

# **Design and Implementation of an e- Healthcare Subsystem for Chronic Renal Failure Patients**

**Collaborative and integrated approaches to health 2009:3**

Li Yu, Sibin Zhao, Eric Chen, Kerstin Blomqvist

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## Design and Implementation of an e-Healthcare Subsystem for Chronic Renal Failure Patients

**Abstract:**

This degree project deals with the analysis, design and implementation of an e-healthcare subsystem. The subsystem is a prototype for the patients in the chronic renal failure unit. The main purpose of this project is to make research on information and communication technology (ICT) applied on health care system and data presentation. The expected result is that a worked e-healthcare subsystem is implemented to demonstrate the application of modern ICT, and a good foundation for applying for new e-healthcare projects.

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**Approved by:**

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Date

## **Summary**

This degree project deals with the analysis, design and implementation of an e-healthcare subsystem. The report is divided into three main sections; analysis, design and implementation, conclusion and further work recommendations.

The main aim and purpose of this project is to make research on the using and application of information and communication technology (ICT) in the e-healthcare system with the analysis of data presentation and system integration. The growing elder population is a great challenge in the society. To meet the needs of this increasing population, development and implementation of an e-healthcare subsystem that provides better test processing, test result presentation and self-care guidance is important and necessary. A worked e-healthcare subsystem which is implemented to demonstrate the application of modern ICT, and a good foundation for applying for new e-healthcare project are the expected results for this project.

In the analysis chapter, an appropriate and improved data presentation is derived. After the analysis of requirement, the main functions of the subsystem are formed. From the design chapter, the guidelines and recommendations for web design of e-healthcare system for the elderly are laid out. The elementary design for the system is also followed the guidelines. The first interview with the end-users and the suggestion from the end-users will be described in design chapter too. There will be a discussion and problem solving of implementing a prototype of the system in Chapter Implementation. The second meeting and testing with end-users is also included. The conclusion and recommendation for further work are also referred after the implementation chapter.

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# 1. Introduction

## 1.1. Background

### *1.1.1. Swedish health care system*

Nowadays, Sweden's entire population has equal access to health care services. The Swedish health care system is government-funded and heavily decentralized.

The health care delivery system, managed by the county councils involves primary care, hospital care as well as public health and preventive care. The county councils are in health care districts with responsibility for the health of the population in its area. The care facilities are organized as regional hospitals, district county hospitals. Primary care is provided in health care centers (vårdcentraler) [15]. In the most southern part of Sweden, Skåne, where Malmö is situated, the health care is managed by county council Region Skåne.

### *1.1.2. Aging*

The world's pensioners are growing in number and increasing in age, and are making new demands regarding their quality of life. These demographic and social changes are creating new business opportunities and technologies such as digital healthcare services in the home, where Sweden is in the forefront.

The life expectancy of the Swedish population continues to rise. In 2005 the life expectancy was 78 years for men and 82.8 years for women [3]. A little more than 5 percent of the population is 80 years or older, which means that Sweden has proportionally Europe's largest elder population [3].

Satisfying the needs of the world's soon-to-be-gigantic elderly population is – without exaggeration – a political and socioeconomic challenge. Providing health care for a growing elder population is a great challenge. It requires better cooperation between the county councils' health care services and the elder care that is the responsibility of the municipalities [3].

One way to achieve this is within the framework of a relatively new concept, "integrated care." This involves a variety of care providers, such as local hospitals, health centres and social services, which coordinate their services in order to meet patients' needs.

In the future, integrated care will take care of most everyday health care needs – particularly common and recurring conditions – as well as the needs of those who have multiple chronic conditions.

### *1.1.3. Problem of Hospitalizing in Sweden*

Malmö, with its 280,000 residents, is Sweden's third-largest city. To see a physician, a

patient must go to one of two local clinics before they can see a specialist. The clinics have security guards to keep patients from getting unruly as they wait hours to see a doctor. The guards also prevent new patients from entering the clinic when the waiting room is considered full [16]. Uppsala, a city of 200,000 people, has only one mammography specialist. Sweden's National Cancer Foundation reports that in a few years most Swedish women will have no access to mammography [16].

More patients and few doctors make this problem more serious.

#### ***1.1.4. Obstacles for Information Communication Technology (ICT) in Health Care***

Within the Health Care sector, there are many strong professional cultures, the strongest of them being those of doctors and those of the nurses. People are used to seeking for these professions, and are not much up for abstract systems such as computers [5].

Patient care is very culturally bound, and especially the administrative processes behind vary greatly from one country to another. This, of course, makes standardization very difficult and the industry a bad target for suppliers of standard software and platforms.

## **1.2. Presentation for Target Group**

### ***1.2.1. Growing Requirement***

Sweden is already amongst the countries with the highest percentage of elderly, and now the large generation born in the '40s is going into retirement [4]. This is a generation that is accustomed to consuming a lot, used to traveling and capable of utilizing new technology.

Chronic diseases that require monitoring and treatment – and usually a lifetime of medication – place high demands on the health care system [3]. For many elderly, receiving care in the home increases quality of life and reduces healthcare costs.

### ***1.2.2. Feature of the Target Group***

The target group in this project is the patients who are not familiar with how to use the digital products of information communication technology (ICT) usually in their daily life. However, they really need a lot of information of their condition at intervals, such as the blood test result and routine examination result, and the easiest way to acquire such information is using ICT.

Most people in the target group are the aged. The older users were more likely to assign blame when using ICT product. They may appear to blame themselves or blame the product for any difficulties which they encountered. For example, they may say that 'I don't really know what I'm doing' when they want to browse a webpage but it requests to install a plug-in. Some people may also say that 'Well, that's stupid'

when a website using too many confusing links.

They often suffer from visual impairments. It is difficult for such users to read characters that are too small. Placing too much strain on their cognitive capabilities can distract them.

Increased age was associated with increased motor noise and slower movements.

### **1.3. Aim and Purpose**

#### ***1.3.1. Necessity of an E-Healthcare system and ICT application***

According to the facts that mentioned above, hospitalizing problem is getting more and more serious with aging and growing elder population.

Health-care –related expenses grow in all modern societies. People live longer, and even severely handicapped or sick people can be offered quite normal live environments and conditions. New diseases are being discovered all the time, and even small malfunctions in the human body, that before went unnoticed, are being addressed by modern medical science [5]. This all is of course to cause enormous costs for the society. If new extra resources are not available from other sectors of the society, the only way to answer to the increased demand is increased efficiency. A key to this efficiency is information technology, which frees Health Care professionals from routine tasks to patient care [5].

Actually, at the moment, telecommunications-based systems are developing faster than traditional information systems. Keywords in this area are Internet and mobile communications, both to be integrated in the near future. Advances in telemedicine and especially in graphical data manipulation should neither go unnoticed. Computer files are slowly beginning to substitute old media for x-ray picture storage. Computers, for example, can too very effectively scan vast amounts of pictures and select outstanding cases for further human inspection.

Education of Health Care staff is growing in intensity and coverage [5]. Computers are essential tools for future doctors already in the education phase, and they get into interaction with them even in the private lives, say at homes. Internet and other digital sources are substituting traditional books and journals as sources of knowledge in the sector [5].

Chronic Renal Failure is a condition that often progresses during a number of years. When the condition worsens, it requires dialysis treatment or a kidney transplant. To slow the damage of the kidneys, medications and life-style restrictions are important. Such treatment needs regularly checking with blood tests and urine analysis.

However, in Swedish health care system, when a physician orders a blood test for a

patient for example, the patient goes to the care centre to leave the blood samples that are transported to some laboratory for the analysis. The results are sent to ordered doctor. If the results are un-normal, the patient may be informed about the test results via telephone or letter. Test results that are normal are not necessarily informed about. So the patient does not receive so much information or feedback on the test. However, for many patients, they would like to know about their test results, and meaningful feedback can be a great help for them to do self-care.

As a chronic disease patient of hyperthyroidism, I (the present writer, Sibin Zhao) need to do the blood test every month for observing my health condition. The Swedish health care system is quite different from my motherland. The patients here cannot do anything after the blood test in the care centre. I must wait for several weeks to get the letter from my doctor, and the content of the letter is only several sentences like “All the results are normal. Don’t worry.” Furthermore, the way I tried to get my detailed test results after my last blood test is to write a letter to my doctor and ask him to send a copy of my results to me. After two weeks, I got the letter from my doctor and he just wrote 3 values of my test results and said “Other results are normal.” It’s quite inconvenient for the patients to get their detailed results. The only thing I can know is normal. If there is any problem in my results, my doctor will also gave prescription and advice in the letter or ask me go to the hospital. In my opinion and advice, the easy, effective and convenient communication between patients and doctors is supposed to exist.

ICT has been used widely in our society as mentioned before. So the better use of ICT in the test process, test result presentation and self-care guidance would be welcome by the patients and provide new dimension in the modern healthcare.

### ***1.3.2. e-Healthcare Subsystem Projects***

This e-Healthcare Subsystem for Chronic Renal Patients is collaboration between nursing and computer science. The project took its starting point in a participatory action research project, “What happens when you view the patients as experts?”, where patients, nurses, the head of the hospital development unit and a researcher from Forskningsplattformen för Närsjukvård explored how the health care could be developed. The patients expressed the importance of having access to blood tests and urine analysis.

“I have got used to that you contact me if something is wrong. Not everyone does, but it should be obligatory. Then you know, you get twice as happy if the tests are Ok. It is important to know when it is a bit better” (Patient with Chronic Renal Failure).

During the project, the group made contact with researchers from the Department of Computer Science at Kristianstad University College and asked for their help to develop a feed-back system.

### ***1.3.3. Objectives and Methods***

As the mentioned necessity of e-healthcare system, this project focuses on using modern ICT to build a subsystem of test result presentation and self-care guidance for the renal patients in Skåne Region.

In this project, the research and implementation of e-healthcare subsystem was based on literature study in web and system design for special people, interview and analysis the end-users' requirement, research and integration with existing systems, and using modern ICT to implement. Through these aspects, a high efficient and sustainably developed e-healthcare prototype subsystem for the renal patients in Skåne Region was expected to be created.

This system can greatly decrease enormous costs for the society and relieve the pressure from growing elder population in hospitalizing problem using ICT. Moreover, this system is more beneficial to the patients. With the system, the patients will not only wait from the doctors. After leaving the blood samples in care centre and test results coming out, they can get their results timely. Not this merely but also for the patients, they can get the introduction of the blood samples and the suggestion from the doctors, which really promote the communication between patients and doctors. At the same time, the patients can also do the self test by the system.

Through the literature study and interview with end-users, this project found a good solution to the web and system design for elderly people. With the investigation of test data presentation and analysis of users' requirement, the appropriate system function and the data presentation must be easy to understand and easy to perform.

