corpora in advance. The main focus of the experiment was to evaluate and compare these reports on a number of key properties: understandability, accuracy, fluency, helpfulness and overall quality. In preparation, the same patient model simulated data used during the focus groups was inputted in the CARE system, which resulted in the machine generating two medical and one patient automatic summary reports to be used in the evaluation. The experiment was structured in three parts as shown in the following table:

**Table 3: Experiment Structure**

Experiment	HW1	HW2	HW3	HW4	MG
Part I	Read and rate a total of 5 medical reports intended for health professionals (1 for each of HW1, HW2, HW3, HW4 and MG) based on input data from the first week				
Part II	Read and rate a total of 5 medical reports intended for health professionals (1 for each of HW1, HW2, HW3, HW4 and MG) based on input data from the second week and changes since the first week				
Part III	Read and rate a total of 5 patient reports intended for healthcare consumers (1 for each of HW1, HW2, HW3, HW4 and MG) based on the patient model, input data from the second week and changes since the first week				

The assessment consisted of 15 balanced tasks equivalent to reading 15 different summary reports and rating them on for the following 5 properties:

1. Understandability (extent to which the text is easily comprehensible by the reader)
2. Accuracy (extent to which the text conveys the desired meaning/correct information to the reader according the presented data)
3. Fluency (extent to which the text is coherent/flows and is readable)
4. Helpfulness (extent to which the text would be useful to the reader on its own if the data/some data was not available)
5. Overall quality of the text

The participants were shown a series of 5 summary reports in each part of the experiment, as described in the table above. After reading the reports, the subjects were asked to rate their properties on a 5-point scale and encouraged to enter free text comments to indicate what they liked or disliked about each individual report. Experiment participants were not informed how many or which one of the reports is human-written or machine generated. The answers were recorded and compared over all 5 texts to detect if there are any differences or associations between their properties. The test was built and conducted using the Google Forms platform, where 20 participants were recruited to complete the assigned tasks. Although, ideally a more representative sample with participants that have a strong medical background would have been selected, this did not prove to be a feasible task due to ethical constraints and project time limits, so the constraints for participant eligibility were relaxed, allowing for undergraduate and postgraduate students of any degree in higher education to participate. We ensured that none of the participants completed the test more than once and that the texts were displayed in a random order.

### **First week Medical report**

Report	Length	Content
HW1	35 words	“I believe John needs immediate medical attention as he has got pretty serious physical symptoms such as blood in his urine and fatigue. Moreover, John seems to be depressed and might need some psychological support.”
HW2	56 words	“It seems that John has severe problems, things to note are his urinating problems, as well as his growing depression. I believe that he should see a specialist. He has stool problems as his frequency is very high. Also he wants to contact a nurse. He weighs 62 kg and he is physically feeling very bad.”
HW3	81	“Dear doctor, reading this week patient's report I would like to notify you about John's symptoms. He shows severe physical discomfort (pain,

	words	fatigue, nausea) which affects his daily way of life. His stool according to the form is very frequent per day, as well as being a runny/wet type. His weight could be attributed to his daily amounts of excretion. Rectal/abdominal pain as well as bleeding could be looked at and see if it is linked to fatigue and nausea symptoms.”
HW4	139 words	<p>“John's ECOG performance shows that he is capable of taking care of himself but not able to do any work. The patient presents several symptoms, abdominal pain bloating, pain, and bleeding. He also reports a change in bowel habit and a loss of appetite. Both urinary and rectal bleeding have been mentioned. The patient also feels tired and sick.</p> <p>John weighs 62kg and has presented anxiety, depression and mentions not being able to stop worrying nearly every day. On more than half the days John says he has no interest in doing things. He has major difficulties dealing with his physical symptoms and managing his family and work. Stool type is liquid and very frequent, 7-8 times per day and he takes prescribed pain and chest infection medicine. Patient said he would like to be contacted by a nurse.”</p>
MG	167 words	“This week the patient has expressed very poor wellbeing overall, but he is dealing with a few current problems. The patient has reported the following new symptoms this week: abdominal bloating, variation in bowel habit, rectal bleeding, haematuria, frequent urination, difficulty urinating and heartburn or indigestion. The patient has started taking new medication: 'Pain relievers and medicine for my chest infection.' Currently, the patient's stool frequency is above normal range at 7 or 8 stools per day. The patient has reported Type 7 average stool consistency, indicating serious inflammation of the gut. The patient shows good ECOG performance at Grade 2. His report indicates lack of interest in activities on more than half the days. He shows severe complications as he is experiencing anxiety, lack of control and depression on a daily basis. He is managing very poorly with his physical symptoms and relationships and managing poorly with activities and interests. John's weight is 62.0kg. He wishes to be contacted. His preferred method of contact is telephone.”

## Second week Medical Report

Report	Length	Content
HW1	62 words	"It looks like the patient is feeling a bit anxious. Patient has been experiencing new abdominal pain and rectal bleeding and has been feeling tired and sick. The stool consistency is liquid but moderately frequent. John seems to be improving in mental and physical health, although his note at the end needs to be reviewed. He is worried about his new symptoms."
HW2	70 words	"Patient exhibits a new set of abdominal pain (lower left area) and also shows signs of stool complications (consistency). The patient shows signs of depression claiming that he lost interest in day to day activities which he still feels physically capable of doing. It seems that John has improved on many points. He feels less depression, some pains have disappeared, stool frequency has been reduced and he is physically better."
HW3	77 words	"Dear doctor, John's situation seems as it will take a slight upward spike. Concerning aspects still include symptoms, including pain in abdominal area and exhaustion and lack of interest (possible depression). Most concerning is the rectal bleeding. A checkup might be necessary. Compared to the previous week the patient seems to be improving in most of his life areas, however there are some serious symptoms that still persist. The patient seems to be rather worried about that."
HW4	160 words	"John shows improved ECOG performance, he is capable of light effort at home and work and can also take care of himself. The patient report no more urinary symptoms this week. He indicates that he is still suffering from the rest of the symptoms (abdominal pain and bloating, a change in bowel habit with rectal bleeding, he feels sick and tired and shows a loss of appetite and also has sexual problems). John now weighs 75kg. The patient now presented anxiety not being able to stop worrying only on several days but on more than half the days John says he has no interest in doing things and feels depressed. John copes better this week in all areas, physical symptoms, relationships, activities and general well-being Stool type is still liquid but frequency has lowered to 3-4 times per day and he mentions no new medication. John doesn't want to be contacted but mentions that he is worried about his symptoms."
MG	212 words	"This week the patient has expressed good wellbeing overall, but he is dealing with a few current problems. The patient is currently experiencing: feeling of nausea and emesis, variation in appetite, tiredness and sexual

		dysfunction. His abdominal pain, abdominal bloating, variation in bowel habit and rectal bleeding have been persisting for over two weeks. Currently, the patient's stool frequency is within normal range at 3 or 4 stools per day. The patient has reported Type 7 average stool consistency, indicating serious inflammation of the gut. The patient shows very good ECOG performance at Grade 1. However, he has shown anxiety and lack of control on several days. His report indicates lack of interest in activities and depression on more than half the days. He is managing poorly with his physical symptoms, managing well his relationships with family and friends and managing very well with activities and interests. John has gained weight below the acceptable range in a very short period of time and is now weighing 75.0kg. Last week he was weighing 62.0kg. The patient has left the following notes: 'I feel very tired all the time and my abdomen hurts a lot in the lower left area. I do not think it is because of my diet. Should I be worried?'."
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## Second week patient report

Report	Length	Content
HW1	28 words	"Dear John, you seem to have improved from last week. I have made a note to the doctor about your concerns for the new symptoms that have surfaced."
HW2	29 words	"John, it seems that your results are a show of improvement. We will have in mind the new symptoms, although they are not worrying. Overall, your state is improving."
HW3	47 words	"John, your overall condition seems to be improving. Very happy to know that your emotional state is getting better. The only thing that is rather concerning is the abdominal pain you get. The doctor will look over your report and decide whether you require any medical condition."
HW4	71 words	"John, you show an overall improvement this week. You managed to gain weight which is good and also now you are coping better with your symptoms. Your urinary problems seem to have ameliorated and now you also have a more regular stool frequency while consistency is still similar to last week, this all represents a good development. The doctor will be informed of the symptoms that persisted from the previous week."

MG	134 words	<p>“This week you have reported good wellbeing overall which is reassuring progress. You have reported that you are unable to do anything physically strenuous but mobile and able to carry out light tasks which represents very good performance. However, you have mentioned feeling anxiety on several days. This is normal from time to time, but if you would like to talk to us about it, please do not hesitate to let us know. You have told us about your feelings of lack of interest in activities on more than half the days. We will report this to your doctor. It is good to hear that you are managing positively with your relationships with family and friends and activities and interests. Since your previous submission you have gained some weight and are now weighing 75.0kg.”</p>
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## 9.2 Evaluation Results

A summary of the results is included below, together with the conclusions drawn from the comments provided by the participants.

One of the challenges faced during the creation of the NLG system was the construction of a hypothesis that would correctly encompass the expected outcome of the research. In most cases, there are two types of hypothesis, the null hypothesis ( $H_0$ ) and the alternative hypothesis ( $H_a$ ). Traditionally the null hypothesis encompasses the situations where the final outcome indicates towards zero relationship between the elements of the experiment and the result. The opposite is true for the alternative hypothesis which makes the case for direct relationship between result and elements of the experiment.

In the case of the NLG system, the desired outcome would be that there is no significant differentiation between the human and computer generated reports. As such  $H_0$  was formulated as “Reports created using an NLG system are perceived by users similarly to human generated reports based on the same range of criteria”. In this research,  $H_a$  is constructed as such “Reports created using an NLG systems are not perceived by users similarly to human generated reports based on the same range of criteria”.

**Table 4: P-values**

Week	P-value of NLG text versus samples					
		Understandability	Accuracy	Fluency	Helpfulness	Quality
1 doctor	1	0.6217	0.0002	1.0000	0.0017	0.0081
	2	0.8735	0.0015	0.2154	0.0063	0.0156
	3	0.1941	0.0389	0.2380	0.2979	0.5737
	5	0.4201	0.0535	0.2154	0.3405	0.4773
2 doctor						
	1	1.0000	0.0144	0.7786	0.0269	0.1154
	2	0.1593	0.0417	0.6535	0.0329	0.1220
	3	0.8572	0.0722	0.7636	0.1058	0.2971
2 patient						
	1	0.3055	0.0003	0.4290	0.0001	0.0045
	2	0.1615	0.0020	0.7913	0.0030	0.0241
	3	0.5848	0.2843	0.0972	0.1648	0.8849
	5	0.6123	0.4922	0.3808	0.4688	0.6602

The two hypotheses were tested out using the P-value method, where by a threshold ( $\alpha$ ) of 0.05 was used to distinguish between reports that rejected  $H_0$  in favour of  $H_a$ . The testing included was conducted on 20 users who had the task of rating 15 reports on 5 type of criteria, understandability, accuracy, fluency, helpfulness and overall quality. Out of the 15 reports, 3 were generated using the NLG system. Users were not told which text is NLG and which one is not. Two of the reports were aimed at professional and included a first week of monitoring and another report for the second week. The other report was aimed at patients during the second week.

The P-values between for the NLG report and each human generated report was calculated for all the criteria. For the null hypothesis to be rejected, the calculated P-value has to be bellow or equal to 0.05, this was the case for 17 of the 60 criteria situations. Data indicates that only 28% of the reports present created by the NLG system failed to achieve similar standards to the human texts. Overall the results show that the null hypothesis was proven true and that users perceive NLG texts as meeting similar criteria to those generate by humans. According to the P-value, this statement hold true especially for the understandability and fluency of the reports

where the null hypothesis has been proven true on all the 15 cases. The second week of the doctors reports also show good similarities between the NLG and human reports for the quality section.

It is required to point out that despite the failures of the NLG to be perceived similarly in human reports on 28% of the cases, this does not contribute in any way towards disproving the NLG system as a viable report generation solution. The P-value tests can only be used to distinguish between similarities of the two approaches and makes no implication on the actual correctness, quality and reliability of either technique. For example comparison between a high scoring NLG text and a poorly scoring human text would result in very low P-value between the two. The low perceived similarities between the two texts should not be used against the NLG system since in this situation, it is the NLG system that actually provided the high quality report. This view is backed by a simple comparison of the overall average value for each criteria (table 2).

