Web-based Child Health Risk Query System

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Abstract

Children under the age of five are more susceptible to diseases. 6.3 million children die each year and more than half of deaths are due to lack of early prevention or early treatment. This thesis presents the results of my investigation on children health risks. Based on these results, I design and implement a new health risk system for children under five years old. Parents can upload data of their children. Then the system can evaluate the current growth and development status, identify unhealthy habits, predict potential chronic disease, report health related factors (e.g. vaccination coverage) in the nearby environments and finally provide personalized solutions to prevent health risks as early as possible. Compared to a well known health-care system, *eRedBook*, which is mainly used for recording and managing child health data, the proposed system focuses on risk evaluation and prediction as well as alerting and providing personalized solutions.

Acknowledgements

Many thanks to my supervisor Professor Stuart Anderson, who, with his sound knowledge, suggestions, and guidance helped me accomplish this thesis; and of course to those software engineers, the friends of supervisor, who also give me some reasonable advices.

Professor Anderson guides me in the field of Personal Health Record and inspire my interests in Child Risk. He not only guides me to complete the project and thesis step by step and evaluates these work at each stage, but also tell me what is research and what is most important in each stage.

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

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Chapter 1

Introduction

This chapter proposes the problems in existing health systems. Inspired by these inadequate interventions at hospital as well as high mortality of under-five children. We proposed use computer technology to offer missing health services, like child risk query and alert to support modern health system. The proposed CHRQ sytem will address the proposed problems and achieve the goal of the project. In the end of this chapter is the structure of the thesis.

1.1 Problem Statement and Motivation

Children under the age of five are more susceptible to diseases. 6.3 million children die each year and more than half of deaths are due to lack of prevention or treatment with access to simple, affordable interventions, according to World Health Organization[**?**]. The parents of these children usually have limited time, energy, money, risk consciousness but have several children. Even though most of parents are responsible, they find it is difficult to ensure their children regular check-ups. Local health communities may not be enable to offer efficient treatment because of limited expert knowledge. While capital hospital usually asks parents to wait for an appointment because relatively inadequate medical resource compared with a large number of patients. When they are visiting the doctor, they cannot expect get enough explaination for the physical examination and fast analysis on the habits of the child. They only can get advice on current diseases rather than predicting latent disease, because the experts have not get enough disease history of the child. Besides the risk inside the body and lifestyle, the outside world also produces risk factors for child based on areas.

Furthermore, basic physical examination and disease diagnosis at hospital are not

enough for protecting children. These general examinations of vision, teeth, spine, height, weight just offer a series results that are difficult for parents to interpret. Test results need direct evaluated and personalized interpretation. As for disease diagnosis, it can work after obvious symptoms appear, but children may already suffer a lot from the illness. Additionally, most experts will not alert parents of latent risks without solid evidence or requirement after looking through the growth chart and the clinical record. This can delay prevention and treatment of children. Moreover, many serious chronic diseases have their origins in childhood. Thus, problem identification on growth and chronic disease prediction are worth to be developed.

Apart from direct risks to children, environment-related problems are also a leading cause of mortality, especially infectious diseases. However, most parents are not aware of infectious disease risk and environmental problems around their home locality and travel destinations. Existing work also does not offer such a environmental and infection risk retrieval function based on addresses.

Besides, most online experts point out that lifestyle change is a practical way to tackle health problems but their advice is too general to follow. Parents expect personalized solutions based on age, gender, location, etc. After all, children's diet, activity and sleeping time vary considerably with age and gender. Advice nees to be personalized to take account of this individual variability.

Althrough many programmes are established for saving children and mortality and leading causes are published to public, it is still hard to take advantage of health care resource. Recently computer technology as a persuasive tool makes accessible and affordable health service available. Tipically, Personal Health Record offers alerts, notifications, reminders, personalized health guidance and decision support for diseases to assist the user to manage their health record, and interact with health-care providers. However these web-based health care systems have limited risk alert and representation along with personalized solution for children under age of five.