## **1.4. Main Functions**

As the introduction of this subsystem's background, it is a web subsystem for the chronic renal failure patients. Due to the system is still a prototype, it only have two group of roles, Administrators and Users (Patients). With the interview and analysis of the end-users' requirement, the functions are divided into four main parts for the users and admin system.

### ***1.4.1. Admin System and Login***

The admin part in this subsystem is for the administrators to edit user profile and update the information in database. The administrator has the permission to modify the user profile and update the user's test results. The updating for the result suggestion and add new blood samples into the database are included in administrator's permission.

The normal user will use the login page to login to the system. After login, they will find their profile on the webpage, which contains their name, address and the haunts hospital of the user.

#### **1.4.2. “Mina resultat” – My result**

This e-healthcare subsystem is developed for chronic renal failure patients who periodically need to do a blood test. The mainly important function is to offer the patients to check their blood test result.

Collect and list the entire tests in the first page of this function with the date and the care centre where they did the blood test. The user can click the date to view the detailed results.

The system will show the result in graph like a bar chart. The graph also contains the samples which the blood test includes. If the mouse moves onto the name of the blood test sample, it will show a short paragraph of the introduction of this sample. If the mouse moves onto the result in graph, it will show the test result value of this sample and the suggestion from the doctor. The user can also click the other date above, and then the graph will show the test result on that date.

#### **1.4.3. “Min dagbok” – My diary**

In the diary function, the user can write the diary and save it into the database. It's the function for the users to write their health condition. It is more efficient and convenient way for the patients and doctors communicating with each other. Although it might increase the doctors' workload cause the doctors need to read more information from the patients, this function can also help the patients to remember their condition in one period, and prepare for the next appointment with doctor. Moreover, the patient can also use the diary to investigate the change of their health condition from their feeling, and might adjust their living habits or eating habits by themselves referring to the conditions record in their diary.

First page of “My diary” is the list of user's diary with the date and title. Click on the date or title, it will come to the content. In the page of the content, it also contains the result graph as “My result” in the same page. That function will help the patients get a better understanding of their health condition. The user can write new diary, and all of the diaries can be edited or deleted by the user.

#### **1.4.4. “Jämföra Resultat” – Result Comparison**

This is the hardest and most important function in this project. Blood test result comparison is a visual representation of the patient's health condition trend. From the fluctuation and variation shown in the graph, the patients can understand and comprehend the progression of their disease.

Collect and list all the blood test samples, the date, the name of care centre, and the results on the page. The user can choose one sample firstly. Click the results you want to compare, and the checked results comparison will be shown on the graph as broken line graph. Every point in the graph represents the result of every test in this blood

sample. The fold line shown on the graph can give a visual representation of their disease trend.

There is another part in this comparison. This function is required by the end-users. They not only want to have the result comparison in graphic view, but also in table view. List the checked results in a table with date and result comparison.

#### ***1.4.5. “Övriga resultat” – Other result***

“Other result” function can be also called “Self test”. The chronic renal failure patient can do some simple test by themselves at home, for example, BMI test, blood pressure etc. These tests are self test which means the patients do the test without the nurses and laboratory analysis. Due to this case, how the patients get the correct diagnosis and suggestion of improving his health condition is the aim and purport of this function.

There are three self tests in this subsystem, BMI test, blood pressure and blood sugar test. After the user fill in their test result and click “Test”, the system will show the diagnosis, introduction of the test and suggestion of the result to the user.

## **1.5. Report Organization**

This report is divided into six chapters. From the analysis, design and implementation, these three parts, the report will describe and present the whole project.

The first chapter is Introduction Part. It introduces the project’s background, aim and purpose, functions etc. in a briefly way.

The second chapter is Analysis Part. All of the analysis in this project will be listed in this chapter. A brief introduction of ASP, data presentation research in this project and analysis on requirement list are described in this part.

The third chapter is one of the most brilliant parts in this project. The first point in this chapter is literature study which contains the study of web and system design for elderly people. From the literature study, the elementary design of the subsystem was created. After introduce the design roughed out, the interview with the end-users help us to decide the final effect drawing for this subsystem.

The implementation and test part states and discusses how the functions of the system are achieved and implemented. The first part will describe how to achieve the main functions in this project by using which technology or technical application. The second part discusses the design and foundation of database. The third part will show the main problems what we meet in the implementation time and how we solved. The following parts describe the test with end-users and what we improved after the test.

The fifth is the conclusion part which is the rearrangement of introduction. Moreover, conclusion part included the review of analysis, design and implementation part. The last chapter is about future work. The modifiability of this system and the sustainable further work are stated in this chapter.

## **1.6. Acknowledgements**

This project would not have been possible without the support and encouragement of our instructors Dr. Eric Chen and Dr. Kerstin Blomqvist, under whose supervision we chose this topic and began the project. We would like to thank Ms Eva Theander, who is our collaborator and helped us to solve the problem with the professional knowledge of health care. Moreover, we are really grateful for that Dr. Kerstin Blomqvist and Ms Eva Theander arranged the meeting for us with our end-users, communicated with the nurses in Hässleholm Hospital and supported the data what we needed for this project. Thanks for their help. We would also like to thank the nurses from the chronic renal failure unit and the patients who attended in our meeting and gave us great help in our main idea in design.

## 2. Analysis

### 2.1. Technology Selection

#### 2.1.1. *ASP Technology Introduction*

Active Server Pages or ASP, as it is more commonly known, is a technology that enables you to make dynamic and interactive web pages [18]. ASP uses server-side scripting to dynamically produce web pages that are not affected by the type of browser the web site visitor is using. The default scripting language used for writing ASP is VBScript.

ASP pages have the extension .asp instead of .htm, when a page with the extension .asp is requested by a browser the web server knows to interpret any ASP contained within the web page before sending the HTML produced to the browser [18]. So all the ASP is run on the web server and no ASP will ever be passed to the web browser. Any web pages containing ASP cannot be run by just simply opening the page in a web browser. The page must be requested through a web server that supports ASP, this is why ASP stands for Active Server Pages, no server, no active pages.

#### 2.1.2. *Comparison between ASP and PHP*

When building web sites, ASP and PHP are very popular languages. They are both programming languages that are commonly used to create websites. Unlike the usual static html web pages, ASP and PHP websites are dynamic and can allow users to interact and exchange information using the website's databases.

ASP (Active Server Pages) is from Microsoft and is used with IIS (Internet Information Server) that runs on Microsoft servers. PHP (PHP: Hypertext Preprocessor) is from Rasmus Lerdorf, who originally designed this parsing language which was later modified by different people. It runs on Unix and Linux servers and the more updated PHP programs can now run on Microsoft Windows.

PHP is based on C++ language and the syntax used in PHP is quite similar to C/C++. C/C++ is still considered the best programming language by many programmers and people who love this language would surely feel more comfortable with the syntax of PHP. ASP on the other hand has a more Visual Basic kind of syntax that again is closely related to only Microsoft products.

To run ASP programs which needs IIS installed on a Windows platform server, which is not free. PHP programs run on Linux, which is free. Even the connectivity of the database is expensive in the case of ASP as MS-SQL is a product of Microsoft that needs to be purchased. PHP generally uses MySQL, which is freely available.

Loading speed is a big factor in maintaining a website. If you are particular about

speed, then you need to go with PHP [19]. PHP codes runs much quicker than ASP basically because it runs in its very own memory space while ASP uses an overhead server and is uses a COM (Component Object Model) based architecture [19].

In conclusion, both PHP and ASP have its own advantages and disadvantages. Both languages have their advantages specific to users. Some would argue that both the languages have their own importance and depending on the user's requirements the language and the platform can be chosen.

### ***2.1.3. Selection for E-healthcare subsystem for chronic renal failure patients in Skåne Region***

With the information from the collaborator in Skåne Region that the user environment is Microsoft Windows and ASP is used in the implementation of Skåne Region website, we decided to use MS ASP technology to build the web site [28].

## **2.2. Data presentation**

### ***2.2.1. Introduction***

In the management of socio-medical institutions at all levels, effective data keeping is very essential. Keeping data is not an end in itself; rather it is a means to an end. The end is to generate or procure relevant data to be processed into information on which effective administrative decisions are based. In this information age, effective management of information, using manual and computerized techniques, is a necessity. Effective Management Information System (MIS) ensures adequate capture, processing, storing, retrieving and communicating relevant and timely information to school personnel and the general public on which action for the current and future developmental activities could be based [6].

In our point of view, data presentation is the techniques of presenting unwieldy and cumbersome data in concise and meaningful forms, for proper interpretation and analysis of the existing situation.

It is obvious that data and information differ. Data refer to raw, unprocessed facts or observation which is not interpreted, which may take the form of words, numbers or characters. Information on the other hand, refers to processed or analyzed data that meaningfully inform the recipient about a situation and as such empowers efficient action.

There is therefore the need to process data into information and present the information in a form that can be easily understood and utilized.

### ***2.2.2. Literature Study***

Good data presentation skills are to data-based analysis what good writing is to literature, and some of the same basic principles apply to both. More important, poor

graphical and tabular presentations often lead both readers and writers to draw erroneous conclusions from their data and obscure facts that better presentations would reveal. Some of these practices involve deliberate distortions of data, but more commonly they involve either unintentional distortions or simply ineffective approaches to presenting numerical evidence.

There are the development of a substantial literature on the art and science of data presentation, much of it following Edward R. Tufte's path breaking work, *The Visual Display of Quantitative Information* [1]. With his admonitions to "show the data," "minimize the ink-to-data ratio," and avoid "ChartJunk", Tufte established many of the basic rules and principles of data presentation and demonstrates over and over again how effective data presentations combined with clear thinking can reveal truths hidden in the data. Howard Wainer's work extends Tufte's standards and demonstrates the many errors that have ensued from statistical fallacies and faulty tabular and graphic design [1]. The development of spreadsheet and other software has greatly simplified the tasks of tabular and graphical data presentation [1].

### ***2.2.3. Various Forms***

Data can be summarized and presented in various forms. These include the following [6]:

#### *Tabulation*

This deals with presentation of data in tabular form. A table is an array of data in rows and columns. Tabulation condenses a large mass of data and brings out the distinct pattern in a data in an attractive form. It enables comparison to be made easily among classes of data and takes up less space than data presented in narrative form.

#### *Pie Chart (Circle graph)*

A Pie chart consists of a circle, divided into sectors, which are proportional to the data. The sum of angles in circle is 360 degrees. A total of all cases are found and the percentage of each case is found in relation to 360 degrees.

This is a convenient way of showing the sizes of the component figures in proportion to each other and the overall total.

#### *Bar Chart*

Bar chart consists of separated rectangular bars drawn such that the height is equivalent to the frequency. The bars can be horizontal or vertical. Unlike the pie chart, it is easier to make comparison of the heights than of sectors.