**Table 5: Average ratings**

Week	Average rating values for samples					
		Understandability	Accuracy	Fluency	Helpfulness	Quality
1 doctor	1	4.15	3.20	3.75	3.20	3.40
	2	4.05	3.50	3.35	3.25	3.40
	3	4.40	3.95	4.15	3.95	4.00
	4-NLG	4.00	4.55	3.75	4.25	4.15
	5	4.25	4.00	4.15	3.95	3.95
2 doctor						
	1	4.05	3.35	3.70	3.35	3.40
	2	3.65	3.55	3.65	3.45	3.45
	3	4.00	3.60	3.70	3.60	3.60
	4-NLG	4.05	4.20	3.80	4.10	3.90
2 patient						
	1	3.70	2.70	3.95	2.55	2.70
	2	4.055	3.805	3.78	3.705	3.72
	3	4.20	3.80	4.20	3.65	3.95
	4-NLG	4.05	4.10	3.65	4.10	3.90
	5	3.90	3.90	3.95	3.85	3.75

Data shows similar trends to the P-value analysis but it also makes it easy to understand how the NLG systems compares with the human texts in certain situations. A very important advantage of the NLG system is apparent across all situation, the NLG text shows consistently average

ratings above 3 in all categories with the lowest average at 3.65 points and the highest at 4.55. It becomes apparent when comparing the accuracy NLG average rating results with the P-value for the same criteria that despite proving the null hypothesis true, the NLG system is only dissimilar to the human reports due to its better overall accuracy. This proves that when statistically analysed, NLG reports might prove to be perceived differently to human generated reports but a more subjective, user based analysis would indicate that the NLG systems are preferred over the human solutions. This can be the due to the NLG portraying more accurately the original data set without omitting important factors.

User feedback received during the testing of the NLG highlights some of the strengths and weakness of each report. Users were not aware of the nature (human or NLG) of the reports. Many of the issues raised are direct at human generate reports. A very common negative response was linked to certain reports omitting information that the might prove important, this is linked into the low scores that some of the human generated reports received. For example during the first week users indicates that “the report is too short and not cover important information” or “the new medication and bowel habit information seems too relevant to be left out of the report”, both complaints target human generate reports as the NLG contains the information. Users indicated that the application is contains some grammatical errors and that in some cases reports are too long because they repeat what users consider to be redundant information, either information that is easy to see in the forms or that carriers over from the previous week. This has been the case with both the human and the NLG texts. Users also indicated that the application could benefit from a few new functionalities, such as in the patient report, only professionals and doctors that the patient knows should be mentioned. For the user report, most users highlighted the fact that it provides the information in a very personal and reassuring way. The testing showed that the patient report is sometimes considered too detailed and if the volume of text is great, it could be a source of unnecessary stress for the patient.

The conclusion of the p-value and average rating analysis shows that reports created using an NLG system are perceived by users similarly to human generated reports based on the same range of criteria. The data indicates that in 72% of the situations the NLG system was received similarly to the human texts. The 28% of cases where the alternative hypothesis hold true can in some situation be linked to NLG reports actually being considered by users too superior to human generated texts.

## 10. Conclusions and Future Work

This chapter will conclude the work for this project, followed by a discussion about the development experience and any possible bug fixes. The chapter ends by proposing possible future work for the project.

## **10.1 Project Summary**

The key objective of the CARE eHealth tool is to develop a report generation system using Natural Language Generation in order to address the problem of creating adaptive reports for colorectal and prostate cancer and healthcare professionals. At present there are no tools creating custom reports based on weekly forms for such a specific type of cancer and also no tools that aim their terminology and structuring differently according to the status of the reader. The idea of a Natural Language Generation tool that could construct reports which contain wording aimed at reassuring the patient or provide a concise summary of the patient's status and progression through the weeks could prove to be an invaluable asset in the struggle to improve doctor-patient communication. The CARE eHealth tool encompasses the digital platform for form submission and report generation. Patient users are required to submit one form per week with details of their status such as weight, present symptoms, ECOG performance and anxiety levels. Patients get instant access to the generated reports or to the database of previous reports, the application tracks their progress through time and makes this information available alongside the personal reports. The professional using the CARE eHealth tool get access to detailed patient reports which highlight changes and progressions of symptoms through time. Professionals are given the administrative rights over the application controlling the creation of patient accounts. The expected result of the CARE eHealth tool is to provide evidence of the usefulness of Natural Language Generation with assisting communication between doctors and patients for colorectal and prostate cancer. The outcome of the project could indicate that tools similar to CARE eHealth could be adapted to other types of cancer and other conditions due to the versatility of Natural Language Generation systems. The effectiveness of Natural Language Generation in the case of patients-doctor communication was tested out on 20 users. The user testing session compared NLG based reports with reports produced by humans, results indicated that overall the NLG reports perform well in some aspects even outperforming human generated work. The form web platform for submitting forms and receiving reports was tested by 10 users who gave positive feedback on the applications ease of use, design and the tools responsiveness.

## **10.2 Conclusion**

The CARE eHealth tool provides a good example of the usefulness of Natural Language Generation systems in monitoring the condition of treated patients who previously suffered from colorectal and prostate cancer. Communication between healthcare professionals and patients is crucial in any form of treatment, but the wide discrepancies between the language used by the two groups often leads to vital information being wrongfully ignored while in other situations unnecessary terminology can cause unwanted stress for patients. Natural Language Generation systems offer a solid solution that can bridge the doctor-patient communication gap. In this study

a Cancer Aftercare Reporting Engine was created for the purpose of building reports based on periodic forms completed by cancer patients monitoring their symptoms and weekly wellbeing. The generated reports adapt themselves to the targeted reader, doctors receive a comprehensive summary of the patients weekly input, while patients receive a personalised summary that focuses on reassuring terminology and acknowledgments of improvements in the patient's state. Both type of reports follow the progression of the patient through time and adapt themselves accordingly to the patients improving or aggravating condition. User testing shows very good feedback on the use of reassuring phrases and ability to adapt the text so it highlights more important changes first in patient reports. The success of NLG systems in boosting communication between doctors and patients could find uses in other similar situation in healthcare. The speed, reliability and ease of use of the CARE eHealth tool could be adapted to fit a wider range of cancer type or even other conditions that would benefit from reassuring report generation and from specialised text aimed at professionals.

### **10.3 Future Work**

Following the user testing for the CARE eHealth tool, a number of possible areas of improvement were discovered along with ideas for extensions that could make the application a more robust solution. The feedback gathered from the validation and evaluation sessions indicates that the web application would benefit from increasing the ease of access on the website through features such as customizable layouts, font sizes and colour pallets. Other features that could potentially make the application easier to use in would be the function to download reports to a text file or to print directly from the website. The proposed upgrades concerning the web application could be implemented during a later stage, due to time constraints, attention was given to the report generation segment and the web functions that support it. Testing of the generated reports resulted in 20 users providing ratings and feedback on the NLG text in conjunction with human generated reports. This method ensured that improvement for the NLG reports could be also be deduced from feedback on human generated reports which act as the desired standard and which in turn received constructive critique that helped with better understanding what was perceived as a good report. The conclusions from the user testing is that the NLG reports portray relevant data about the condition of the patient, the report aimed at doctors was better received by users with patient reports showing potential areas of improvement. Given the nature of the report and the fact that patient input data manually, some users considered it redundant for reports to contain some information that patients could already know. Adapting the patient report so that it only references professionals that the patient knows represents one of the features desired by users. This future addition to the application is unlikely as it could potential prove a burden for the healthcare system to provide access only to professional known to the patient. In the situation in which access would be granted to professional outside of the patient's personal knowledge but they would not be referenced in any

report, this feature could possibly be implemented during a later version of the application. Overall the application was well received by users with more room for improvement in the patient report section. There are no foreseeable major improvement in the near future in respects to the report generation part of the CARE eHealth tool. This is mainly due to the absence of a gold standard for report generation, with colorectal cancer and prostate cancer being specialised subjects but lacking pre-existing forms and reports that could be used to standardize the text generation method.

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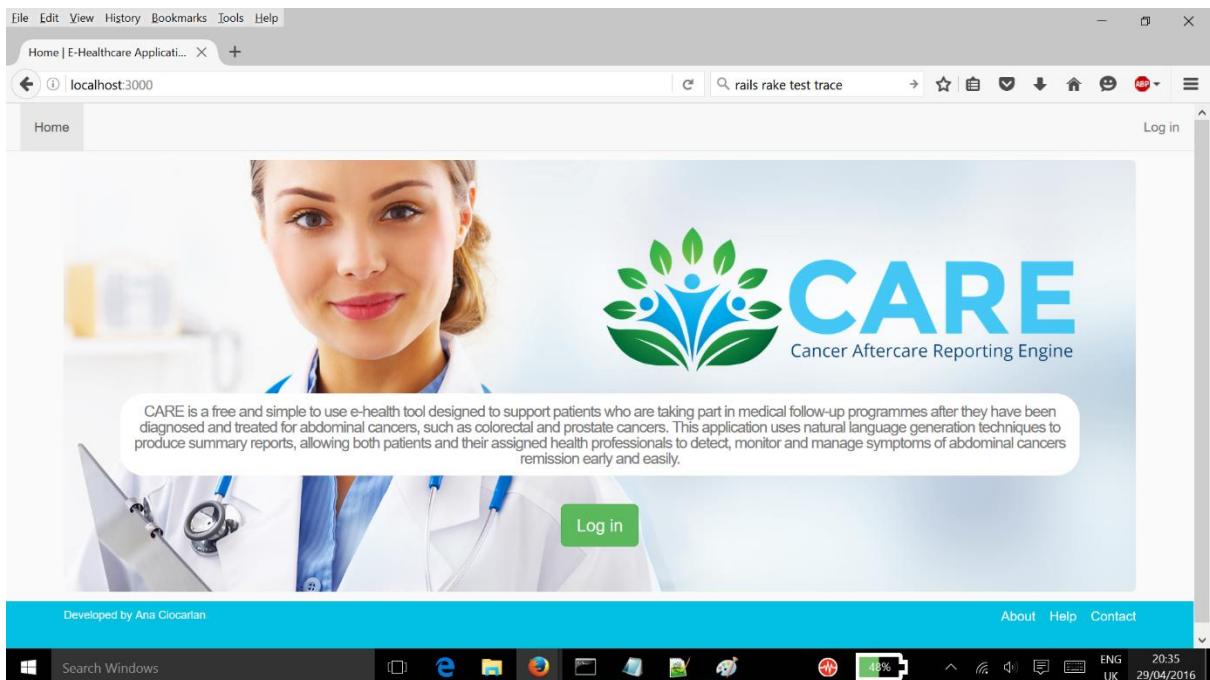
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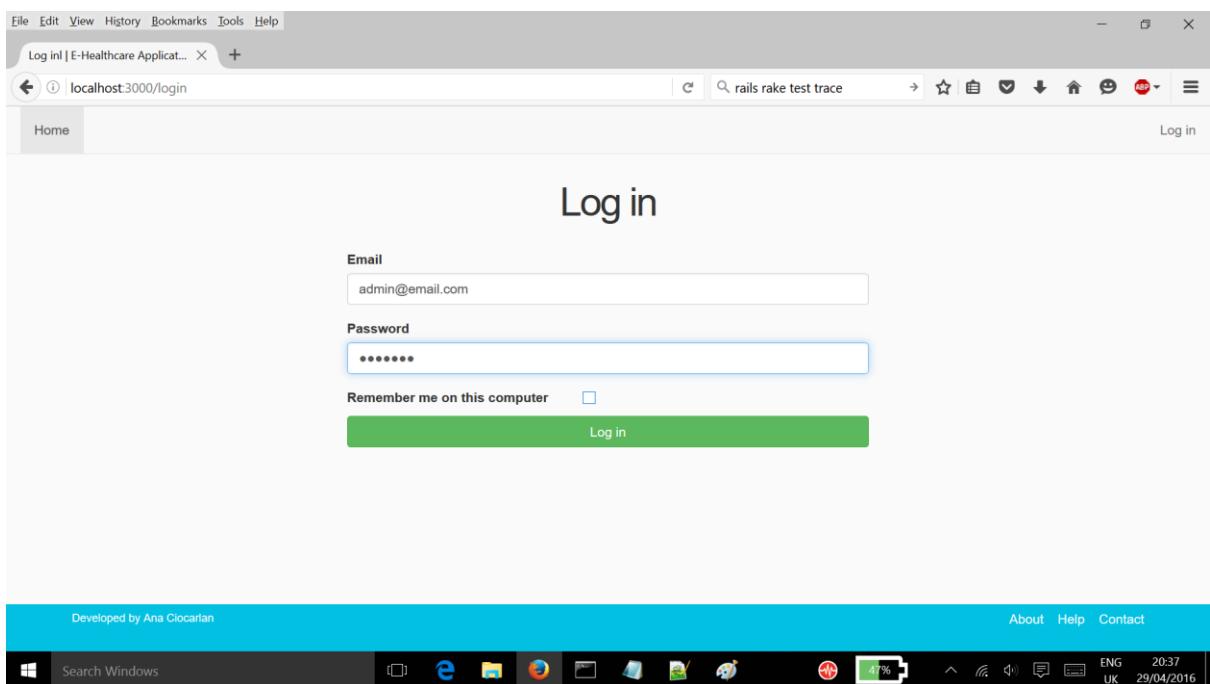
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## **Appendix**