1.2 Proposed Solution and Objective

Child Health Risk Query (CHRQ) is such a Personal Health Record (PHR) system, which focuses on child risk alerts. The web-based Child Health Risk Query system can evaluate the child growth and development (e.g. arm circumference, head circumference, height, weight, BMI) along with psychological trauma test and behavior milestone check up, predict top 5 chronic diseases risk (e.g. cardiovascular diseases,

childhood obesity, teen-hood obesity, adulthood obesity, cancer, hypertension, diabetes type I) with proposed risk scores, point out lifestyle problems of children (e.g. diet, activity, sleep quality), retrieve environment-related mortality (e.g. air pollution, unsafe water, poor hygiene, second hand smoking, climate change, etc), infection rate (e.g. flu, meningitis, cholera), vaccination coverage rate (e.g. BGG, DTP3, HEPB3, HIB3, Measles, Tetanus, Polio) at each location (e.g. home, school, often-stay, traveling destination). By regular checking on the web application, parents can be alerted the risk as early as possible.

To design the reasonable solution, I evaluated existing health care systems and found child related clinical work and data. Then corresponding risk scores are proposed along with the design of CHRQ to support disease prediction. Child growth and lifestyle data are reorganized and used for evaluating the child growth and development and habits of any one of children with personalized solution. As for the outside risk, I reselect risk factors and set warning level for children based on their addresses.

Considering the efficiency of the solution, it should have a unified style and integrating operation interface for one kind of risk query and show corresponding result on the same view. It also has been expect to automatically fill out repeated information and prompt users during operation. Additionally, the tested result should be easy to understand by parents in a direct facial expression. To save time for busy parents, the fast entry in the menu list can help a lot.

The goal of this project is to evaluate existing PHRs and design a CHRQ which can address the proposed problems above with high usability. The CHRQ is expected to facilitate young child risk query, and raise the awareness about child health risk. The web-based CHRQ system is expected to offer online growth and development and lifestyle evaluation, online disease prediction and infectious risk retrieval based on addresses. Besides, it will provide tailored or personalized health guidance and decision support according to evaluated result. The impact of the sense of empowerment and adoption of suggested behaviors is considered in the evaluation chapter.

1.3 Structure of the thesis

Chapter 2 offers background of PHR and points out the relationship and difference between PHR and CHRQ. Based on an efficiency experiment of PHR and the evaluation of several classic samples of PHR, CHRQ is developed and described in following Chapter 3, which includes an function overview and a comparison with eRedBook.

This core chapter introduce the function of each module and the algorithm and implementation details of these modules. Besides, interface design, input and output design and the features of the system have been described clearly. Additionally, the data source and data management are clarified in the end of this chapter (these data are attached in the appendix). The next chapter (chapter 4) is for testing. It points out what aspects are important and black-box testing results reflect the usefulness of the system. The following chapter 5 uses three traditional usability evaluation methods to collect the comments from volunteers, and shows the confidence of user on the CHRQ system. In the final chapter 6, I made the conclusion of the project and proposed future direction of web applications of Child Health Risk.

Chapter 2

Background

This chapter provides a review of the Personal Health Record (PHR) and point out its advanced features. It is followed by an experiment proving the efficiency of PHR and four classic implementations highlights what kinds of functions of PHR can serve in modern life. Child Health Risk (CHR) as one kind of PHR has some differences compared to the eRedBook PHR. This choice of topic is driven by the goal of the MSc project and the result of our investigation of child mortality. At the end of this chapter I outline related work on CHR.

2.1 Personal Health Record

2.1.1 Review of PHRs

The Markle Foundation's Connecting for Health collaborative defined Personal Health Record (PHR) in their report on the subject as: "An electronic application through which individuals can access, manage and share their health information, and that of others for whom they are authorized, in a private, secure, and confidential environment.[49]" This formal definition is distinct from the concept of the electronic health records (EHRs)-software systems designed for health care providers who need to store the legally mandated notes for patients.

Although this definition represents a good starting point, more clarity is necessary to understand the development of PHRs, and what benefits they can bring to the public.

In the early 1950s, clinical administrators asked patients to fill out a paper-based PHR without the need for a connected electronic copy. Its low cost, flexibility[24], and portability are appreciated by physicians who may fill in forms or reading charts while

Family history

Parents: Mother's name:..... Date of birth:...../...../.....

Mother's educational level:.....

Father's name:..... Date of birth:...../...../.....

Are there any other children in the family?

Siblings name(s):..... ....