#### *Histogram*

This is similar to the bar chart except that the bars are joined to one another. The area of each rectangular bar is proportional to its frequency. The line joining the midpoint of one bar to the other is referred to as the frequency polygon.

### Line Graph

Data can also be represented in the form of line graph. The points on the line, represented by any symbol indicate the occurrence of the phenomenon of interest.

From the fluctuation and variation shown in the graph, the trend of each point in one period is in a visual representation.

#### 2.2.4. Selection for the forms

The purpose of putting results of test into graphs, charts and tables is two-fold [27]. First, it is a visual way to look at the data and see what happened and make interpretations. Second, it is usually the best way to show the data to others. Reading lots of numbers in the text puts people to sleep and does little to convey information.

There are two parts in this project that should use data presentation. In “My result”, the blood test results of each test should be presented to the users. Moreover, there also need to have the data presentation in “Result Comparison” to help the patients comprehend the progression of their diseases. How to present the data should be considered.

In “My result”, the data concerning several categories (blood test sample) should be presented. These categories are not extremely related with each other. To show these kinds of data, we improved little in the form of the bar chart. Keep the top of bar chart and discard the “bar body”.

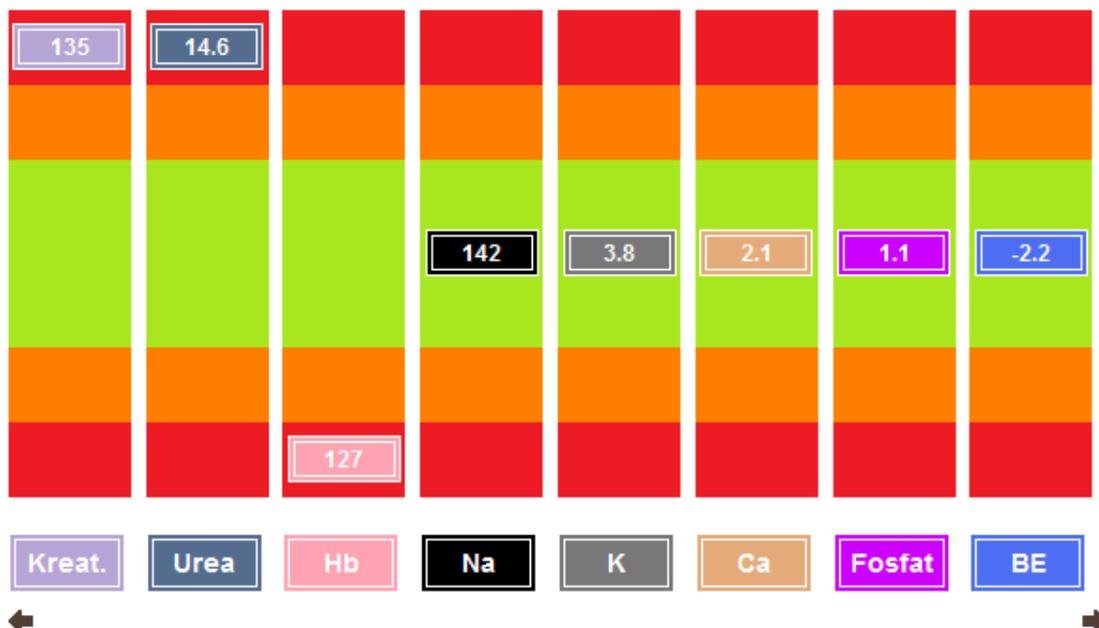


Figure 2.2.4.1 Graph for test results

In the Figure 2.2.4.1, the graph is what we selected to the users. The reason of only keeping the top of bar chart is that the value of data is quite important to the user, and

at the same time, the height of the bars is not meaningful here. On the other hand, changing the tops of bar chart to blocks is for considering our special user group. Lines or points are small and invisible. It cannot make the users be clear at a glance of the graph.

However, about the “Result comparison”, the patients are more concerned about the trends. That is the reason we choose line graph.

One category, one line and several points, the line graph is quite appropriate to present the trend of several data. The test date can be regarded as the equivalent frequency.



Figure 2.2.4.2 Graph for results comparison

Furthermore, after the interview with our end-users, they required to have a table of presenting the results in comparison way. (Figure 2.2.4.3)

| Datum      | Kreat. | Urea | Hb  | Na  | K   | Ca  | Fosfat | BE   | PTH | U-Alb. |
|------------|--------|------|-----|-----|-----|-----|--------|------|-----|--------|
| 2007-6-5   |        | 11.2 | 130 | 141 | 4.1 | 2.3 | .9     | -1.1 |     | 3      |
| 2007-6-15  | 126    |      |     |     |     |     |        |      |     |        |
| 2007-9-16  | 122    | 10.5 | 131 | 140 | 3.8 | 2.2 | 1.2    | -1.3 |     | 3      |
| 2007-12-1  | 130    | 13.2 | 127 | 139 | 4.1 | 2.2 | 1.3    | -1.6 |     | 3      |
| 2008-4-16  | 135    | 14.6 | 127 | 142 | 3.8 | 2.1 | 1.1    | -2.2 |     | 5      |
| 2008-7-24  | 145    | 18.6 | 130 | 143 | 3.9 | 2.4 | .9     | -3.1 |     | 9      |
| 2008-11-13 | 140    | 16.5 | 135 | 143 | 3.9 | 2.3 | 1.4    | -2.4 |     | 15     |
| 2009-2-14  | 170    | 20.9 | 118 | 138 | 4.4 | 2.4 | 1.8    | -2.9 |     | 30     |

Figure 2.2.4.3 Table for results comparison

We found the practicability solution of table view and graphic view [9]:

Tables work best when the data presentation:

- Is used to look up individual values
- Is used to compare individual values
- Requires precise values
- Values involve multiple units of measure.

Graphs work best when the data presentation:

- Is used to communicate a message that is contained in the shape of the data
- Is used to reveal relationships among many values.

In a word, a great data presentation must basically depend on people's own personal preference. Tabulation enables comparison to be made easily among classes of data. On the other hand, a graph is a drawing or figure used to convey statistical information. Graphs greatly simplify communication because figures have easily visualized shapes.

## 2.3. Requirement Analysis

### 2.3.1. Requirement List

Table 2.3.1 Table of requirement list

| Requirement Name  | Priority  | Actor                        |
|---|-----------|------------------------------|
| R1. Log in  | Essential | User(patient), Administrator |
| R2. Blood test result examine in graph                                | Essential | User(Patient)                |
| R3. Diary   | Essential | User(Patient)                |
| R4. Comparison for one blood test sample in graph and tabulation      | Essential | User(Patient)                |
| R5. Comparison for several blood test samples in graph and tabulation | Desirable | User(Patient)                |
| R6. Self-Test   | Essential | User(Patient)                |
| R7. Administrator system  | Essential | Administrator                |
| R8. Log in as a doctor or a nurse                                     | Optional  | User(Doctor or Nurse)        |

### 2.3.2. Requirement Description and Analysis

**R1.** User and administrator log in to the system by personal number and the password.

The users as the patients can log in to the system by their registered personal number and the password. After login, the user's profile should be listed on the left of

the web page. The Administrator can log in to the admin system.

**R2.** Blood test result examined in graph.

The user can examine their detailed blood test results in graphic view by the system. The graph is required to have all the blood samples which the user tested in the specific blood test.

The graph is necessary to be readily comprehended and be clear at a glance.

**R3.** The user writes diary of their health condition.

Diary is for the user to record their health condition, and they can review the contents what they previously recorded. Plain text is adequate for the users.

**R4.** Comparison for one blood test sample is required to be presented in graph and tabulation.

The user will choose one blood sample, and then choose the test which they want to compare. After it, the system is required to present the comparison in appropriate data presentation form.

**R5.** Comparison on several blood test samples presented in graph and tabulation

This is the desirable requirement in the project. The user may want to compare the blood test results with several samples. Several broken lines are required on one graph. The problem of this requirement is too hard to implement.

**R6.** Self-Test and get correct diagnosis and suggestion at home

The chronic renal failure patients need to do some simple test by themselves at home. After the test, the patients need to get the correct diagnosis and suggestion of improving his health condition from the system.

**R7.** Admin system

Admin system is generally required in this kind of web subsystem. The administrator who can log in to the admin system has the permission to add, view and modify the data stored in the database, and publish an announcement in the login page.

**R8.** Log in as a doctor or a nurse

Doctors and nurses can also log in to the system. After log in, the doctor has the permission to examine and modify his patients' blood test results and the self-test results, which can improve the communication between patients and doctors, nurses.

## **3. Design**

### **3.1. Literature Study**

#### ***3.1.1. Aging-Related Functional Impairments and Their Impacts on Web Interaction***

Older people often suffer from visual impairments. It is difficult for such users to read characters that are too small. Placing too much strain on their cognitive capabilities can distract the older user [7]. They really preferred “big and simple” design, even 800x600 to 1024x768 resolution [17].

One thing to note about these impairments is that, even though individual functional impairment might not result in a noticeable difference in the user experience, taken together they may have a cumulative effect that makes Web interaction more difficult for older adults [7].

Some physical and psychological changes are responsible for the hesitation of older people using the Web [12]. These include a decline in working memory, which was evidenced from the problems older Web users had remembering which pages they have seen, or how they arrived at the current page. It was also reported preferring websites that changed the color of their visited links cause a decline in working memory. Increased age was associated with increased motor noise and slower movements, which could affect the use of scroll bars or image maps [7]. Which means our older users maybe regularly failed to scroll down a page [21].

More positively, however, research has shown cognitive adaptability in older people. In general, older people may respond well to training in complex tasks. Older people were also shown to be able to navigate the Web quite well when the sites are properly designed. The immediate implication is, with proper design and training, older people can use the Web quite effectively [7].

Most websites failed to adhere to simple guidelines such as providing large and highly contrasted text. They didn’t provide backward and forward navigation aids, which might hamper access by older Web users with reduced vision and cognition [7].

It’s also hard for old people to understand the technical language, like hard understanding of “Home” [21].

For the data presentation part, too much number and complex graph will confuse our elder user to understand the result of showing these data.

#### ***3.1.2. Web Design Guidelines***

The first step in helping Web designers to ensure the usability and accessibility of websites is by providing them with Web design guidelines.

The epitome of Web accessibility guidelines, as most people would agree, is perhaps the World Wide Web Consortium's Web Content Accessibility Guidelines [23]. The current version of WCAG, version 1.0, comprises 14 guidelines and 65 Checkpoints that designers can use to help them design accessible websites, not only for older users but also for users with disabilities in general [23].

There does not seem to be one set of Web usability guidelines that is used as reference. The most important point is to choose the things the systems really need.