### ***User Manual***

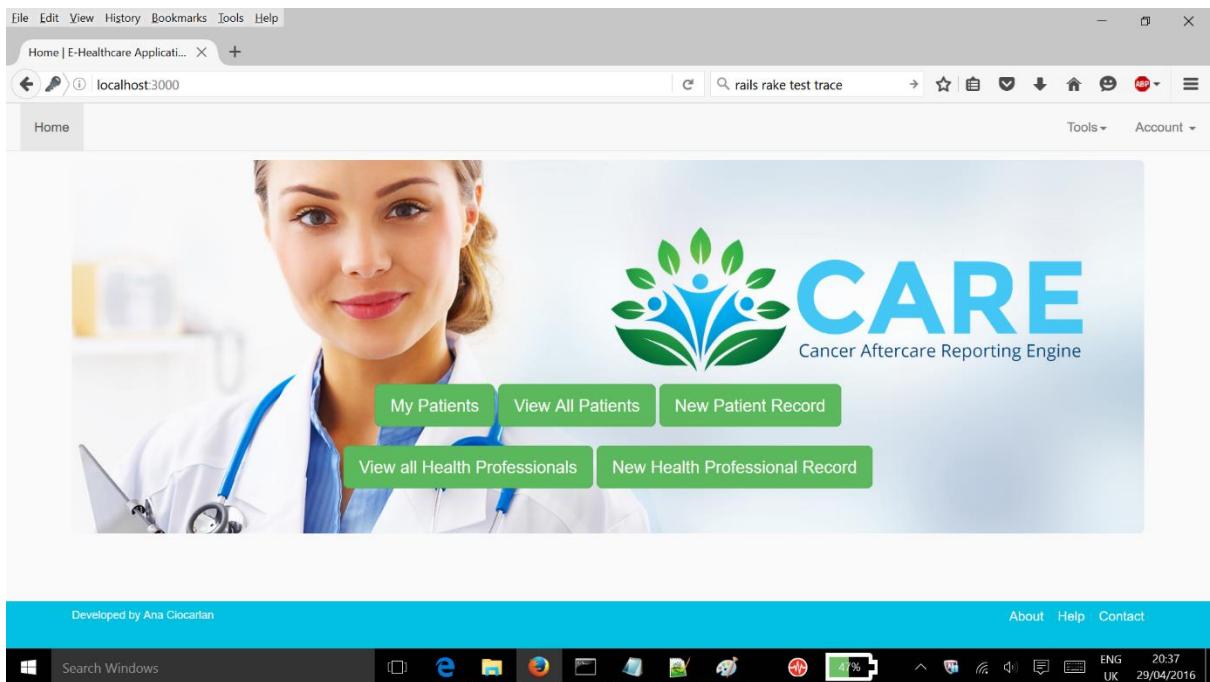


- The Homepage of the CARE eHealth tool
- Click “**Log in**” button to be redirected to the log in page

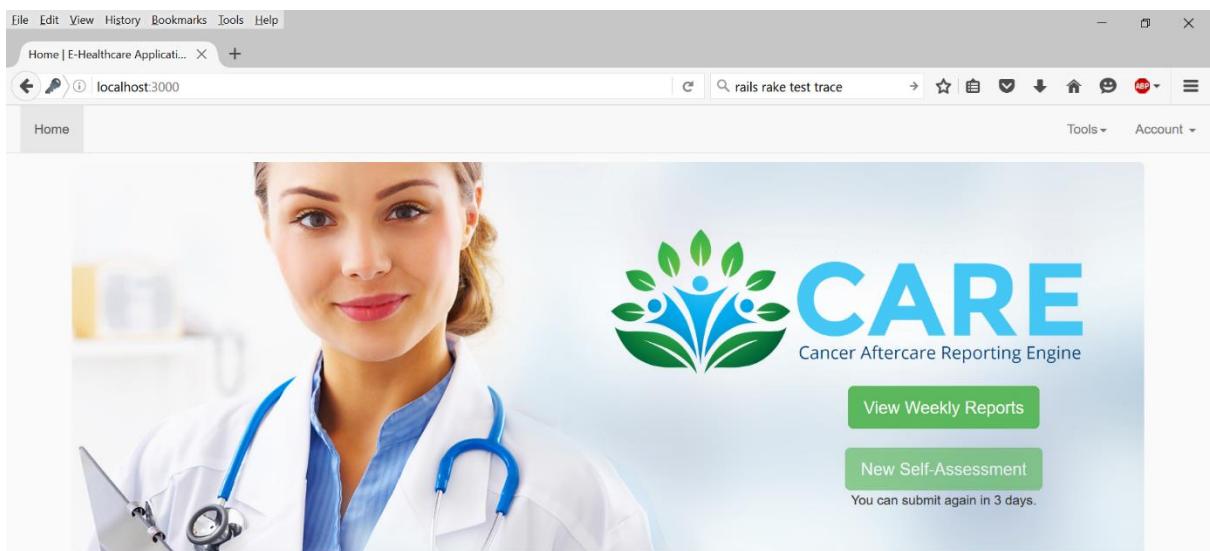


- The log in page
- To In the “**Email**” section write your authenticated email e.g **user@email.com**
- In the “**Password**” section insert your password

- Optional: tick the box in the “Remember me on this computer”  so that you do not have to input your email and password on your next log in.



- Homepage of the CARE eHealth tool as seen by a logged in professional
- Click “**My Patients**” button to access page containing all patients assigned to your account
- Click “**View All Patients**” button to access page all registered patients
- Click “**New Patient Record**” to register a new patient
- Click “**View all Health Professionals**” to access page containing all registered professionals
- Click “**New Health Professional Record**” to register a new professional



- Homepage of the CARE eHealth tool as seen by a logged in patient
- Click “**View Weekly Reports**” to access the history of weekly reports you submitted
- Click “**New Self-Assessment**” to submit a new report. Only one every 7 days, button stays deactivated until 7 days pass.

The screenshot shows a web browser window with the following details:

- Header:** File, Edit, View, History, Bookmarks, Tools, Help.
- Title Bar:** Helen | E-Healthcare Applicat... X +
- Address Bar:** localhost:3000/healthprofessionals/4
- Toolbar:** Back, Forward, Stop, Refresh, Home, Search (rails rake test trace), Favorites, Download, Help.
- Page Content:**
  - Left Sidebar:** Shows a portrait icon, the name "R.N. Helen Jones", and the title "Oncology Nurse". Below this are contact details: Address (123 Street Aberdeen AB22 2AA), Telephone (01224123123), Email (admin@email.com), and Working Hours (Full-Time).
  - Center:** A heading "My Patients (2)" followed by two patient entries:
    - Sandra Johnson, Date of birth: 1996-09-13, Cancer type: Colorectal Cancer
    - Legolas Greenleaf, Date of birth: 1926-03-17, Cancer type: Colorectal Cancer
  - Bottom:** A blue footer bar with "Developed by Ana Cioacarlan", "About", "Help", and "Contact" links. The Windows taskbar at the bottom shows various pinned icons and the date/time (29/04/2016).

- Page opened by clicking on the “**My patients**” button when logged in as a professional
- On the left of the page there are details of the professional: Portrait, Name, Specialisation, Address, Contact details and Working Hours.
- Click on “**Update Record**” button to access page where you can modify the record of the professional.
- Centre of page contains list of the patients assigned to this professional.

File Edit View History Bookmarks Tools Help

Update Health Professional Re... X +

localhost:3000/healthprofessionals/4/edit rails rake test trace

Home Tools Account

## Update Record: Helen Jones

**First Name**  
Helen

**Last Name**  
Jones

**Date of Birth** January 17 1930

**Gender** female

**Specialisation**  
Oncology Nurse

**Address**  
123 Street Aberdeen AB22 2AA

**Telephone Number**

Developed by Ana Ciocarlan About Help Contact

Search Windows ENG UK 29/04/2016

- The “**Update Record**” page of the professional.

File Edit View History Bookmarks Tools Help

Update Health Professional Re... X +

localhost:3000/healthprofessionals/4/edit rails rake test trace

Home Tools Account

**Telephone Number**  
01224123123

**Email**  
admin@email.com

**Working Hours**  
Full-Time

**Change password**  
Enter new password...

**Change password confirmation**  
Please provide a password confirmation...

**Save changes**

 change

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Search Windows ENG UK 29/04/2016

- Continuation of the “**Update Record**” page of the professional.
- Write in the boxes bellow each detail the according information, for example in the “**Specialisation**” box write the appropriate profession, Oncology Nurse, General Practitioner, etc.
- Drop down menus are used for some of the information such as “**Date of Birth**” and “**Gender**”. Click the arrow pointing downwards to access the content.

The screenshot shows a web browser window displaying a patient management application. The title bar reads "View all patients | E-Healthcar...". The main content area is titled "All patients". Below the title, there is a navigation bar with links for "Home", "Tools", and "Account". A search bar contains the text "rails rake test trace". The main content area displays a list of patients:

	Robert Black   delete	Date of birth: 1966-03-16 Cancer type: Colorectal Cancer
	John Brown   delete	Date of birth: 1974-06-18 Cancer type: Colorectal Cancer
	Malcolm Ford   delete	Date of birth: 1931-01-16 Cancer type: Colorectal Cancer

At the bottom of the page, there is a footer with links for "About", "Help", and "Contact". The status bar at the bottom right shows "47%", "ENG", "20:39", "UK", and the date "29/04/2016".

- The “**All patients**” page lists all the registered patients in the system.
- Click “**Previous / Next**” to cycle through the pages of the database

All health professionals

	Dr. Ana Ciocarlan   delete Oncologist
	Dr. Emilia Gray   delete Oncologist
	R.N. Helen Jones Oncology Nurse
	Dr. Robert Davidson   delete Oncologist

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- The “**All health professionals**” page lists all the registered professionals

File Edit View History Bookmarks Tools Help

New Patient Record | E-Health... X +

localhost:3000/new\_patient\_record rails rake test trace

Home Tools Account

## New Patient Record

**First Name**  
Please enter patient's first name...

**Last Name**  
Please enter patient's last name...

**Assigned health professional** Dr./R.N. Ana Ciocarlan

**Date of Birth** Select Month Select Day Select Year

**Gender** Select...

**Patient weight (kg)**  
Please enter patient's weight in kilograms...

**Patient height (m)**  
Please enter patient's height in metres...

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Search Windows 20:41 ENG UK 29/04/2016

- The “New Patient Record” contains the form required for registering of a new patient record

File Edit View History Bookmarks Tools Help

New Patient Record | E-Health... X +

localhost:3000/new\_patient\_record rails rake test trace

Home Tools Account

**Diet**  
Please enter patient's diet...

**Smoking habit** Select...

**Alcohol consumption** Select...

**Colostomy present** Select...

**Cancer type** Select...

**Tumor stage** Select...

**Tumor location** Select...

**Lymphovascular invasion present** Select...

**Perineural invasion present** Select...

**Surgery date** Select Month Select Day Select Year

**Chemotherapy** Select...

Developed by Ana Ciocarlan About Help Contact

Search Windows 20:42 ENG UK 29/04/2016

- Continuation of the “**New Patient Record**” contains further information for the registration of a new patient.
- Data specific for each patient is selected from the drop down menus e.g. “**Tumour stage**”, “**Colostomy present**”, “**Surgery date**”.

The screenshot shows a web browser window with the following details:

- Address Bar:** New Patient Record | E-Health... | localhost:3000/new\_patient\_record
- Toolbar:** File Edit View History Bookmarks Tools Help
- Search Bar:** rails rake test trace
- Page Content:**
  - Chemotherapy:** Select... dropdown menu
  - Address:** Please enter patient's address...
  - Telephone Number:** Please enter patient's telephone number...
  - Email:** Please enter patient's email address...
  - Password:** Please provide a temporary password for the patient...
  - Confirmation:** Please provide a password confirmation...
  - Create patient record:** A green button at the bottom of the form.
- Bottom Navigation:** Developed by Ana Ciocarlan, About, Help, Contact
- Taskbar:** Windows Start button, Search Windows, Taskbar icons (File Explorer, Edge, File Manager, etc.), Battery level (45%), Date (29/04/2016), Time (20:42), Language (ENG UK)

- Continuation of the “**New Patient Record**”, the final details required for the registration of a new user
- Click “**Create patient record**” to finalise the registration of a new patient.

Screenshot of a web browser showing the "Create Health Professional Re..." page at localhost:3000/new\_healthprofessional\_record. The page title is "New Health Professional Record". The form fields include:

- First Name**: Please enter health professional's first name...
- Last Name**: Please enter health professional's last name...
- Date of Birth**: Select Month ▾ | Select Day ▾ | Select Year ▾
- Gender**: Select... ▾
- Specialisation**: Please enter health professional's specialisation...
- Address**: Please enter health professional's address...