Sex:..... ....

Date of Birth:..... ....

Is there any family history of:	**Yes**	**No**	**Comments**
Childhood deafness	☐	☐	.....
Fits in childhood	☐	☐	.....
Eye problems in childhood	☐	☐	.....
Hip problems in childhood	☐	☐	.....
Reading and spelling difficulties	☐	☐	.....
Asthma / eczema / hayfever / allergies	☐	☐	.....
Tuberculosis (TB)	☐	☐	.....
Heart Conditions	☐	☐	.....

Are there any other particular illnesses or conditions in the mother's or father's family that you feel are important?

.....

Is an interpreting service needed? No ☐ **Yes** ☐ **If yes, which language?**.....

Figure 2.1: outlook of paper-based Redbook

moving between wards or operating theatres, and taking notes on a clipboard while interviewing patients. Some successful paper PHRs shed light on this point, such as the hand-held pregnancy record[28], Scottish Woman-Held Maternity Record[15], Wales Maternity Record and perinatal Institute notes[4]. However, paper records are easier to misplace and harder to recover in the case of accidental damage, so electronic health record (EHR) have been widely introduced in medical management. The information of users can be typed and stored, be backup in the personal computer and printed out as laboratory reports, copies of clinical notes and health histories when necessary. To avoid loss of handwritten information, scanners have also been introduced. Nevertheless, rigid electronic format is hard to modify and adding necessary explanations into the record can be difficult. These in-completed parts of the record may be as informative as the completed parts, according to Harper[29].

Up to present, Web-based PHRs are popular among patients and health-providers owing to their easy extension and security. Such a web-based solution allows for the import of medical data from external sources, and many PHR platforms are more easily

integrated with other services. Besides, these electronic records will be kept up to date, and user information will be backed up in a timely fashion. In addition to security of users' profile, encryption algorithms and policy will ensure the rights of the user. These web-based applications allow users to directly enter and manage their information (e.g. diagnosis, medications, laboratory tests, immunizations and other data associated with their health). A list of features and corresponding benefits of web-based PHRs are given below (here PHR stands for the web-based PHRs).

(a) Interoperability: makes the communication between patients and a range of providers possible.

(b) Continuity: With the assistance of monitoring and tracking devices, the individual's health profile can be continuously recorded and analysed. These analyses include drug interaction, current best medical practices, gaps in current medical care plans, and identification of medical errors. These continuous records will eliminate the communication barriers and allowing documentation flow between patients and clinicians in a timely fashion. However, it may be that clinicians find the volume of data too difficult to process.

(c) Timeliness: these platforms ease the process for patients to ask questions to the caregivers and set up appointments to report problems. Additionally, in the case of an emergency, the platform may quickly provide critical information, proper diagnosis or treatment, so substantially shortening the time to address problems that may arise.

(d) Predictability: latent health threats can be identified using data stored in the PHR, so it may be possible to foresee and prevent incidents that threaten health.

(e) Manageability: The user can access to a wide array of health information, data, and topics easily on multiple locations covered with Internet, in which they can store, retrieve, backup and manage their health information to improve their health[16].

(f) participation: the wide use of PHRs against the outbreak of the epidemic and promotes the public health[17], and these descriptions of patients' symptoms have potential to be used in research and education.

(g) Decision-support: it can assist patients in managing chronic conditions and help devise reasonable solution for living with the condition.

2.1.2 Experiment on Efficiency of Existing PHRs

An increasing number of digital Personal Health Records (e.g. Mayo Clinic[3], MedlinePlus[1], WebMD[2], etc.) are becoming available. Did these PHRs actually motivate and persuade potential users, and have an influence on their behavior? (Here, the users of PHRs are patients instead of parents so it is easier to observe user behavior change.) To find the answer, we used two methodologies-one is posting a questionnaire on the social networking site (e.g. Renren[6]) to collect feed-backs, the other is calculate the support rate from researches. Relatively, the second method is more convincing and easier to collect result in a short period. Next, we will describe how this experiment works.

The scope of the experiment is to find users' attitude towards PHRs and calculate what percent of users think it is easy to use.