### ***3.1.3. Recommendations and Guidelines for Design in E-Healthcare System***

- a) Provide larger targets  
---- Important for those with visual impairments
- b) Older adult should not be expected to double click
- c) Graphs should be relevant and not for decoration. No animation should be present.  
---- Important for those with cognitive impairments. Older users often get annoyed with animation. Animation also distracts users.
- d) Clear navigation should be provided  
---- Helps users move smoothly through the pages of the web site. Users would get frustrated if they couldn't find what they are looking for and they would probably just not bother using the website.
- e) Not use a deep hierarchy and group information into meaningful categories  
---- Improves content clarity and minimize density of the web site. Helps users find relevant information quickly
- f) Provide only one open window  
---- Multiple windows may cause confusion. Minimize distraction
- g) Avoid irrelevant information on the screen  
---- Reduced page density and increased comprehension. It is always important to keep a page simple.
- h) There should be differentiation between visited and unvisited links  
---- Important for those with cognitive (particularly memory) impairments. Helps users who don't remember which links they had visited.
- i) Avoid moving text  
---- Reduces confusion. Older users are more likely to have problems reading moving text.
- j) Use normal font. Avoid other fancy font types.  
---- Increased readability, important for people with visual impairments.
- k) Use large figure, obvious structure and contrast color. Avoid too much lines and figures to show.

## **3.2. Elementary Design**

According to the guidelines and literature study, the elementary design of the system

centered on the needs of people and “people-centered” as guiding principle. As mentioned, from the end user's perspective, the whole design of the system is bright in color and intelligible in style, more information and less complicated functions [Guideline c].



Figure 3.2. The ensemble in bright color and conciseness principle

### 3.2.1. Log in Window

As the Figure 3.2 shown, the font used is big and bold. Moreover, the button as a large target is designed [Guideline a]. A blank area above the log in field is for the administrator to make a public announcement. Simple without useless information follows the guideline c, g, and j.

### 3.2.2. Sidebar

After the user log in to the system, the personal information of the user will be shown on the page.



Figure 3.2.2.1. The user's name and personal number are shown on the top.



Figure 3.2.2.2. The user's profile includes the phase and hospital information.

The user profile area is designed to include the useful information for the users. “Fas” (Phase) is required by the nurses and the collaborator. The patients in the chronic renal failure unit are differed into early phase, patients in pre-dialytic phase and patients who are treated with dialysis. For that reason, we design to add the phase information to the profile area. Hospital information added here is designed for our users humanizedly. The users can easily find the hospital information which is a haunt of him. About the other hospitals, the information will be shown after the user click “Mer sjukhus” [Guideline g]. The user can read the information and change the hospital in profile area [Guideline j].



Figure 3.2.2.3. The menu

Different from the other website, the menu which we designed for this system is simple with big and bold font, bright in color [Guideline a]. We divided the menu as the four main functions in our system [Guideline d, e, k]. When the user clicked one function, the background color of that function will be changed, which can make the elderly user remember which function they are using [Guideline h].

### 3.2.3. *Mina resultat*

Collect and list the entire tests in the first page with the date and the care centre where they did the blood test. The user can click the date to view the detailed results.

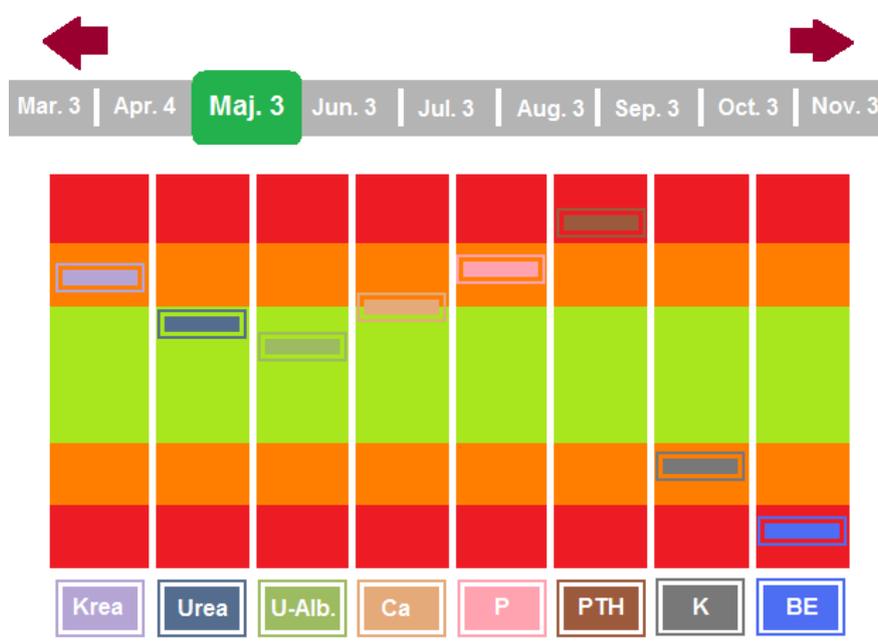


Figure 3.2.3. Graph presents the blood test results.

The graph also contains the samples which the blood test includes in different colors [Guideline a, k]. All the blood samples will be listed on the bottom. If the number of the samples is greater than eight, the user can use a button to turn to next page. [Guideline g] Every sample in the database has different color to present. The background we designed is visualized. Green means normal. Orange means abnormal. Red means serious [Guideline c, k]. Bright in color, different color for different sample and the background would give the users a preferable visual effect [Guideline k]. If the mouse moves onto the name of the blood test sample, it will show a short paragraph of the introduction of this sample. If the mouse moves onto the result in graph, it will show the test result value of this sample and the suggestion from the doctor. The user can also click the other date above, and then the graph will show the test result on that date [Guideline b, e, g, f].

In order to satisfy the demand of end-users, we exert ourselves to disuse the scroll bar and reduce the click. For that reason, we choose to move the mouse onto the target instead of click it. Three-level background is designed for readily understood and clearly at a glance. Presenting the results in graph and different color for different sample are all for a visual representation.

### 3.2.4. Min dagbok

The interface consists of a grid of 8 columns and 4 rows of colored cells. The colors from top to bottom are red, orange, green, and red. Each cell contains a small input field. Below the grid are buttons for 'Krea', 'Urea', 'U-Alb.', 'Ca', 'P', 'PTH', 'K', and 'BE'. There are also two dropdown menus and a large text input area. At the bottom are 'Avbryt' and 'Spara' buttons.

Figure 3.2.4. Diary writing

Combination with the diary and blood test result presentation is designed for the users to record and help them remember their health condition [Guideline e, k]. At the same time, if the day when the user wrote diary is the same day when the user took a blood test, the shown graph of test results is practical [Guideline c]. The user can examine the diary of health condition on the specific date with the test results, which is convenient and practical to observe the relationship between health condition and test result [Guideline d, j, k].

### 3.2.5. Jämföra Resultat

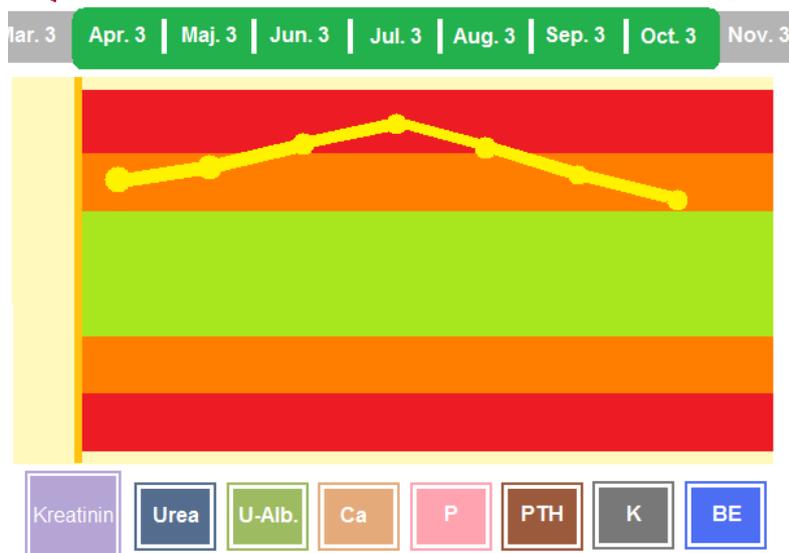


Figure 3.2.4. Graph presents the result comparison

As the design in “Mina resultat”, background of the graph is also designed to three-level [Guideline c, k]. The samples are all shown below the graph and users can choose the sample they want to compare [Guideline d, e, g]. The chosen sample will be a little bit larger which can help the users to remember which sample they have chosen. Chosen dates in different color are obvious for the users [Guideline h]. Every point in the graph represents the result of every test in this blood sample. The fold line shown on the graph can give a visual representation of their disease trend. Moreover the line graph is also the best presentation for the trend of test results [Guideline c, e, g].

### 3.2.6. Övriga resultat

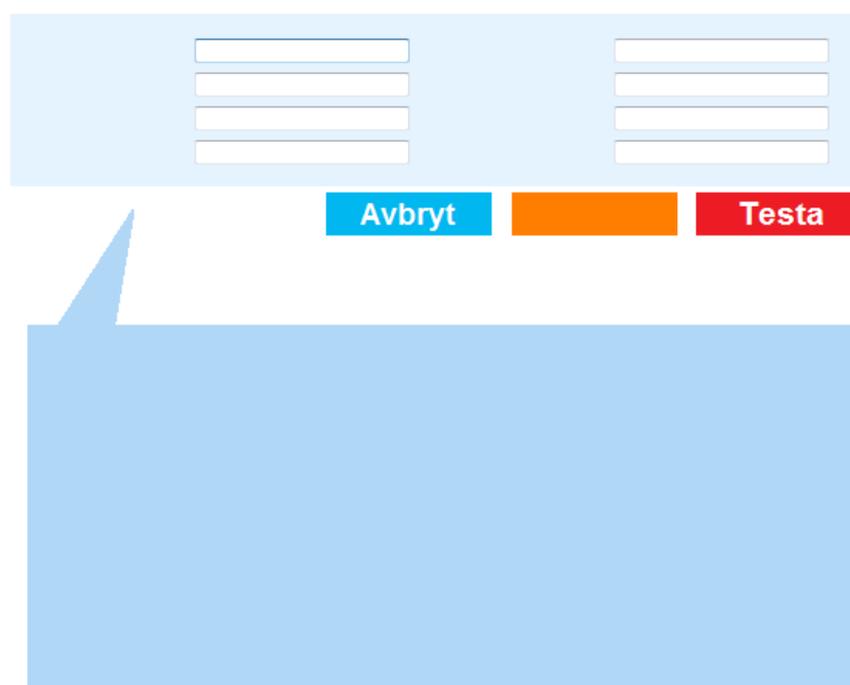


Figure 3.2.4 Self-Test page

For the “Övriga resultat”, the users are freely to fill in their test results and click “Testa” to see the diagnosis, introduction of the test and suggestion of the result [Guideline d, e, g, k]. Design that the diagnosis and suggestion part in the same page is avoid the opening of a new window, which might confuse our user [Guideline f]. Large target, bright in color and simplicity to use are also designed in this function [Guideline a, k].