The browser toolbar shows "rails rake test trace" in the search bar. The taskbar at the bottom includes icons for File Explorer, Edge, and other applications, along with system status indicators like battery level (46%) and date/time (29/04/2016).

- The “**New Health Professional Record**” page contains the information required to be completed for the creation of a new professional account.

Screenshot of a web browser showing a form for creating a new health professional record. The browser window has a title bar with File, Edit, View, History, Bookmarks, Tools, Help, and a search bar with the query "rails rake test trace". The address bar shows "localhost:3000/new\_healthprofessional\_record". The main content area contains fields for Address, Telephone Number, Email, Working Hours, Password, and Confirmation, each with a placeholder message. A green button at the bottom right labeled "Create health professional record" is highlighted. The status bar at the bottom shows "Developed by Ana Ciocarlan", "About Help Contact", and various system icons.

The screenshot shows a web browser window with the following details:

- Title Bar:** File, Edit, View, History, Bookmarks, Tools, Help, rails rake test trace
- Address Bar:** localhost:3000/new\_healthprofessional\_record
- Content Area:**
  - Address:** Please enter health professional's address...
  - Telephone Number:** Please enter health professional's telephone number...
  - Email:** Please enter health professional's email address...
  - Working Hours:** Please enter health professional's working hours...
  - Password:** Please provide a temporary password for the health professional...
  - Confirmation:** Please provide a password confirmation...
- Buttons:** Create health professional record (highlighted in green)
- Status Bar:** Developed by Ana Ciocarlan, About, Help, Contact, Search Windows, system icons (battery 46%, date 29/04/2016, time 20:40), ENG UK

- Continuation of the “**New Health Professional Record**” page, contains the final details required for the registration of a new professional
- Click “**Create health professional record**” to finalize the registration process.

The screenshot shows a web application interface for a healthcare professional. At the top, a navigation bar includes File, Edit, View, History, Bookmarks, Tools, and Help. A tab labeled "Legolas | E-Healthcare Applica..." is open, with a search bar containing "rails rake test trace". Below the header, a breadcrumb trail shows "Home". On the left, a sidebar displays a blue circular profile icon and the patient's name, "Mr. Legolas Greenleaf", followed by the date "17 Mar 1926". The main content area has tabs for "Weekly Reports" and "Overall Report", with "Weekly Reports" selected. A section titled "Weekly Self Assessments (3)" lists three entries, each with a blue circular icon, the title "Patient Self-Assessment", the submission date "Submitted 2 days ago", and links to "View Self-Assessment" and "View Report". Below this, contact information is listed: Address: 123 Aberdeen Street UK AB22 2AA, Telephone: 01224123123, Email: legolas.greenleaf@email.com. At the bottom, a footer bar includes "Developed by Ana Ciocarlan", "About", "Help", and "Contact". The taskbar at the bottom of the screen shows the Windows logo, a search bar with "Search Windows", and icons for various applications like File Explorer, Firefox, and Paint. It also displays system status like battery level (45%), network connectivity, and the date/time (29/04/2016).

- The “**View All Self-Assessment**”, from the professionals view contains details of the patient and a list of the submitted reports
- On the left side, contact and personal details profile photo are listed
- Click “**View Self-Assessment**” to open the self-assessment window for that particular entry.
- Click “**View Report**” to open the generated report for that particular entry
- Click “**Overall Report**” to switch to the overall data on the progression of the reports. To go back to the weekly self-assessment, click the, “**Weekly Reports**”

**Patient Report**

### This week's report

This week the patient has expressed very good wellbeing overall, but he is dealing with a few current problems. The patient has reported 1 new symptom this week. He is currently experiencing diarrhoea. His variation in appetite has been persisting for over two weeks. Legolas's weight is maintained at 67.0kg. Currently, the patient's stool frequency has increased from 5 or 6 in the previous week to 7 or 8 stools per day and it is above normal range. The average stool consistency has changed from Type 4 reported in the previous week to Type 7, indicating serious inflammation of the gut. The patient describes his stoma function as unsatisfactory but mentions no complications. At the moment, the patient shows stable ECOG performance at Grade 1. The patient displays no evidence of lack of control or depression this week. However, he has shown lack of interest in activities on several days. His report indicates anxiety on more than half the days. He is managing very well with his physical symptoms and relationships with family and friends and managing excellently with activities and interests. The patient has not had a scan in more than 1 month.

**Assigned Health Professional:** R.N. Helen  
**Age:** 90  
**Gender:** male  
**Weight:** 66.0 kg  
**Height:** 1.9 m  
**Diet:** standard  
**Smoking:** Regular Smoker (weekly or daily)  
**Alcohol:** Occasional alcohol consumption  
**Colostomy Present:** Yes

**Address:** 123 Aberdeen Street UK AB22 2AA  
**Telephone:** 01224123123  
**Email:** legolas.greenleaf@email.com

Developed by Ana Ciocarlan

About Help Contact Close

- The “View Report” from the professionals perspective
- Click “Close” to go back to the “View All Self-Assessment”.

**My Report**

### This week's report:

This week you have reported good wellbeing overall which is reassuring progress. You do not present any symptoms. This is great! Since your previous submission you have gained some weight and are now weighing 66.0kg. Your stool frequency has decreased from 3 or 4 last week and it is within normal range. It seems you might be slightly constipated. This can happen when you have very little amounts of fibre in your diet. You have reported that you are spending more than 50% of waking hours in bed or chair and restricted in managing alone. This is an improvement in comparison with last week. We are happy to see that you are not experiencing any lack of control. However, you have mentioned feeling anxiety on several days. This is normal from time to time, but if you would like to talk to us about it, please do not hesitate to let us know. Your self-assessment also indicates that you are experiencing depression on a daily basis. We'll continue to monitor your condition and provide you with all the support you need. It is good to hear that you are managing well with your physical symptoms, relationships with family and friends and activities and interests.

**Assigned Health Professional:** Dr. Ana Ciocarlan  
**Age:** 23  
**Gender:** male  
**Weight:** 67.0 kg  
**Height:** 1.8 m  
**Diet:** Standard  
**Smoking:** Non-Smoker  
**Alcohol:** No alcohol consumption  
**Colostomy Present:** Yes

**Address:** 123 Aberdeen Street UK AB22 2AA  
**Telephone:** 01224123123

New Self-Assessment

You can submit again in 3 days.

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About Help Contact Close

- The “View Report” from the patient’s perspective (different patient than the above).

- Click “Close” to go back to the “View All Self-Assessment”.

Patient Self-Assessment

### Section 1: ECOG Performance Status

**Option B:** I am unable to do anything physically strenuous but I am mobile and able to carry out light tasks (e.g. light housework or office work).

### Section 2: General Wellbeing

(4 = "Not at all", 3 = "Several Days", 2 = "Over half the days", 1 = "Nearly every day")

**Feeling nervous anxious or on edge:** 2  
**Not being able to stop or control worrying:** 4  
**Having little interest or pleasure in doing things:** 3  
**Feeling down, depressed or hopeless:** 4

**Physical Symptoms:** 7  
**Relationships & Support:** 8  
**Activities & Interests:** 9  
**Overall Wellbeing:** 8

### Section 3: Weight

**Weight:** 67.0 kg  
**Scan results:** false

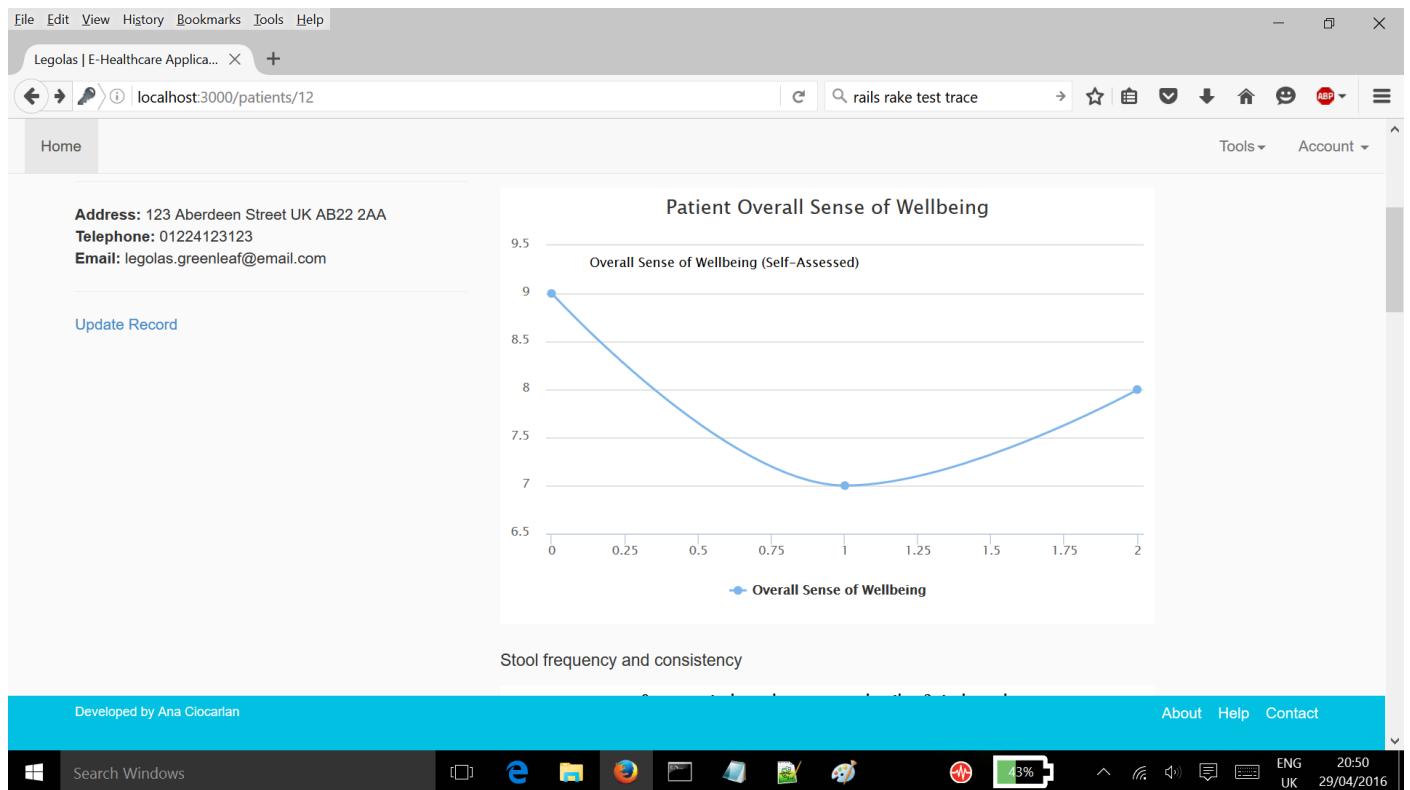
- The “View Self-Assessment” page containing the submitted form for the selected week.

The screenshot shows a web browser window displaying a medical application. The URL is `localhost:3000/patients/12`. The page title is "Legolas | E-Healthcare Applica...". The main content area shows a patient profile for "Mr. Legolas Greenleaf" (17 Mar 1926). On the left, there's a sidebar with patient details: Assigned Health Professional: R.N. Helen; Age: 90; Gender: male; Weight: 66.0 kg; Height: 1.9 m; Diet: standard; Smoking: Regular Smoker (weekly or daily); Alcohol: Occasional alcohol consumption; Colostomy Present: Yes. Below this are address, telephone, and email fields, and an "Update Record" button. The right side contains several sections: "Section 4: Medication" (Current medication: None), "Section 5: Symptoms" (Diarrhoea, Changes in appetite, Symptoms notes:), "Section 6: Toilet Talk" (Average stool consistency: Type 7, Average stool frequency: 7 or 8 per day, Stoma function: Unsatisfactory, Stoma complications: false), and "Section 7: Other notes" (To be contacted by nurse: false, Other notes:). A "Close" button is located at the bottom right of the modal window. The browser toolbar includes icons for back, forward, search, and refresh, along with a search bar containing "rails rake test trace". The status bar at the bottom shows system information: Windows logo, Search Windows, taskbar icons (File Explorer, Edge, File, etc.), battery level (44%), network signal, volume, and system status (ENG UK 29/04/2016).