The result of this statistics has been divided into two groups-group A with positive attitude toward the PHRs and group B with negative attitude. Such a kind of division based on answer of the following questions: (1) whether or not existing PHRs were capable of functioning as persuasive applications which tell users tailored and personalized health information, guidance for current disease or medication management, and health-related decision assistance; and (2) whether or not the characteristics of the PHRs had a positive effect on patients' sense of empowerment and adoption of suggested behaviors associated with disease and medication management.

Result 1 on users' feedbacks there are totally 75 valid replies on the Renren site, and 67 positive replies against 8 negative replies. So, the support rate is nearly 90 percent.

Result 2 on researchthere are 14 supporting papers which are nearly as twice as disagreements. The following facts is divided group A and B.

Group A: [51] and [56] expressed their preferences for access to personalized over general health information platforms, while [25] like the features of timely feedback on their health conditions with guidance on what to do next. [34][48][30] think a PHR increases their sense of empowerment since they can prepare for the upcoming disease as early as possible, and [19][46][35] appreciate its motivation while [48] identifies the potential for positive behavior change. Chira et al. found that teenagers, especially those who are interested in using electronics, like use their mobile to generate and manage their PHR online in order to discuss their health state with others [19]. Similarly, Slagle et al. reported that children have a more serious attitude towards advice

from the medication administration than adults [46]. In addition, patients were in favor of reminders and notifications component of PHR, these components even can engage their record in different health care level. As for potential privacy and security issues, these users did not mind the provider of PHRs having access to their records [34]. Most patients expect the platforms of PHRs can interact with more external devices and they believe the health system will be strongly complimented by PHRs in the future.

Group B: Wiljier et al, point out that PHRs do not make any progress on their self-efficacy [56]. While, Hess et al. found that although PHRs provided users with the sense of empowerment by offering health self-management tools, the actual number of doctor visits did not change [30]. Based on the feedback of user testing, PHRs are expected to improve their usability for some functionalities [51]. Additionally, Sequist et al. reported that electronic outreach promotes an initial increase in colorectal cancer screening rate among users but the increase is not sustained [44]. As well as a low rate of use, the registration rate is too low to produce an improvement in diabetes mellitus care [18]. Finally, Grant et al. found that the use of a PHR did not create a statistically significant effect on patients' knowledge, beliefs, and behaviors associated with influenza prevention. The statistical result is included in the table below [27].

These results reveals that most patients are willing to use PHRs that have alerts, notifications, or reminders to assist user manage their health record, and it also can be used as a mean to interact with health-care providers. Therefore, PHRs could provide tailored or personalized health guidance and decision support for diseases and medication management.

2.1.3 Samples of classic web-based PHRs

Google Health was a personal health information centralization service, introduced by Google in 2008 and cancelled in 2011. It created a user profile (e.g. health conditions, medications, allergies, and lab results) and give them a merged health record, guidances on conditions, and possible interactions between drugs, conditions, and allergies. Although it did not retrieve any part of personal records without the permission, it did encourage users to set up profiles in this field[10].

World Medical Card is business that sells health information technology products. The international personal medical card system allow users to carry essential medical information with them all the time and everywhere in the world when visiting doctors. In order to improve the security, recently, the product gives each user a emer-

References	Examples of PHRs' Capability to Persuade, Motivate, and Influence				Feedback Delivery	PHRs' Efficiency	
	Health risk assessments	Recommendations/ guidelines on disease/medication management	Links to educational resources	Decision support	Reminders/alerts/ notifications	Found efficient	Found inefficient
Chronaki et al. (2010)	+			+	+	n/a	n/a
Yang et al. (2010)	+	+			+	n/a	n/a
Rubel et al. (2005)	+				+	+	
Tuil et al. (2006)		+	+			+	
Wang et al. (2009)		+			+	n/a	n/a
Helmer et al. (2010)		+		+	+	n/a	n/a
Wiljer et al. (2010)		+	+				+
Chira et al. (2010)		+	+			+	
Slagle et al. (2010)		+			+	+	
Sequist et al. (2011)					+		+
Mandl et al. (2007)		+		+	+	+	
"New-Age PHR Comes with Decision-Support, Multiple Opportunities for DM"	+	+		+	+	+	
Bourgeois et al.	+	+		+	+		+

(2008)							
Luo et al. (2011)	+	+			+	n/a	n/a
Fonda et al. (2010)		+	+	+	+	+	
Sands and Halamka (2004)		+	+			+	
Zeng et al. (2008)		+	+			+	
Grant et al. (2008)		+		+	+		+
Tang and Lansky (2005)			+			+	
Hess et al. (2007)			+		+		+
McInnes et al. (2011)					+	+	
Wright et al. (2012)					+		+

Figure 2.2: The result of experiment on efficiency of existing PHRs coming from[42]

gency code that allows physicians to access to a read-only web profile describing the cardholder[11].