## 3.3. Interview with End-Users

Date: Apr. 14<sup>th</sup>, 10:00 am – 12:00 am

Place: Hässleholm Hospital

Participant: Two nurses and three patients from the chronic renal failure failure unit

## Subject: Communication with End-Users, Usability Testing and Questionnaire

At the first of this meeting, we did a short presentation about our elementary design. Explain the sketches to the patients and nurses. We tried the think aloud methods in Human Computer Interaction (HCI). We treated our patients as talkative people. At the beginning, the patients would be little shy to say their thinking. We stopped a lot to ask them that “Do you have any questions for this page?” or “Do you like this design?” More positively is that our patients entered into their characters quickly. They talked a lot in the page of “Mina resultat” and “Resultat Jämföra”, which is like what we expected. After the short presentation, we sat down with the patients and nurses, and did a questionnaire which is about the usability and their familiarity with web interaction and internet. The questions and answers are in the appendix B.

From the interview, some useful information is gained.

- Most of our users are elderly people. Nevertheless, they are familiar with the web interaction and internet. One of the patients who we interviewed even uses the internet every day.
- Most of the users can use most of the functions of a web page freely and without any problems including a scroll bar or image maps
- The users who we interviewed are all satisfied with the color and style which we designed. Our elementary design has no big problems.
- The more information which the users need is the telephone number of the hospitals’ receptions.
- One more function is required by the users. The results in comparison should be presented also in figures in a table. That is to say, tabulation is also necessary for presenting test results data. “Maybe some other people like to examine the results in a direct way.” said by one of the patients.

## 4. Implementation

### 4.1. Function

#### 4.1.1. General Function Implementation

The system can be divided into several separate subsystems according to different roles of our user. Due to the limited time, we focused on the implementation part of users' data presentation, and developed two subsystem, user system and admin system.

The administrator has the highest permission of managing all the data in the database.

Administrator's permission:

- Add, View, **M**odify and **D**elete the user information.
- **A**, **V**, **M**, **D** the hospital information.
- **A**, **V**, **M**, **D** the blood samples and normal range for blood test result.
- **A**, **V**, **M**, **D** the items in self-test and normal range for self-test result.
- **A**, **V**, **M**, **D** the phases which indicate the users' condition.
- **A**, **V**, **M**, **D** the user's blood test results.
- **A**, **V**, **M**, **D** the user's self test results.
- **A**, **V**, **M**, **D** the doctors' suggestion for users' blood test results.
- **A**, **V**, **M**, **D** the doctors' suggestion for users' self-test results.
- **V**, **M** the content of users' diary.

The functions in the user system are separated into the following parts.

#### 4.1.2. Specific Function Implementation – Login Window and User's profile

SKÅNE

Hälsa & vård

Välkommen till E-Healthcare delsystemet.

**Välkommen att testa e-hälsovård delsystemets!**

Du kan logga in som två prov användare:  
Manliga användare: personnummer :19121212-1212 Lösenord: 12  
Kvinna användare: personnummer :19131313-1313 Lösenord: 13

**Personnummer och Lösenord**

Personnummer  
(Ex. 19580101-0101) :

Lösenord :

Figure 4.1.2.1 index.asp

In the index.asp, the web page which we implemented contains a login window. Above the login window, the blank area is an editable field where the administrator can write some announcement, help tips or other information in HTML in admin system.

After the user click “Logga in”, the page turn to the function of “Mina resultat”.

Every page except the index.asp which we implemented contains three parts, top.asp, left.asp and the content in the page.



Figure 4.1.2.2 top.asp

The top.asp will display on the top of all the pages in our system. This part contains the login user’s information and a button of logout. The user’s information is from session, and if the user click “Logga ut”, the system will implement logout.asp, which is for clearing the session, and go back to index.asp.



Figure 4.1.2.3 left.asp

Left.asp is the sidebar of all the web pages, which displays the login user’s profile. This part contains user’s detailed information, the hospital information which is a haunt of the patient and the menu. The user’s picture which stored in the database will be displayed on the top of this part. If there is no data for the user’s picture in database, it will display the picture below as default. Our users can set the hospital which he wants to display via the link “Mer sjukhus”. This is a human-oriented function which is designed in order to make our patients convenient to find the hospitals information they want.



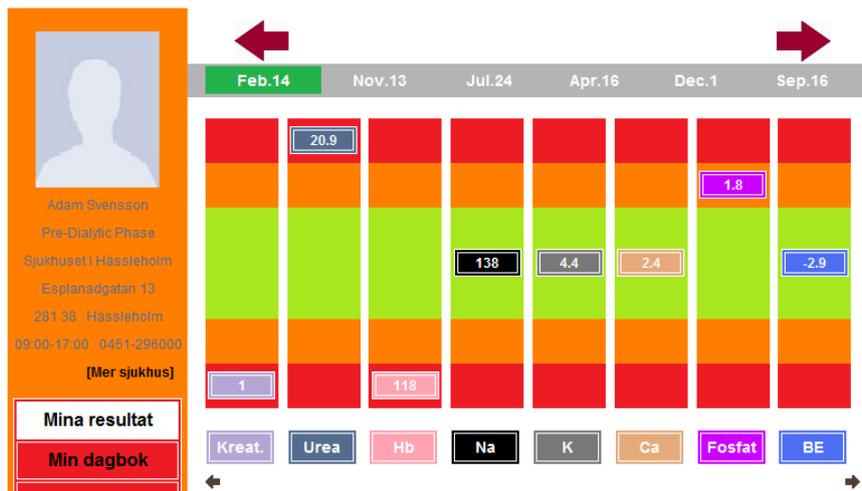


Figure 4.1.3.2 Resultat\_2.asp

In page Resultat\_2.asp, the data of the test result on that specific date will be presented. Above the graph in this page, all the test dates in the database are displayed in the grey area. The user can click the red arrow to change to the next page of dates.

We divided the graph into 5 ranges, seriously high, little high, normal, and little low, seriously low. All the results of the samples are displayed one by one using loop which can determine how many tables of results should be displayed in the graph. The five ranges are displayed by the background color of the cells in the big table. After using SQL query statements to select all the information from database, we compare the value of the test results to determine in which range the result should be displayed. For instance, if the result value is larger than NormalMin (the minimum value of normal range) of that sample and smaller than NormalMax (the maximum value of this normal range), the square with the same color of the sample will be displayed in the normal range in green. The squares of result value are also built as a table. The background color is the same as the sample background color in the database. The value of the result will be displayed in the cell of that table.

Every sample which was tested in that date will be displayed on the graph with different colors. The color is also stored in our database. If the sample was not tested on that date, the column will be a blank.

If the user moves his mouse onto the sample, there will be a paragraph of the introduction of that sample appears by using ALT tags. If the mouse moved to the squares, the suggestion of that result will be displayed also.

#### 4.1.4. Specific Function Implementation – Diary



Figure 4.1.4.1 Dagbok\_c.asp

When the user click “Min dagbok” in the menu, it will turn to Dagbok\_c.asp which is the list of the user’s all the diaries and sorted by the latest day. The title and the date will be displayed in the list. The user can click “Skriv ny” to write a new diary, click “Redigera” to edit the content of diary and click “Radera” to delete the diary.

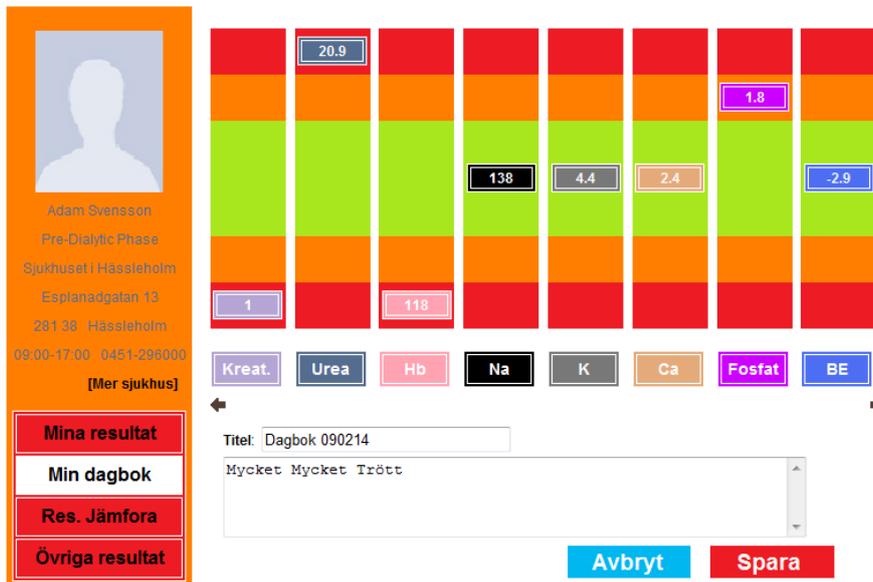


Figure 4.1.4.2 Dagbok\_d.asp

If the user clicks the date and wants to see the diary, the page will turn to Dagbok\_d.asp.

#### 4.1.5. Specific Function Implementation – Result Comparison

The broken line graph is quite different from the graph of test result inspection. To implement this graph, we need to combine JavaScript and VML technology.

JavaScript is a scripting language used to enable programmatic access to objects within other applications [23]. It is primarily used in the form of client-side JavaScript for the development of dynamic websites [23].

Vector Markup Language (VML) is an XML language used to produce vector graphics [24].

An implementation of VML will fall into one of two classes [25]. A viewer implementation will normally implement the full specification, although it can avoid the need to implement any functionality to edit VML (beyond that required by any script language which the viewer supports) [25]. An editor implementation may only need to implement those specific features necessary to output the data which the editor manipulates [25]. Even an editor which potentially manipulates VML produced by other applications may need nothing more than a subset of the CSS2 visual rendering model. Such an editor can correctly position the VML produced by other applications even though it may not be able to render individual shapes.

An implementation can proceed in five separate, independent, steps [25].