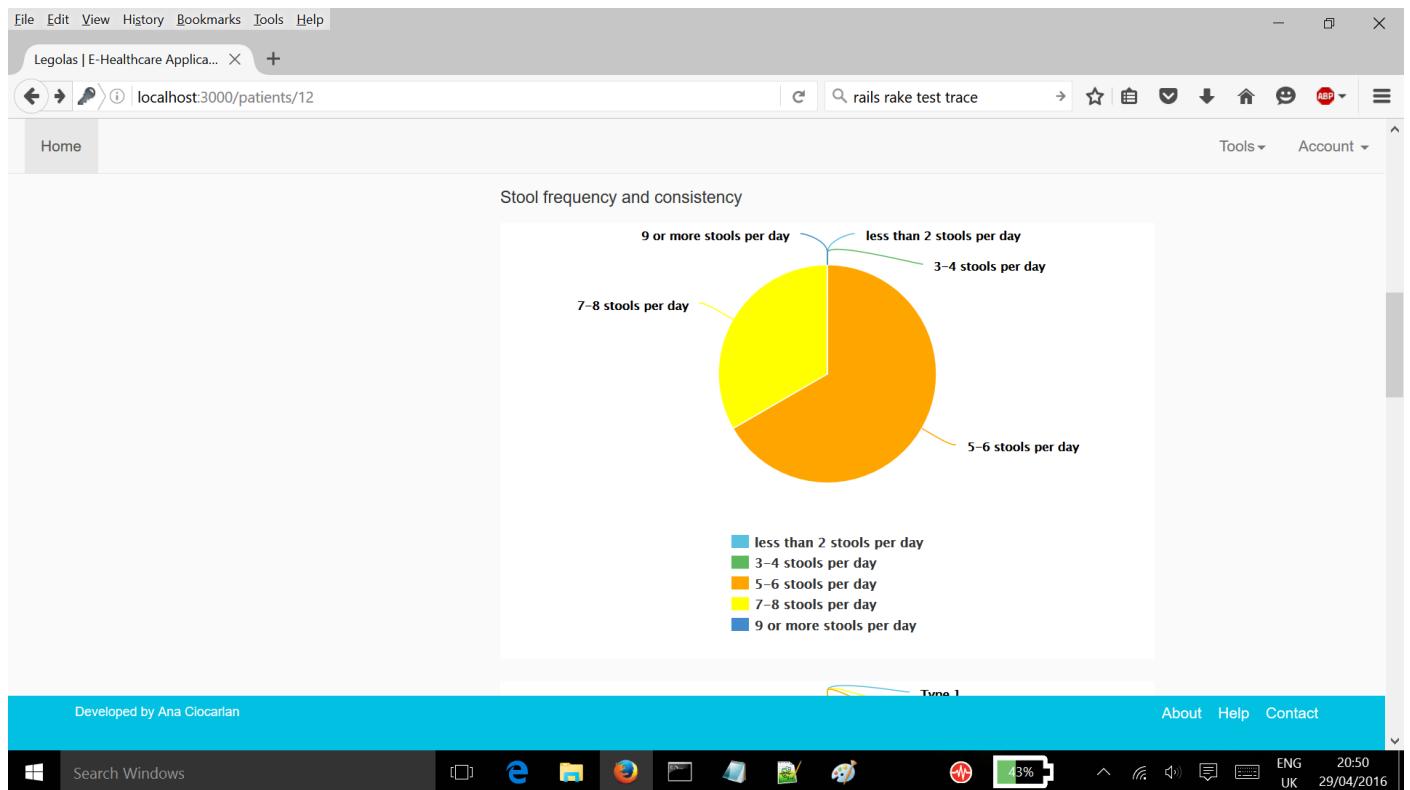
- Continuation of the “**View Self-Assessment**” page containing the rest of the submitted form for the selected week.

The screenshot shows a web application interface for a healthcare professional. At the top, there is a navigation bar with links for File, Edit, View, History, Bookmarks, Tools, and Help. Below the navigation bar, the title "Legolas | E-Healthcare Applica..." is displayed, along with a search bar containing the text "rails rake test trace". The main content area shows a patient profile for "Mr. Legolas Greenleaf" (17 Mar 1926). The profile includes a blue square icon with a white power symbol. Below the icon, the patient's name and birth date are listed. To the right of the name is a "Home" button. Further down, there are tabs for "Weekly Reports" and "Overall Report", with "Overall Report" currently selected. The main content area displays the "Overall Report" section, which contains a detailed description of the patient's medical history and current status. It mentions a 90-year-old male with Colorectal Cancer, successful surgery, and continuous improvement. The report also includes a self-assessment chart titled "Patient Overall Sense of Wellbeing" with a scale from 9 to 9.5. The chart shows a blue dot at approximately 9.1, labeled "Overall Sense of Wellbeing (Self-Assessed)". At the bottom of the page, there is a footer with links for About, Help, and Contact, and a copyright notice: "Developed by Ana Ciocarlan". The bottom right corner shows system status icons for battery level (44%), signal strength, and date/time (29/04/2016).

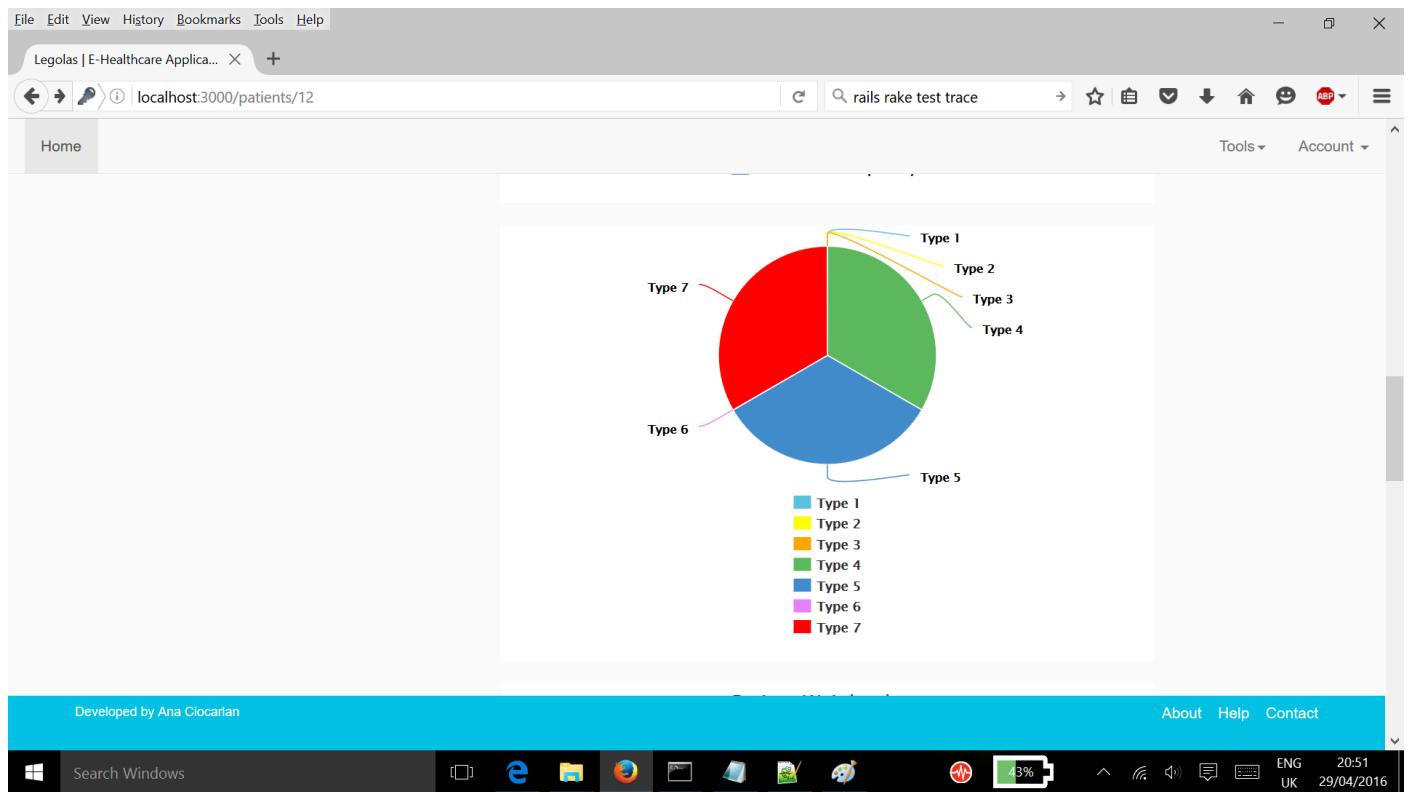
- The “Overall Report” page contains a short description of the state of the patient with data collected from all the submitted forms.
- Click “Weekly Reports” to return to the “View All Self-Assessment”



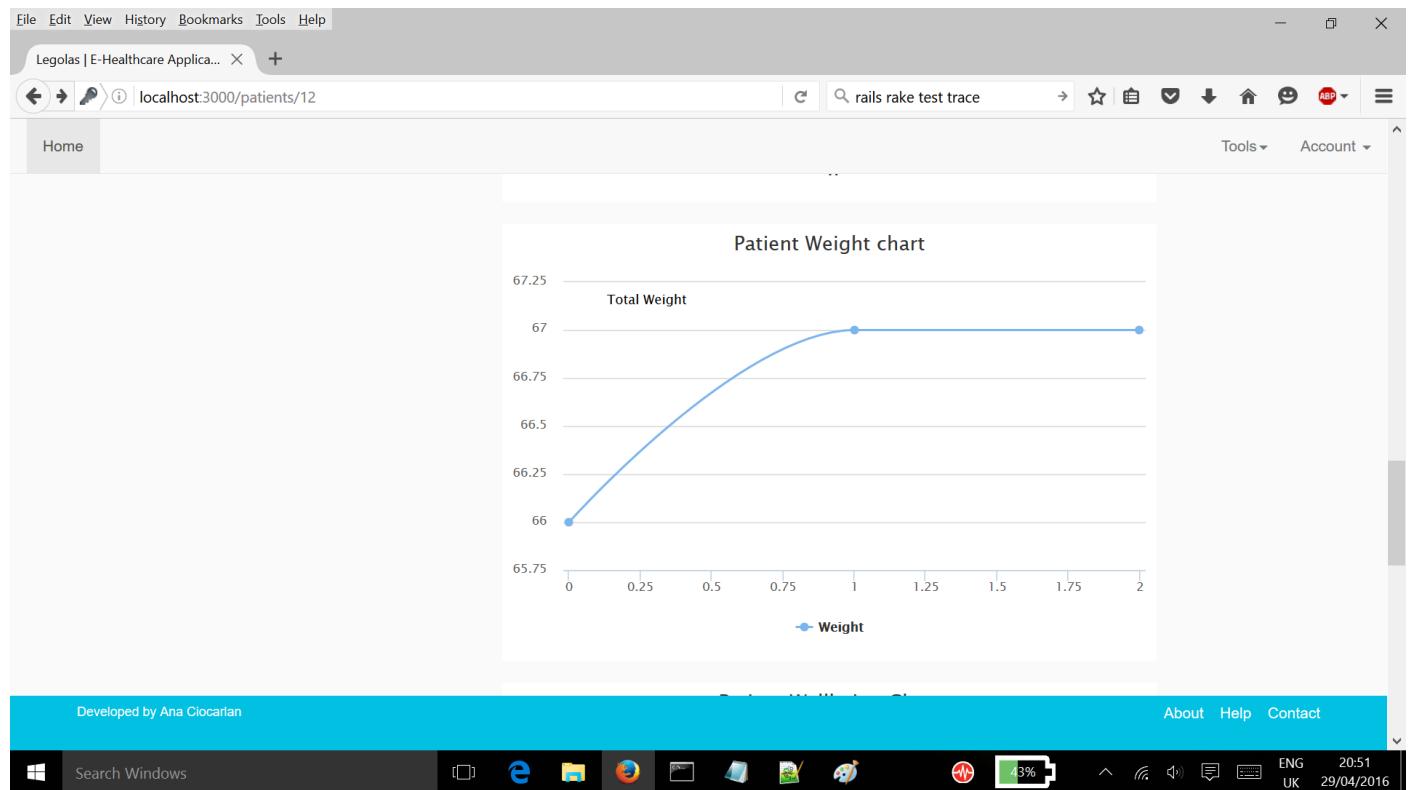
- Continuation of the “**Overall Report**” page contains diagrams reflecting the progression of the patient through time.