Up to now, Microsoft Health Vault has the largest number of users, and it can be used to support other web-based health platforms (e.g. eRedbook). It launched in October 2007 in the US and from 2013, the website can addresses both individuals and healthcare professionals in the UK and Germany and the list of national deployments constantly grows, according to Nikolas et al.[53]. With a single Microsoft account, a mother can manage each of her children's health information. The parent has authority to access a specific set of data types and he or she also can share their health record with another interested individual such as a doctor, a spouse, a parent, etc[53].

eRedbook, a digital version of Redbook which is a under-five growth guidance and diagnosed booklet, also promotes collaboration between parents and health professionals, but its aim is to engage parents in decisions about their child's care[8]. GP Dr Pixie McKenna reported that 65 percent of new UK mothers are insecure about their child's health and development and want to manage health records of their young children. Fortunately, with the support of Microsoft Health Vault and the open API offered by NHS, eRedbook has the opportunity to serve these potential users. They can keep track of immunisation, measure their child's growth and development using growth charts or retrieving developmental milestones, save health appointments and receive reminders, adding diagnosed record when visiting doctors. These functions

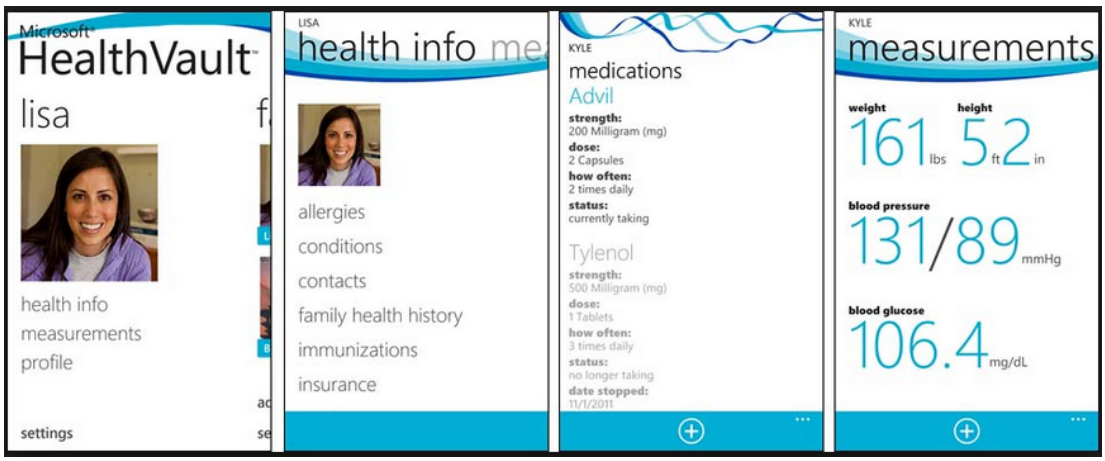


Figure 2.3: Measurement Result from Microsoft Health Vault

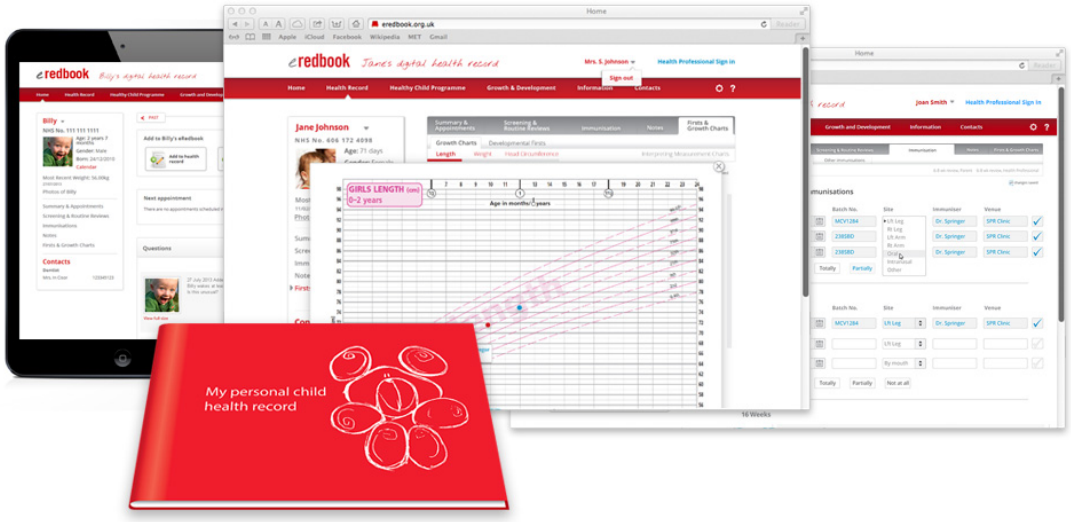


Figure 2.4: outlook of eRedbook and Redbook

release the restriction on time and location for health care, improve the parental understanding of their child's health by personalising content to their needs, and increase the partnership between parents and health professionals, leading to the better health effects, as highlighted on the website[9].

2.2 Web-based Child Health Risk Query

2.2.1 The relation between Personal Health Record and Child Health Risk

Web-based Child Health Risk (CHR) is one kind of PHRs that can be categorised by its characteristics (e.g. type, support of a special health condition, examples of devices or applications interoperable with PHRs, and the ability to send alerts, reminders, and/or notifications)[42]. It also can give information on personalization, guidance for potential disease and decision support, but its research object is children from birth to age 5, type is web-based, and the ability is show alerts to their parents who manage their health records.

The CHR follows the goal of the Msc project that evaluate the professional and non-professional interfaces to eRedBook and develop redesigned interfaces that take account of the evaluation. The evaluation includes identifying new information that could be included in the eRedBook.