- Each implementation requires an XML parser. This performs lexical analysis of VML and identifies the individual elements. XML parsers are already widely available.
- Non-trivial implementations will need to parse the structure of the individual VML attributes. To make this easy, VML defines basic types which have canonical internal representations - no VML implementation is required to store greater accuracy than that implied by the canonical representation and all VML data can be converted to the corresponding representations. This means that the implementer need only write a small number of string parsers to be able to handle all VML data. Most of these parsers are already present either as part of language libraries or as a consequence of the need to parse CSS.
- An implementation must handle that part of the CSS2 visual rendering model used by VML. VML uses a small subset of CSS2 to define the block level boxes for each VML element. Implementing this gives a minimal VML implementation which can handle the layout of elements (using their block level boxes) without doing any rendering.
- Viewing implementations and most editing implementations must handle the path parameterization required by VML - a small set of mathematically defined transformations allow the VML representation of a path to be reduced to a simple set of closed or open line segments. Extensions to VML may add transformations. However VML allows such extensions to be accompanied by equivalent definitions of the same information in not extended VML.
- Finally the implementation must render the path level data in the way specified by the VML rendering attributes. Normally this operation maps easily onto widely available operating system facilities.

The JavaScript and VML technology used in the system is described in the following.

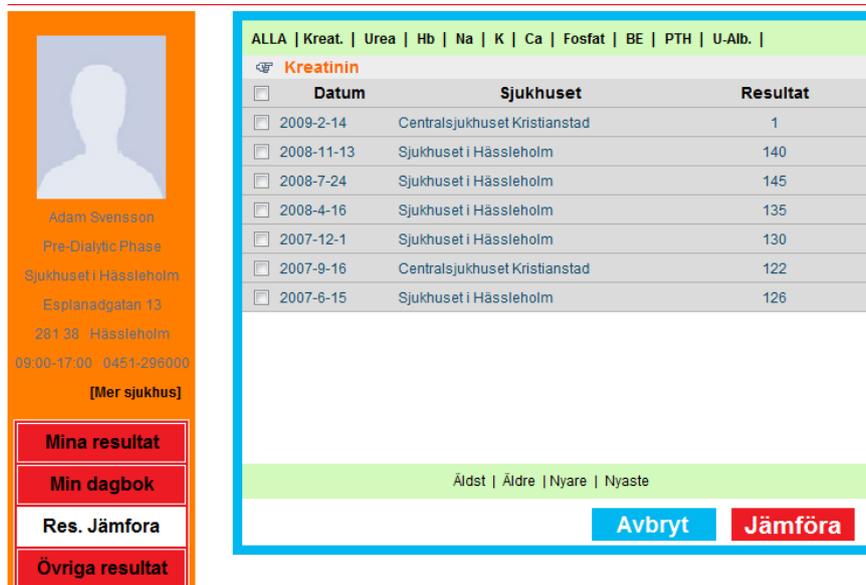


Figure 4.1.5.1 Resultat\_3.asp

When the user clicks “Res. Jämföra” in the menu, it will turn to Resultat\_3.asp. In this page, the list contains all the test results of all the samples and sorted by the latest day. Above the list, there are all the samples in the database. If the user click one of the sample, all the test results of that sample will be displayed on the list and sorted by the latest day. Choose the results with the checkboxes and click “Jämföra”, the page will turn to Resultat\_4.asp

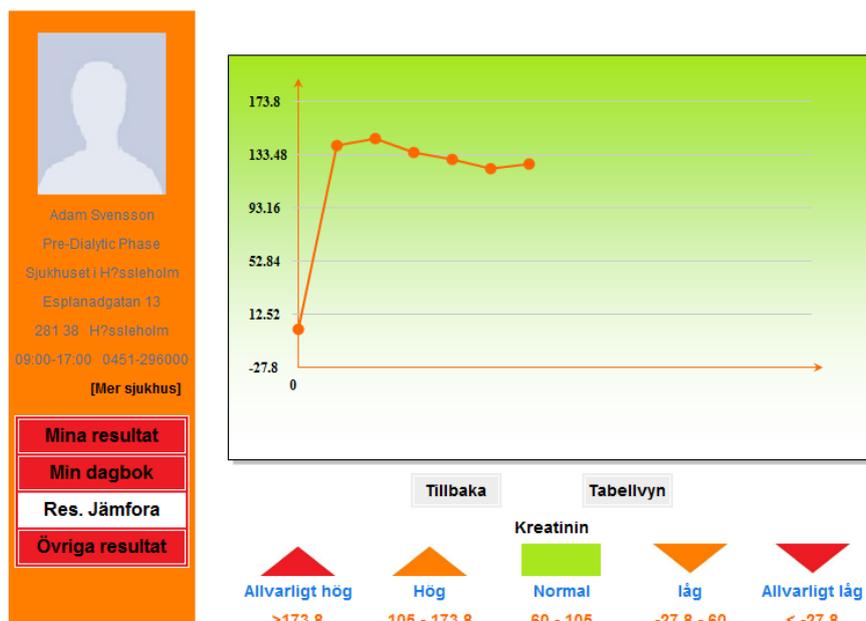


Figure 4.1.5.2 Resultat\_4.asp

Above the two buttons, there will be the area of the broken line graph. If the user clicks “Tabellvyn”, it will turn to the page Resultat\_6.asp, where display the test results in tabulation.

With the study of a sample code [29], the application for JavaScript and VML technology is a great help of our broken line graph in this system. We didn't use JavaScript and VML, even ASP technology before this project. The sample code provides a helpful example of using the JavaScript class, `vmlcurve.js`, and it also a guidance of a simple broken line graph drawing without dynamic data.

X-coordinate in the graph indicates the date of the tests, and y-coordinate indicates the value of the results. The points on the broken line have coordinates determined by the X-axis and Y-axis. However, in the sample code, the coordinates are determined by definite value.

From the code study, we found the values of Y are determined by two parameters, the minimum value and the scale of Y. For that reason, how to find these two values is important. How to solve this problem is described in the Session Problems and Solutions in following.

Firstly, we modified the CSS file to draw the graph in a nice way include the style of all the figures displayed on the graph. In the JavaScript part, the first thing is to create a curve object, using `var vc = new VMLCurve(document.all.curve);`.

Second step is to set the values to X-coordinate and Y-coordinate, which we mentioned above. After the determination of X and Y, we need to determine all the points with the data from database by using an array which the user selected from the last page and draw the points on the graph. After all the points determined, the line between each two points will be drawn on the graph.

With the study of the sample code, we modified some specific values, such as the point radius or the length of coordinates, and kept the part of drawing lines, points and coordinates, because the sample code provided the methods and classes of creating graph. There is also a part of sample codes which is for the number format.

We also add the mouse event on the graph. When the user moves the mouse onto the points, it will show the date of the test and the value of the result.



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09:00-17:00 0451-298000  
[\[Mer sjukhus\]](#)

Mina resultat

Min dagbok

Res. Jämfora

grafisk vy

| Datum      | Kreat. | Urea | Hb  | Na  | K   | Ca  | Fosfat | BE   | PTH | U-Alb. |
|------------|--------|------|-----|-----|-----|-----|--------|------|-----|--------|
| 2007-6-5   |        | 11.2 | 130 | 141 | 4.1 | 2.3 | .9     | -1.1 |     | 3      |
| 2007-6-15  | 126    |      |     |     |     |     |        |      |     |        |
| 2007-9-16  | 122    | 10.5 | 131 | 140 | 3.8 | 2.2 | 1.2    | -1.3 |     | 3      |
| 2007-12-1  | 130    | 13.2 | 127 | 139 | 4.1 | 2.2 | 1.3    | -1.6 |     | 3      |
| 2008-4-16  | 135    | 14.6 | 127 | 142 | 3.8 | 2.1 | 1.1    | -2.2 |     | 5      |
| 2008-7-24  | 145    | 18.6 | 130 | 143 | 3.9 | 2.4 | .9     | -3.1 |     | 9      |
| 2008-11-13 | 140    | 16.5 | 135 | 143 | 3.9 | 2.3 | 1.4    | -2.4 |     | 15     |
| 2009-2-14  | 1      | 20.9 | 118 | 138 | 4.4 | 2.4 | 1.8    | -2.9 |     | 30     |

Äldst | Äldre | Nyare | Nyaste

Figure 4.1.5.3 Resultat\_6.asp

After the user clicks “Tabellvyn”, the page is turned to Resultat\_6.asp. In the table, all the values of test results in database are displayed and sorted by the day.

#### 4.1.6. Specific Function Implementation – Self-Test



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Mina resultat

Min dagbok

Res. Jämfora

Övriga resultat

**BMI**

vikt:  Kg      längd:  M

**Blodtryck**

Systoliskt blodtryck:  mmHg      Diastoliskt blodtryck:  mmHg

**Blodsocker**

Blodsocker:  mmol/L

[Avbryt](#)   [Testa](#)

**BMI:** Normal

**Introduction:** Body Mass Index (BMI) eller kroppsmasseindex anger relationen mellan vikt och längd enligt beräkningen kroppsvikt i kilogram dividerat med kroppslängden i meter i kvadrat.

**Förslag:** Normalvikt

**Systoliskt blodtryck:** Hög

**Introduction:** Blodtryck, det cirkulerande blodets tryck på kärlväggarna. Värdet brukar anges i två tal, till exempel 120/80. Systoliskt blodtryck, det övre trycket, är blodtrycket vid hjärtats sammandragning (systole), vanligen mellan 120 och 140 mmHg (16,0–18,7 kPa) hos en vuxen person. Diastoliskt blodtryck, det undre trycket, är blodtrycket vid hjärtats utvidgning (diastole) och bör inte överstiga 90 mmHg (12,0 kPa).

**Förslag:** Hypertoni – högt blodtryck

**Diastoliskt blodtryck:** Hög

**Introduction:** Blodtryck, det cirkulerande blodets tryck på kärlväggarna. Värdet brukar anges i två tal, till exempel 120/80. Systoliskt blodtryck, det övre trycket, är blodtrycket vid hjärtats sammandragning (systole), vanligen mellan 120 och 140 mmHg (16,0–18,7 kPa) hos en vuxen person. Diastoliskt blodtryck, det undre trycket, är blodtrycket vid hjärtats utvidgning (diastole) och bör inte överstiga 90 mmHg (12,0 kPa).

**Förslag:** Hypertoni – högt blodtryck

Figure 4.1.6 Resultat\_5.asp

When the user clicked the “Övriga resultat” in the menu, it will turn to the page Resultat\_5.asp, which is for the function of self-test.

When the user fill in the blanks in the light blue area, the information in the blue area below will be hidden. After the user click “Testa”, according to the data filled by the user, the diagnoses, the introduction of the sample and the suggestion will be

displayed in the blue area. If the user only fills in the figures for BMI, the page will only display the information for BMI without the other two

## 4.2. Database

The e-healthcare system which is for patients to gain more useful information must contain the patients' information, the test results' value and the information of blood sample.

The following description is about the main content in our database.