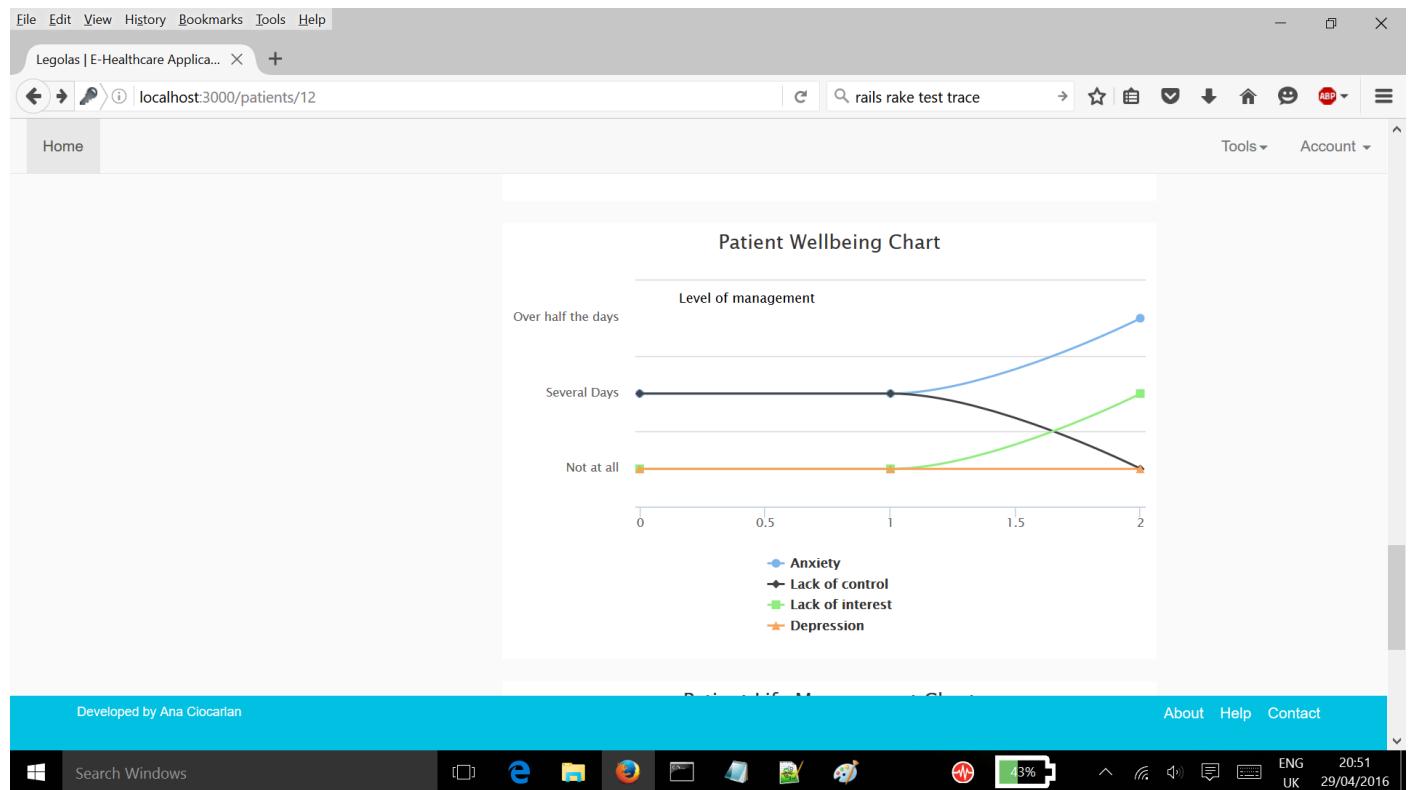
- Continuation of the “Overall Report” page contains diagrams reflecting the progression of the patient through time.



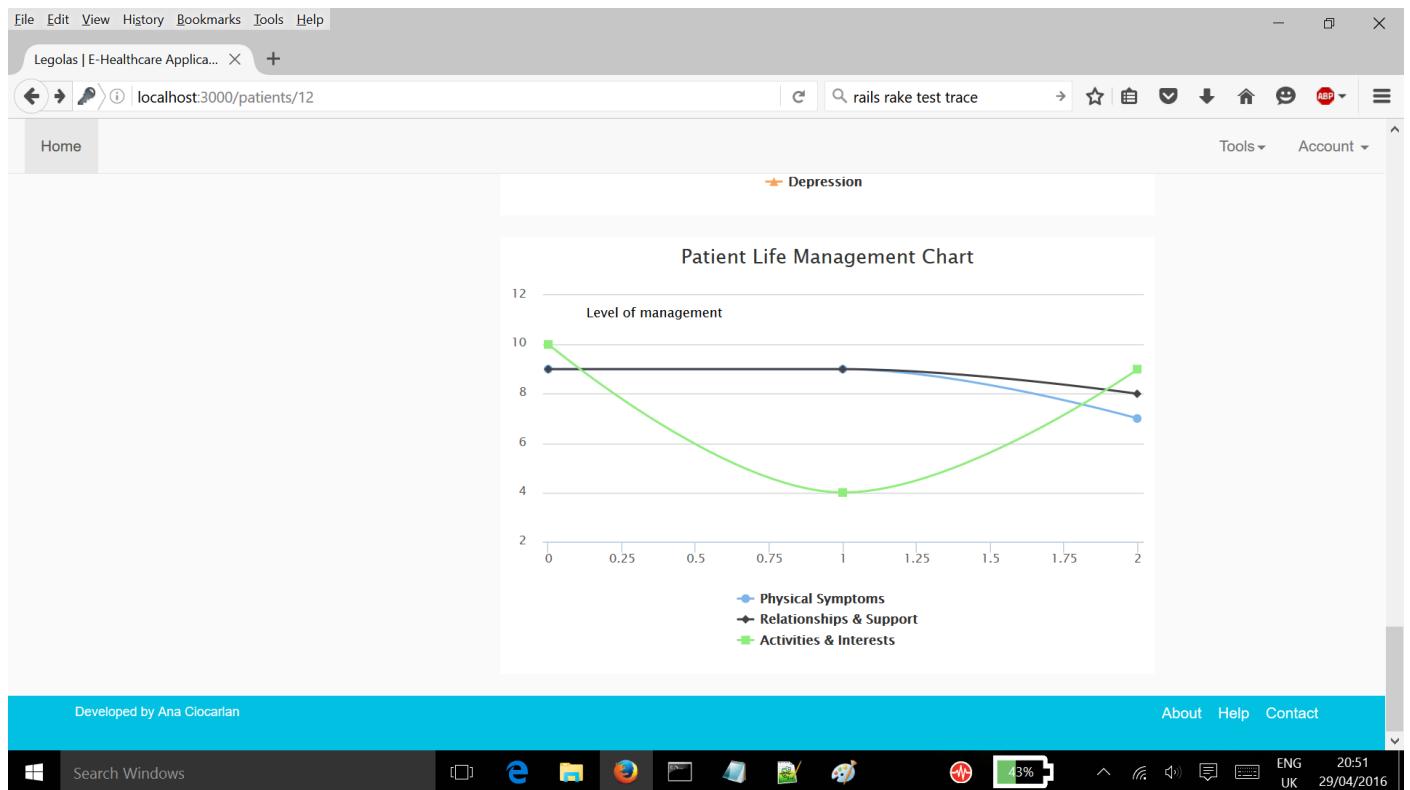
- Continuation of the “**Overall Report**” page contains diagrams reflecting the progression of the patient through time.



- Continuation of the "**Overall Report**" page contains diagrams reflecting the progression of the patient through time.



- Continuation of the “Overall Report” page contains diagrams reflecting the progression of the patient through time.



- Continuation of the “Overall Report” page contains diagrams reflecting the progression of the patient through time.

The screenshot shows a web application interface for a patient named Mr. Edward Grey. At the top, there's a navigation bar with links for File, Edit, View, History, Bookmarks, Tools, and Help. Below the navigation bar, the address bar shows the URL `localhost:3000/patients/13`. The main content area has tabs for "Weekly Reports" and "Overall Report". The "Weekly Reports" tab is selected, displaying a list of "Weekly Self Assessments (141)". Each entry includes a blue circular icon with a white 'G', the text "My Self-Assessment", and "Submitted 1 day ago". There are also links to "View Self-Assessment" and "View Report". On the left side, there's a sidebar with a profile picture of Mr. Grey, his name "Mr. Edward Grey", and the date "17 Apr 1993". Below this, a green button labeled "New Self-Assessment" is visible. A message indicates "You can submit again in 3 days." To the right of the self-assessments, there's a section for "Assigned Health Professional: Dr. Ana Ciocarlan" with details like Age: 23, Gender: male, Weight: 67.0 kg, Height: 1.8 m, Diet: Standard, Smoking: Non-Smoker, Alcohol: No alcohol consumption, and Colostomy Present: Yes. At the bottom of the page, there's contact information: Address: 123 Aberdeen Street UK AB22 2AA and Telephone: 01224123123. The footer contains links for About, Help, and Contact, along with system status indicators like battery level (42%) and date/time (29/04/2016). The browser taskbar at the bottom shows various pinned icons.

- The “**View All Self-Assessment**”, from the patient view contains details of the patient and a list of the submitted reports.
- On the left side, contact and personal details profile photo are listed
- Click “**New Self-Assessment**” to open the new form submission page (only available once every 7 days).
- Click “**View Self-Assessment**” to open the self-assessment window for that particular entry.
- Click “**View Report**” to open the generated report for that particular entry
- Click “**Overall Report**” to switch to the overall data on the progression of the reports. To go back to the weekly self-assessment, click the, “**Weekly Reports**”

The screenshot shows a web browser window with the following details:

- Header:** File, Edit, View, History, Bookmarks, Tools, Help.
- Title Bar:** New Self-Assessment | E-Heal... X +
- Address Bar:** localhost:3000/new\_patient\_selfassessment
- Search Bar:** rails rake test trace
- Toolbar:** Back, Forward, Stop, Refresh, Home, Tools, Account.

The main content area displays the following:

# New Self-Assessment

## Section 1: ECOG Performance Status

Tick one of the boxes below to let us know how you are coping just now:

- Option A:** I am fully active and able to carry on all my previous activities without restriction.
- Option B:** I am unable to do anything physically strenuous but I am mobile and able to carry out light tasks (e.g. light housework or office work).
- Option C:** I am up and about for more than 50% of the waking hours. I am able to look after myself, but unable to carry out any work activities.
- Option D:** I am spending more than 50% of waking hours in bed or in a chair and I am limited in what I can do for myself.
- Option E:** I am in bed or a chair all the time. I am completely disabled and unable to look after myself at all.

At the bottom of the page, there is a footer bar with the following information:

Developed by Ana Ciocarlan About Help Contact

Windows Search Windows Taskbar icons: File Explorer, Edge, File, Firefox, Task View, Mail, Photos, Paint, System, Battery (40%), Volume, Network, Language (ENG UK), Date (29/04/2016)

- The “**New Self-Assessment**” page contains the form required by patients to complete weekly in order to provide information about their status.
- The page contains a number question, answering a question requires the patient to click on the appropriate box, this will then highlight indicating that the values in the box has been selected.

**Section 2: General Wellbeing**

- Over the last week, how often have you been feeling nervous anxious or on edge? (Please tick your response)
- Over the last week, how often have you not been able to stop or control worrying? (Please tick your response)
- Over the last week, how often have you had little interest or pleasure in doing things? (Please tick your response)
- Over the last week, how often have you been feeling down, depressed or hopeless? (Please tick your response)

Developed by Ana Ciocarlan      About    Help    Contact

Search Windows      21:00      ENG UK 29/04/2016

- Continuation of the “New Self-Assessment” page.

5. Looking back over the last week, please mark the scale under each item below to indicate how well you have been managing in this area of your life.

- 1 = having major difficulties in this area, not managing at all well.
- 10 = managing very well despite any difficulties in this area.

Physical Symptoms (E.g. pain, fatigue, nausea)

Relationships & Support (E.g. family, friends)

Activities & Interests (E.g. work, home, leisure)

Overall Wellbeing

### Section 3: Your weight

Developed by Ana Ciocarlan      About    Help    Contact

Search Windows      21:00      ENG UK 29/04/2016

- Continuation of the “New Self-Assessment” page.

The screenshot shows a web browser window with the following details:

- Header:** File, Edit, View, History, Bookmarks, Tools, Help.
- Title Bar:** New Self-Assessment | E-Heal... X +
- Address Bar:** localhost:3000/new\_patient\_selfassessment
- Search Bar:** rails rake test trace
- Page Content:**
  - Section 3: Your weight**: A text input field asking "Measured on your own scales, what is your weight today? (kg)" with placeholder "Please enter your weight in kilograms..." and a "Submit" button.
  - Section 4: Your medication**: A text input field asking "Since your last check has your GP prescribed any new medication for you?" with "Yes" and "No" buttons.
  - Section 5: Your symptoms**: A list of symptoms with checkboxes: Abdominal pain, Abdominal bloating, Constipation, Diarrhoea, Changes in bowel habit, Rectal bleeding, Blood in urine.
- Footer:** Developed by Ana Ciocarlan, About, Help, Contact.
- Taskbar:** Windows icon, Search Windows, Start button, Taskbar icons for File Explorer, Edge, Firefox, File Manager, Mail, Photos, OneDrive, Task View, Power, Battery (40%), Volume, Network, Language (ENG UK), Date (29/04/2016), and Time (21:01).

- Continuation of the “New Self-Assessment” page.

File Edit View History Bookmarks Tools Help

New Self-Assessment | E-Heal... X +

localhost:3000/new\_patient\_selfassessment

rails rake test trace

Home Tools Account

## Section 5: Your symptoms

Please tick the boxes below to let us know if you are currently suffering from any of the following symptoms:

Abdominal pain	Abdominal bloating	Constipation	Diarrhoea
Changes in bowel habit	Rectal bleeding	Blood in urine	
Frequent urination	Incontinence	Difficulties when urinating	
Pain during urination	Heartburn or indigestion	Bladder spasms	
Feeling sick or vomiting	Changes in appetite	Feeling tired	Hotflushes
Sexual problems	Jaundice		

Please use this box to tell us more about your symptoms or about any other symptoms that might be bothering you.

Developed by Ana Ciocarlan

About Help Contact

Windows Search Windows

21:01 ENG UK 29/04/2016

## Section 6: Toilet Talk

- Continuation of the “New Self-Assessment” page.

File Edit View History Bookmarks Tools Help

New Self-Assessment | E-Heal... X +

localhost:3000/new\_patient\_selfassessment

rails rake test trace

Home Tools Account

## Section 6: Toilet Talk

Over the last week, what was your average stool consistency per day?

	Type 1: Separate hard lumps, like nuts (hard to pass)
	Type 2: Sausage-shaped, but lumpy
	Type 3: Like a sausage but with cracks on its surface
	Type 4: Like a sausage or snake, smooth and soft
	Type 5: Soft blobs with clear cut edges (passed easily)
	Type 6: Fluffy pieces with ragged edges, a mushy stool
	Type 7: Watery, no solid pieces, entirely liquid

Developed by Ana Ciocarlan

About Help Contact

Windows Search Windows

21:01 ENG UK 29/04/2016

- Continuation of the “New Self-Assessment” page.

The screenshot shows a web browser window with the following content:

- Header:** File, Edit, View, History, Bookmarks, Tools, Help. Address bar: New Self-Assessment | E-Heal... X + localhost:3000/new\_patient\_selfassessment. Search bar: rails rake test trace. Toolbar icons: back, forward, search, refresh, etc.
- Section 1:** Home. Three images of stools with labels:
  - Type 5: Soft blobs with clear cut edges (passed easily)
  - Type 6: Fluffy pieces with ragged edges, a mushy stool
  - Type 7: Watery, no solid pieces, entirely liquid
- Section 2:** Over the last week, what was your average stool frequency per day? Buttons: Less than 2, 3 or 4, 5 or 6, 7 or 8, 9 or more.
- Section 3:** How would you describe your stoma function? Buttons: Satisfactory, Unsatisfactory.
- Section 4:** Did you have any stoma complications in the past week? Buttons: Yes, No.
- Section 7:** Other notes. Subtext: Developed by Ana Ciocarlan. Navigation: About, Help, Contact.
- Windows Taskbar:** Search Windows, Start button, Taskbar icons for File Explorer, Edge, File History, Task View, Mail, Photos, OneDrive, Paint 3D, Control Panel, Task Scheduler, Task Manager, Battery (40%), Volume, Network, Language (ENG UK), Date (29/04/2016).

- Continuation of the “New Self-Assessment” page.

File Edit View History Bookmarks Tools Help

New Self-Assessment | E-Heal... X +

localhost:3000/new\_patient\_selfassessment

rails rake test trace

Home Tools Account

Less than 2 3 or 4 5 or 6 7 or 8 9 or more

How would you describe your stoma function?  
 Satisfactory  Unsatisfactory

Did you have any stoma complications in the past week?  
 Yes  No

**Section 7: Other notes**

Would you like to be contacted by a nurse?  
 Yes  No

Please use this box if there is anything else you would like to tell us.

Submit Self Assessment

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Windows Search Windows

21:02 ENG UK 29/04/2016

- Bottom of the “**New Self-Assessment**” page.
- Click on “**Submit Self-Assessment**” to finalize a new weekly form entry.

File Edit View History Bookmarks Tools Help

Edit Weekly Self Assessment | ... X +

localhost:3000/patients/13/selfassessments/183/edit rails rake test trace

Home Tools Account

# Edit Self-Assessment

## Section 1: ECOG Performance Status

Tick one of the boxes below to let us know how you are coping just now:

Option A: I am fully active and able to carry on all my previous activities without restriction.

Option B: I am unable to do anything physically strenuous but I am mobile and able to carry out light tasks (e.g. light housework or office work).

Option C: I am up and about for more than 50% of the waking hours. I am able to look after myself, but unable to carry out any work activities.

Option D: I am spending more than 50% of waking hours in bed or in a chair and I am limited in what I can do for myself.

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Windows Search Windows File Explorer Edge Mozilla Firefox File Paint 39% ENG UK 29/04/2016

- Top of the “**Edit Self-Assessment**” page, responses can be edited within the 7 day period allowed for each form.
- The design of the question changes in this page to allow users to distinguish better between their previously selected answers and the current options. Ticked boxes indicate previous answers.

File Edit View History Bookmarks Tools Help

Edit Weekly Self Assessment | ... X +

localhost:3000/patients/13/selfassessments/183/edit

rails rake test trace

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**Option E:** I am in bed or a chair all the time. I am completely disabled and unable to look after myself at all.

## Section 2: General Wellbeing

1. Over the last week, how often have you been feeling nervous anxious or on edge? (Please tick your response)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not at all	Several days	Over half the days	Nearly every day

2. Over the last week, how often have you not been able to stop or control worrying? (Please tick your response)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not at all	Several days	Over half the days	Nearly every day

3. Over the last week, how often have you had little interest or pleasure in doing things? (Please tick your response)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not at all	Several days	Over half the days	Nearly every day

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Search Windows 21:04  
ENG UK 29/04/2016

- Continuation of the “Edit Self-Assessment” page.

File Edit View History Bookmarks Tools Help

Edit Weekly Self Assessment | ... X +

localhost:3000/patients/13/selfassessments/183/edit

rails rake test trace

Home Tools Account

4. Over the last week, how often have you been feeling down, depressed or hopeless? (Please tick your response)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Not at all	Several days	Over half the days	Nearly every day

5. Looking back over the last week, please mark the scale under each item below to indicate how well you have been managing in this area of your life.

- 1 = having major difficulties in this area, not managing at all well.
- 10 = managing very well despite any difficulties in this area.

Physical Symptoms (E.g. pain, fatigue, nausea)

<input type="radio"/>									
1	2	3	4	5	6	7	8	9	10

Relationships & Support (E.g. family, friends)

<input type="radio"/>									
1	2	3	4	5	6	7	8	9	10

Activities & Interests (E.g. work, home, leisure)

<input type="radio"/>									
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ENG UK 29/04/2016

- Continuation of the “Edit Self-Assessment” page.

File Edit View History Bookmarks Tools Help

Edit Weekly Self Assessment | ... × +

localhost:3000/patients/13/selfassessments/183/edit rails rake test trace

Home Tools Account

**Overall Wellbeing**

1 2 3 4 5 6 7 8 9 10

**Section 3: Your weight**

Measured on your own scales, what is your weight today? (kg)

66

Have you had the results of your last scan?

Yes No

**Section 4: Your medication**

Since your last check has your GP prescribed any new medication for you?

Yes No

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Search Windows

39% 29/04/2016

- Continuation of the “Edit Self-Assessment” page.

Screenshot of a web browser showing the "Edit Weekly Self Assessment" page. The page displays a list of symptoms for users to check off.

If you answered yes, please write the name(s) of the medicines below and a brief explanation of why it was started.

### Section 5: Your symptoms

Please tick the boxes below to let us know if you are currently suffering from any of the following symptoms:

<input type="checkbox"/> Abdominal pain	<input type="checkbox"/> Abnormal vaginal bleeding
<input type="checkbox"/> Abdominal bloating	<input type="checkbox"/> Frequent urination
<input type="checkbox"/> Constipation	<input type="checkbox"/> Incontinence
<input type="checkbox"/> Diarrhoea	<input type="checkbox"/> Difficulties when urinating
<input type="checkbox"/> Changes in bowel habit	<input type="checkbox"/> Pain during urination

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Windows taskbar at the bottom: Search Windows, File Explorer, Task View, Edge, File, Mail, Photos, Paint, Power, Battery (39%), ENG UK, 29/04/2016, 21:05

- Continuation of the “Edit Self-Assessment” page.

Screenshot of a web browser showing the continuation of the "Edit Weekly Self Assessment" page. The page displays a list of symptoms for users to check off.

Please use this box to tell us more about your symptoms or about any other symptoms that might be bothering you.

### Section 6: Toilet Talk

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Windows taskbar at the bottom: Search Windows, File Explorer, Task View, Edge, File, Mail, Photos, Paint, Power, Battery (39%), ENG UK, 29/04/2016, 21:05

- Continuation of the “Edit Self-Assessment” page.

The screenshot shows a web browser window with the following details:

- Header:** File, Edit, View, History, Bookmarks, Tools, Help.
- Title Bar:** Edit Weekly Self Assessment | ...
- Address Bar:** localhost:3000/patients/13/selfassessments/183/edit
- Search Bar:** rails rake test trace
- Toolbar:** Back, Forward, Stop, Refresh, Home, Favorites, Download, Home, Smile, Help, Tools, Account.
- Content Area:**
  - Section Title:** Section 6: Toilet Talk
  - Text:** Over the last week, what was your average stool consistency per day?
  - Form:** A grid of six items, each with an icon and a description:
    - Type 1:** Separate hard lumps, like nuts (hard to pass)
    - Type 2:** Sausage-shaped, but lumpy
    - Type 3:** Like a sausage but with cracks on its surface
    - Type 4:** Like a sausage or snake, smooth and soft
    - Type 5:** Soft blobs with clear cut edges (passed easily)
    - Type 6:** Fluffy pieces with ragged edges, a mushy stool
- Footer:** Developed by Ana Ciocarlan, About, Help, Contact.
- Taskbar:** Windows logo, Search Windows, Taskbar icons (File Explorer, Edge, File Manager, Firefox, Mail, Photos, OneDrive, Control Panel, Task View, Power), Battery icon (39%), Network icon, Volume icon, Language icon (ENG UK), Date (29/04/2016).

- Continuation of the “Edit Self-Assessment” page.

File Edit View History Bookmarks Tools Help

Edit Weekly Self Assessment | ... X +

localhost:3000/patients/13/selfassessments/183/edit

rails rake test trace

Home Tools Account

Type 6: Fluffy pieces with ragged edges, a mushy stool

Type 7: Watery, no solid pieces, entirely liquid

Over the last week, what was your average stool frequency per day?

Less than 2    3 or 4    5 or 6    7 or 8    9 or more

How would you describe your stoma function?

Satisfactory    Unsatisfactory

Did you have any stoma complications in the past week?

Yes    No

If you answered yes, how was the complication dealt with?

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About Help Contact

Search Windows

21:06  
ENG UK 29/04/2016

- Continuation of the “Edit Self-Assessment” page.

If you answered yes, how was the complication dealt with?

I was able to deal with it myself.  
 It was dealt with by the stoma nurse.  
 It was dealt with by my GP.

**Section 7: Other notes**

Would you like to be contacted by a nurse?

Yes  No

If you answered yes, how would you like to be contacted?

Telephone  Email  Skype

Please use this box if there is anything else you would like to tell us.

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ENG UK 29/04/2016

- Continuation of the “Edit Self-Assessment” page.

It was dealt with by my GP.

**Section 7: Other notes**

Would you like to be contacted by a nurse?

Yes  No

If you answered yes, how would you like to be contacted?

Telephone  Email  Skype

Please use this box if there is anything else you would like to tell us.

Submit Self Assessment

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Search Windows      21:06  
ENG UK 29/04/2016

- Bottom of the “**Edit Self-Assessment**” page.
- Click “**Submit Self-Assessment**” to save the changes done to the report.

The screenshot shows a web browser window titled "Update Patient Record | E-Hea...". The address bar indicates the URL is "localhost:3000/patients/13/edit". The main content area is titled "Update Record: Edward Grey". It displays the following patient information:

- First name:** Edward
- Last name:** Grey
- Assigned health professional:** Dr. Ana Ciocarlan (Oncologist)
- Date of Birth:** 1993-04-17
- Gender:** male
- Colostomy Present:** Yes

Below this, there are input fields for "My weight (kg)" containing "67" and "My height (m)" containing "1.8". There is also a field for "My diet" which is currently empty. At the bottom of the page, a blue footer bar includes the text "Developed by Ana Ciocarlan", links for "About", "Help", and "Contact", and standard system icons for battery level (42%), signal strength, and date/time (20:56, 29/04/2016).

- In the “**Update Record**” patients can update their personal details

Screenshot of a web browser showing the "Update Patient Record" page. The URL is localhost:3000/patients/13/edit. The page contains sections for "My diet" (with dropdowns for diet, smoking habit, and alcohol consumption), "Address" (text input for address), "Telephone Number" (text input for phone number), and "Email" (text input for email). There are two green "Save" buttons: "Save personal details changes" and "Save contact details changes". The browser's status bar shows "rails rake test trace". The taskbar at the bottom includes the Windows logo, a search bar, pinned icons for File Explorer, Edge, and others, battery level (41%), and system status.