- Table Person ----- *store the users' information*  
The attributes in the table: Name, TEL, Street, Postcode, PersonalNumber, Password, LastLoginTime, LastLoginIP, ProfilePicture, *which stored the user's pictures in the database.*  
Foreign keys: HospitalID, *which is used to indicate the hospital for the person*; PhaseID, *which is used to indicate the patient in which phase*; RoleID, *which represents the user's role, for instance, patients or administrator*; CityID, *which indicates the user lives in which city.*
- Table Phase ----- *store the patients' phases*  
The attributes in the table: Name, for instance, early phase or pre-dialytic phase
- Table Role ----- *store the patients' roles*  
The attributes in the table: Name, for instance, administrator or patients, doctors or nurse
- Table Diary ----- *store the patients' diaries*  
The attributes in the table: Title, TextContent, Date  
Foreign keys: PersonID, *which can indicate the diary belongs to which user.*
- Table Hospital ----- *store the hospital information*  
The attributes in the table: Name, Street, Postcode, OpenTime, ReceptionTelNum  
Foreign keys: CityID, *which indicates the city where the hospital located.*
- Table BloodTestResult ----- *store the users' blood test results*  
The attributes in the table: Date, *which is the date when the user do the blood test*; Result, *which stores the value of the test result*  
Foreign keys: BloodTestParameterID *which indicates the result value is for which blood test sample or parameter*; PeronID *which indicates the result belong to which user*; HospitalID *which indicates the test was taken by which care center or hospital.*

- Table BloodTestParameter ----- *store all the blood test samples*  
The attributes in the table: Name, Unit, *which is the unit for the sample*; Introduction, *which contains the introduction of the sample*; NameAcronym, *due to the sample name displayed in the graph, acronym is used for that reason*; IconBgColor, *which contains the color for each sample*.
- Table BloodTestSuggestion ----- *store suggestion from doctors*  
The attributes in the table: SuggestionForNormal, SuggestionForLittleHigh *which indicates the suggestion for the patients whose results in little higher than normal*; SuggestionForMuchHigh, SuggestionForLittleLow, SuggestionForMuchLow  
Foreign keys: BloodTestParameterID *which indicates that these suggestions pertains to which sample*
- Table Group ----- *store patients' groups which indicates the patients character, for instance, male or female, child or the elderly, etc.*  
The attributes in the table: Name
- Table GroupXBloodTestParameter ----- *due to the many-to-many relationship between Table Group and Table BloodTestSuggestion, this table is used to indicate the relationship at the same time it stores the normal, abnormal and serious ranges.*  
The attributes in the table: NormalMin, *which is the minimum value of normal range*; NormalMax, *minimum value and maximum value together can represent the normal range*; LittleHighMax, *the maximum value of a little high range, if the value is greater than this, it would be in serious range, and if it is smaller, then the value is in abnormal range*; LittleLowMin, *as the LittleHighMax*  
Foreign keys: BloodTestParameterID, GroupID. *The reason to have this relationship is that the normal ranges of some samples are different from male and female.*
- Table Group ----- *represent the many-to-many relationship between Person and Group. For instance, Person A is a man and also belongs to the elderly.*  
Foreign keys: PersonID, GroupID. *Indicate which user pertains to which group*
- Table SelfTestResult ----- *store the user's self-test results*  
The attributes in the table: Date, Result  
Foreign keys: PersonID, *indicated the user who did the test*; SelfTestParameterID, *indicated which sample the user tested*.
- Table SelfTestParameter ----- *store the all the self-test samples*

The attributes in the table: Name, Unit, NormalMin, NormalMax, LittleHighMax, LittleLowMin, Introduction

- Table SelfTestSuggestion ----- *store the suggestion from doctors for the self-test results*

The attributes in the table: SuggestionForNormal, SuggestionForLittleHigh, SuggestionForMuchHigh, SuggestionForLittleLow, SuggestionForLittleLow, SuggestionForMuchLow

Foreign keys: SelfTestParameterID, *indicated the suggestions pertains to which self-test item.*

### **4.3. Problems and Solutions**

#### **4.3.1. *How to represent the different normal range for male and female in blood samples?***

Solution: A table called Group is added to the database. The Group represents the user's characters as male or female, child or the elderly. Different group has different normal range of the blood samples. In the GroupXBloodTestParameter, the normal, abnormal and serious range is represented. For instance, Kreatinin, one of the blood samples, the normal range of it for a male is 60-105  $\mu\text{mol/L}$  and for a female is 45-90  $\mu\text{mol/L}$ . There will be two tuples in GroupXBloodTestParameter thereupon. One is the groupID for male, and the BloodTestParameterID for Kreatinin. At the same time, the NormalMin is 60 and NormalMax is 105. For the female tuple, the normal range will be changed to which for female.

#### **4.3.2. *Query with the special characters cannot find any data in the database.***

Solution: In "Mer sjukhus", the function is that the user can select the city and search for the hospitals and care centers in that city. When we implemented, the data cannot be selected when the city name contains the Swedish special characters.

To solve this problem, we tried many methods but failed. After that all, we created a City Table which contains all the cities in Sweden. Use the ID in City table to query the data in Hospital Table. That will solve the problem.

#### **4.3.3. *How to get the minimum value of the Y-coordinate in the graph of Results Comparison?***

Solution: Suppose the user selected  $n$  results from the last page and click "Compare", turn to the graph. We certainly need to record the values of these  $n$  results. At the same time, in the database, there also exists the important data called "LittleLowMin", which is the minimum value of little lower range.

We compare the  $n$  values and the value of LittleLowMin to find the minimum of these  $n+1$  values. The minimum value of these  $n+1$  values is the min of the Y-coordinate.

#### **4.3.4. *How to get the scale of Y-coordinate?***

Solution: With the minimum value, min, of Y-coordinate and the maximum value,

max, of the  $n+1$  result values which mentioned before, the value which equals to max minus min is divided by five. The result after division will be the scale of Y-coordinate.

#### 4.4. Test with the end-users

Date: Jun. 9<sup>th</sup>, 10:00 am – 12:00 am

Place: Hässleholm Hospital

Participant: One doctor, two nurses and three patients from the chronic renal failure failure unit

Subject: Short introduction of the subsystem and usability testing

We did a short introduction at the beginning of the meeting, which provided the users a general comprehension of our subsystem. After the users have a brief concept of the system, we asked them begin to test the system.

The silent observer method in Human Computer Interaction is used widely in usability testing. For this meeting, we tried this kind of method. We didn't provide many introductions about the functions in the system. In this way, the usability of the system would be revealed little by little.

The users can follow the navigation of the website to test all the functions by themselves without big problems. Our system got most positive feedback from our users. However, in some detailed operation, most of the users still have the problems.

The problems and suggestions from our end-users:

- The text and suggestion in my result are not easy for reading. The font is too small and the introduction will disappear in a short time when the user didn't finish reading.

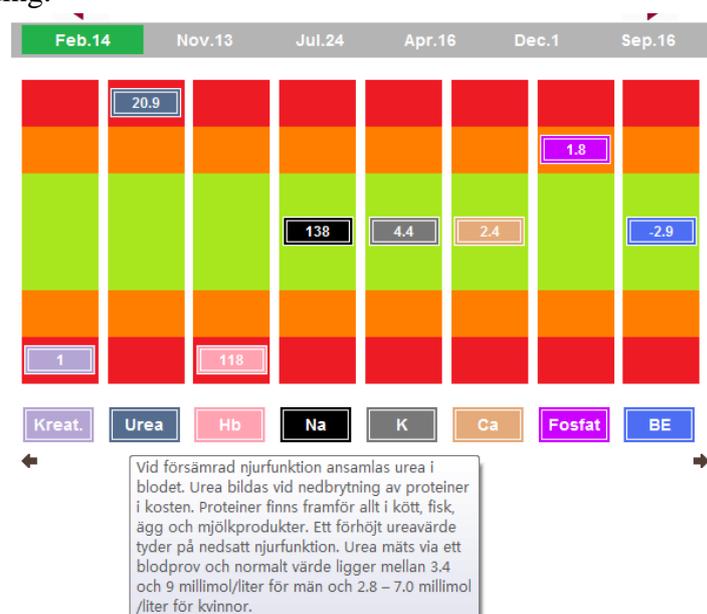


Figure 4.4.1 The font should be larger and stay for a long time to read

- The ranges which displayed below the graph in result comparison should be from seriously lower to seriously higher.



Figure 4.4.3 The sequence of the range should be from low to high, not high to low as the figure shows

- The unit of the height in self-test should be “CM”, centimeter in a normal way. Moreover, the Swedish people are used to use comma instead of dot.
- Add a link for printing out the page of graph.

## 4.5. Improvement

As this is a prototype system, not all the functions are perfect without any problem. Most positively is that our prototype was built in configurable way. It's quite easy to do the improvement.

To make the introduction of each sample clear and easy to read, we decided to display the information in a pop-up window. Moreover, in order to avoid the confusion for older users if they open many windows and forget to close it, we design to refresh the new pop-up window. However, when we try to implement, we met a big problem. We can provide a pop-up window to show the introduction of each sample the user clicked. The problem is that we failed to refresh the new pop-up window but open a new one if the user don't close it and click another sample. This effect goes against the design guidelines which we concluded from our literature study and research on web design. We try to find another method to realize this function. Ajax technology [30] can provide the user a pop-up window, and at the same time disable the parent form until the user close the pop-up window. Due to the limited time, we have to move this to the further work of this project.

The sequence of the range display is changed following the requirement from our users, which should be from seriously low to seriously high.

To fit the custom of Swedish people which using comma instead of dot for the decimal point, we use *if* statement, *InStr* function and *Replace* function in ASP to realize. If the string got ',', we replay it to '.'.

## 5. Conclusion

### 5.1. General Research Review

The aim of this project is to analyze the data presentation and web design using ICT to meet the needs of end-users, at the same time, to implement a worked e-healthcare subsystem. Our primary descriptive tenet is do our best to make every function, every page even every button in the system as a superior design for our special target group. We have tried interview and questionnaire to listening respectfully from our end-users' requirement. We have analyzed the requirement and divided it into four main parts in our functions. We have selected the ASP as the development technology, since using the system integration our system would be ready for the future combination and as a good foundation for applying for new e-healthcare project. We have done the literature study and read many articles and documents to find the suitable web design guidelines for our subsystem.

#### 5.1.1. Data Presentation Review

Graphical glitz can often confuse rather than clarify what's being communicated [9]. To make meaningful judgments about data presentation which applied in our system, we must start with clear principles about the purpose of data presentation and what identifies it when it does work. It really all boils down to one thing: communication. Any presentation of data that you prepare — whether in the form of tables or graphs or in some combination like a dashboard — is only successful to the degree that it communicates to your target users what you intend for it to communicate.