File Edit View History Bookmarks Tools Help

Update Patient Record | E-Hea... X +

localhost:3000/patients/13/edit rails rake test trace

Home Tools Account

My diet

Standard

Smoking habit Non-Smoker

Alcohol consumption No alcohol consumption

Save personal details changes

Address

123 Aberdeen Street UK AB22 2AA

Telephone Number

01224123123

Email

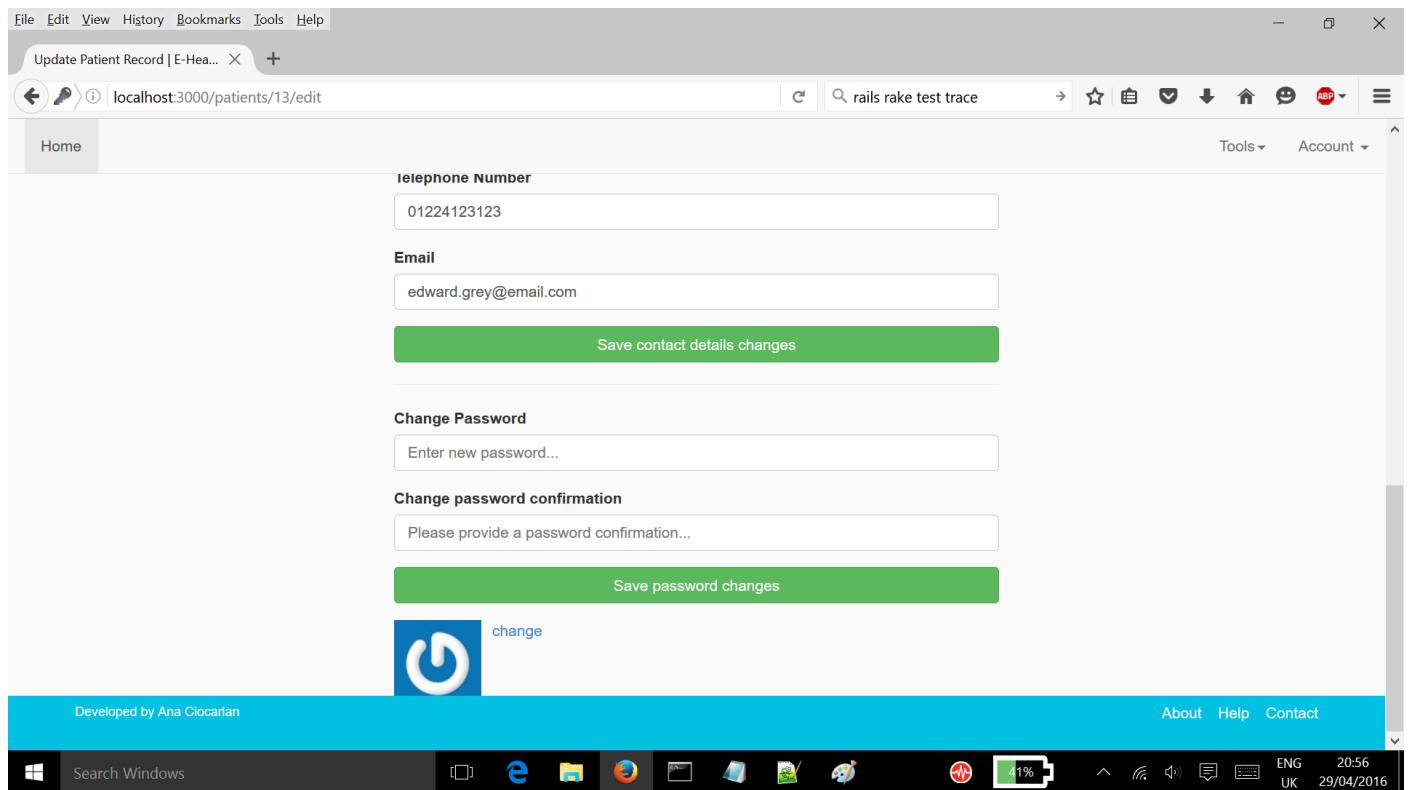
edward.grey@email.com

Save contact details changes

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Windows Search Windows File Explorer Edge Firefox File Notepad Paint Task View Battery 41% 20:56 ENG UK 29/04/2016

- Continuation of the “**Update Record**” page, individual sections can be changed separately
- Click on either “**Save personal detail changes**” or “**Save contact details changes**” to save the changes in their respective category.



- Bottom of the “**Update Record**” page.
- Click “**Change**” to update the patients profile photo.

File Edit View History Bookmarks Tools Help

Update Patient Record | E-Hea... X +

localhost:3000/patients/12/edit

Home Tools Account

## Update Record: Legolas Greenleaf

**First Name**  
Legolas

**Last Name**  
Greenleaf

**Assigned health professional** Dr./R.N. Ana Ciocarlan

**Date of Birth** March 17 1926

**Gender** male

**Patient weight (kg)**  
66

**Patient height (m)**  
1.9

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- The “Update Patient Record” page, professionals are given the right to modify patient record data.

File Edit View History Bookmarks Tools Help

Update Patient Record | E-Hea... X +

localhost:3000/patients/12/edit

rails rake test trace

Home Tools Account

**Diet**  
standard

**Smoking habit** Regular Smoker (weekly or daily)

**Alcohol consumption** Occasional alcohol consumption (monthly)

**Colostomy present** Yes

**Cancer type** Colorectal Cancer

**Tumor stage** T1

**Tumor location** left

**Lymphovascular invasion present** Yes

**Perineural invasion present** No

**Surgery date** February 5 1916

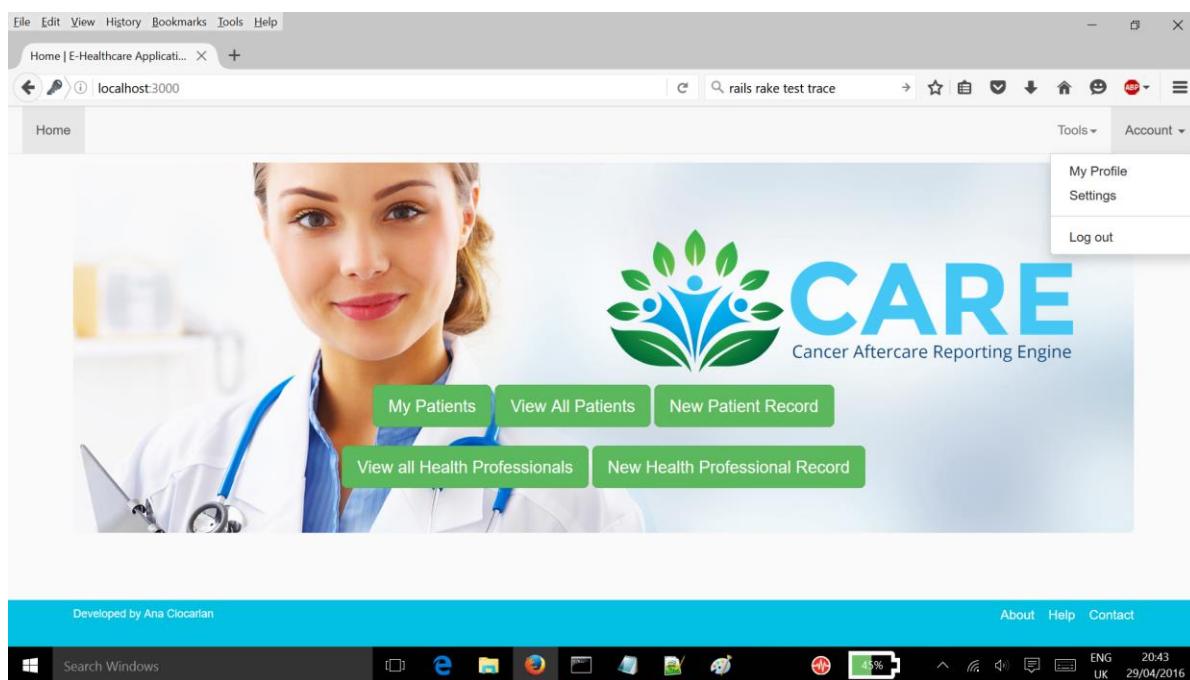
**Chemotherapy** No

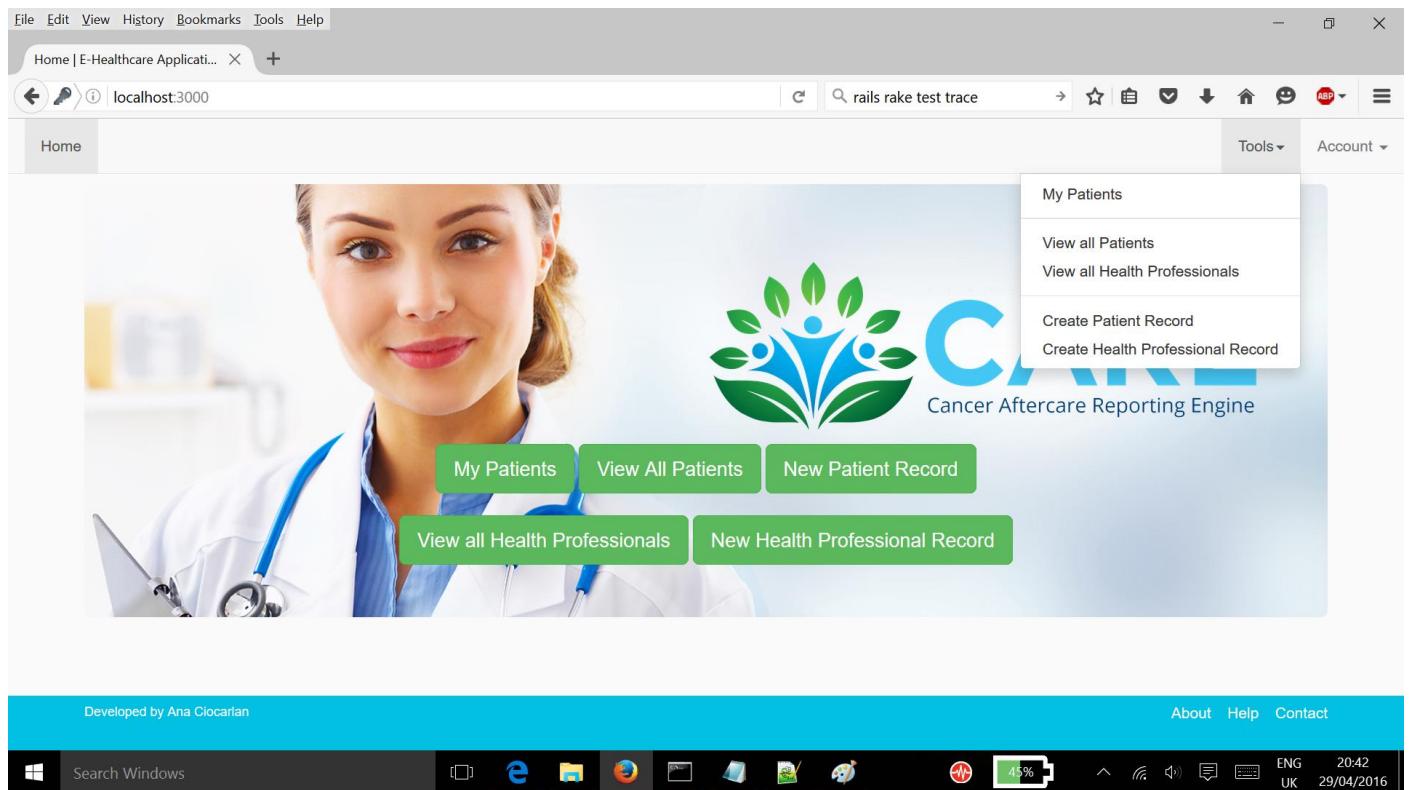
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- Continuation of the “Update Patient Record” page

The screenshot shows a web browser window with the title "Update Patient Record | E-Hea...". The address bar displays "localhost:3000/patients/12/edit". The page content includes fields for "Address" (123 Aberdeen Street UK AB22 2AA), "Telephone Number" (01224123123), "Email" (legolas.greenleaf@email.com), "Change password" (Enter a new password for the patient...), and "Confirmation" (Please provide a password confirmation...). A green "Save changes" button is at the bottom, along with a blue power icon labeled "change". The footer contains links for "About", "Help", and "Contact".

- Bottom of the “Update Patient Record” page.





Click on either “Tools” or “Account” to access drop down menus

### ***Maintenance Manual***

Follow these steps to access the application:

1. Install JRuby
2. Install Java SE
3. Start Terminal
4. Setup a new directory
5. Install bundler: `jruby -S gem install bundler`
6. Install Rails :`jruby -S gem install rails -v 4.2.2`
7. Run Rails Server: `rails s`