After research and study the existing data presentation examples in the reference [1. Bad Charts], we found the first common mistake is complete ignorance of the message that ought to be communicated, which is happened at the very inception of the data presentation process — the point when someone first begins to determine what to present and how — In that case, as our point of view, before you can determine how to effectively present a message you must first know what the message is. Before you decide how to present the data, step back for a moment and think carefully about what you want to say. Actually put it into one or more sentences that are as complete and meaningful as necessary to communicate what your target user needs to understand [9]. For example in our system, we chose the data presentation way with the sentences we talked with ourselves: “These are the results from our user’s blood test. Some of their results are in normal range but some of them are abnormal. The data for our users should be presented clearly at a glance, which results of samples are normal and which of them are abnormal.” To communicate this message effectively, we still have to know about effective graph design, but we won't get a chance of doing it right if we don't begin with a clear understanding of our message.

In our previously design in the data presentation of results comparison, we only

focused on graph, because we thought some people are more impressed with graphs than tables or texts. However, after the interview with our end-users, we found the tabulation is also necessary and efficient with some of our users.

From our viewpoint, effective graph design isn't always an intuitive process. The design of graph also requires perceiving and interpreting visual stimuli, with objects made visible through light, possessing a particular combination of attributes such as color, size, and location in space. That is quite necessary conceptual foundation to effective graph design. As we designed, the background of graph and different colors for different samples will be more effective and easy to perceiving visual stimuli.

### ***5.1.2. System Integration and Design Guidelines Review***

In conclusion, there is increasing awareness and positive acceptance of the Internet among elderly people in the whole world. It is important to investigate whether the current applications used by the elderly are what actually they want to use or if they just use what is available and is taught the computer classes.

With the study of the existing system in Renal Patient View [31], that is not an effective and appropriate website for the elderly although it contains the test results examination and a lot of helpful information. The data presentation is only in table view and without processing, filtering or classification for the data.

The biggest proportion of people with a relevant disability on the web are older people with some vision impairment. Use the professional judgement, speak to our client, and keep abreast of the user groups that might be affected. Building on the other guidelines and suggestions from our literature study, the specific guidelines which we collected are the tenet of our system design, which are quite useful and got positive reply from our users after the interview.

In one word, only the design which is derived from the end-users' standpoint can be the successful.

## **5.2. Implementation and Testing**

Frankly speaking, we implemented and realized nearly all of the expected functions in the system. We met lots of problems in the process of implementation, which is beyond our expectation before the realization. Fortunately, we solved most of the problems we met.

We created an admin system, which makes the management of data in the database convenient for administrator. The user as an administrator can easily modify or add information for all the users.

In the user system, building on the effective and appropriate design for the system, the

four main functions are basically realized. In test result, the graph is presented as the expected effect, background worked and the result of sample can be represented at the same color but different from other samples. The value of the results can be displayed in the square which presented for the results. However, the introduction and suggestion for the users are not easy for reading. We didn't find a good way to solve this problem. We use ALT tags to display the introduction, which is the text that appears when the pointer is over the image, whereas the text in ALT tags cannot be changed by font size, font color and the style. The plain texts are not easy to read, especially for our special users.

Diary and self-test function are all realized exactly as the design according to the guidelines.

The "Result Comparison" function is the stiffest and the most troublesome in the whole implementation part. Using JS and VML technology, we failed in the background of the graph. Moreover, the expected two sample results compared in one graph cannot be implemented. We have no solution for this problem. The graph which was realized can present a broken line graph for one sample's result comparison. The trend of the users' condition is clearly displayed on the graph.

Almost all the functions and detailed requirements are implemented and realized. We are just jackaroos and didn't develop a website in ASP technology at the beginning of the implementation. During the work, we begin to have a good command of ASP technology and primarily comprehend the technology in JS and VML

## **6. Recommendations for Further Work**

### **6.1. Modifiability**

At the beginning of structure design of this e-healthcare subsystem, we did focus on the configurable design and the modifiability of the system.

In our system, we only developed two roles of the users, patients and administrators. However, it is quite easy to add a new role into the system, for example, the doctors. In the database, the administrator can also create a new role for doctors and add the new users who are acted as the doctors. The system of the doctor should be created. Similar to the functions in patients system and admin system, the doctor system would not be created as a new land. The doctor has the permission to examine the data for his patients and the permission to modify the patients' results data. The other roles in the future can also be added into the database, and it is also easy to develop a new system for them.

As we mentioned in the beginning of this report, the subsystem we developed is a prototype system. After the first meeting with our collaborator, they suggested what tests our prototype would handle. Moreover, they mentioned that they wanted to differ between the patients into three phases, early phase, patients in pre-dialytic phase and patients who are treated with dialysis. However, at last, they only supply us the information of the patients in pre-dialytic. This means we must design all the blood test results for the patients in a configurable way. The samples of blood test are not fixed, the same as the suggestion for the patients in different ranges. These all make our system configurable and having strong modifiability.

With all the subsystems which are all in prototype, the structure and design must be configurable and full with modifiability. A good foundation for applying further projects will be like a great pile foundation for a skyscraper.

### **6.2. Sustainable Further Work**

The further work for this system will focus on the process of profile definition as the successful information and service filtering is based on an appropriate profile. For the patients there could be many further functions in the system. In order to support the patient and to attain a good acceptance it is thought to define amplified roles according to the patient life cycle concept.

The patient can make the discussion with the doctors and nurses about his health condition and feeling by the system. Not only communication with doctors, the patients can also manage the appointment with doctors and patients. Moreover, the patients can also communicate with each other in the future. Group functions tend to overcome trust problems resulting from the invisibility of the others and the isolation

of the individual that dominate the internet. Like it is in real life patients shall be enabled to help each other and exchange experiences. In order to achieve this, the profiles can be used. The building of a group identity via symbols and virtual borders has to be supported. Furthermore, continues interaction has to be initiated, e.g. through notification mechanisms and reminders. The technology needed to realize those functions has already been implemented into an intranet portal. At the same time, the functionalities have to be combined, to be linked to information and to be embedded to everyday routines and processes. Our worked subsystem has already proved as a facilitator for planning and implementing other more complex information technology concepts.

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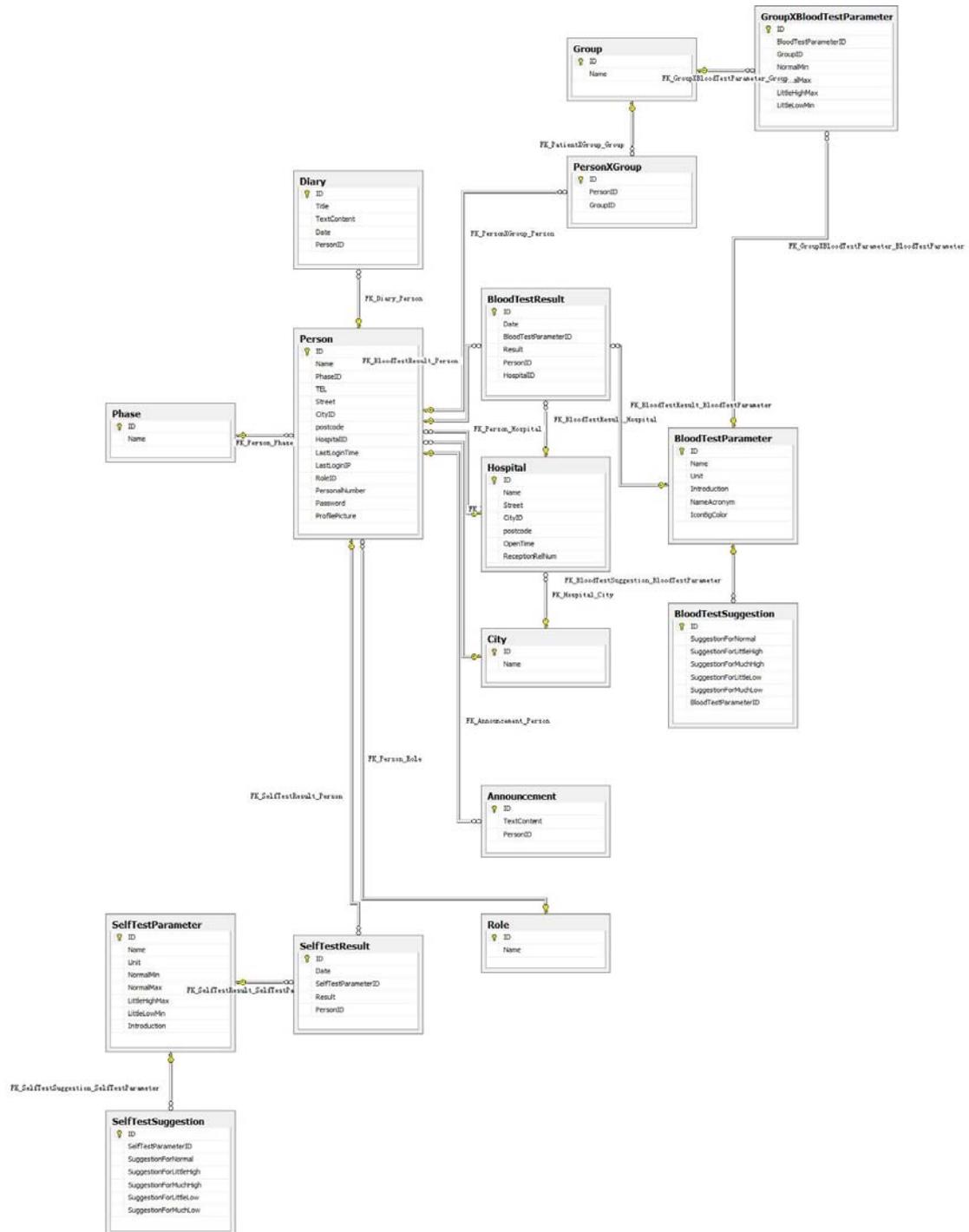
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# Appendix A



Capture of the relationship diagram for database

## Appendix B

Details about the interview with End-Users – Questions and Answers in Questionnaire:

### Part 1

1. How often do you use the internet?

*One of the user answers: Everyday.*

*The other answers: Nearly several days.*

2. Do you familiar with the functions of a web page? (Scroll bar, where should be a link or a button, can you always get the information that you wanted from a website)

*They all gave us the positive answer. They are familiar.*

### Part 2

1. In our website, which is your favorite part?

*The color and the big targets are good for our users. The background of the graph in my result part is very helpful to understand the range and the test results.*

2. Which is the most confused or worst part?

*In the graph of test results presentation, if the background colors of the squares are bright, the values inside are not easy to read.*

3. Is there any other information do you strongly hope to show on the system?

*The reception telephone number of hospitals and more hospital information about the phone number and the opening time is helpful if the user can choose which hospital information they want to know.*

4. What is the suitable name for the test result query and the test result comparison?

*Övriga resultat*