The CHR has the same research object and overlapping research aspects as eRedbook, such as growth development check, immunisation, behavior milestone, and child health topics. However, CHR focuses on risk alerts. The following list shows the difference between the two projects.

(a) In its growth development section, eRedBook offers height and weight growth charts to map the child's development, but it has not give a direct result whether the child is growing too fast or too slow compared to normal development, and what to do next for these children who have development issues. Besides height and weight, CHR adds more risk alerts on arm circumference, head circumference, BMI, and psychological test questionnaire to young children. Additionally, the behavior milestone is reintegrated and represented based on age stages, and it includes the original immunisation schedule of eRedBook.

(b) The immunisation section has been extended to include an environmental part with vaccination coverage retrieval, infectious rate retrieval, travel destination risk, and environment-related mortality retrieval. These retrievals are based on the country. Furthermore, for what percent of vaccination coverage stands for low risk, WHO gives a target-95 percent on a national basis. If the more than 95 percent of children are immunised against diseases (e.g. diphtheria, tetanus, pertussis, polio,

Hib, measles, mumps and rubella, etc.), the young are almost fully protected and epidemic spread is unlikely.

(c) To give reasonable advice on how to promote good growth. The lifestyle section tests the calorie intake, activity, and sleep time of the child to alert the parents to help them adjust their habits.

(d) The clinical risk prediction section has no corresponding section in the eRedBook. This part uses algorithms to calculate the likelihood of top 5 serious conditions for the child in 5 to 30 years later.

As for the reason why choose these areas to do research and implementation can be explained by the following investigation on child mortality.

2.2.2 Under-five Child Mortality Investigation from WHO

World Health Organisation (WHO)[13] has investigated child health all over the world and reports statistics on under-five child mortality annually. We summarise the latest report in 2013: 6.3 million children died (nearly 17000 deaths per day) because of poor or absent prevention and treatment. In developing countries rural areas also suffer 20 percent more mortality than urban areas. The leading causes include preterm birth complications (17 percent); pneumonia (15 percent); intrapartum-related complication(11 percent); diarrhoea (9 percet); and malaria (7 percent). Birth mortality is not considered in this MSc project, because this CHR web application serves for normal young children from birth to age 5, but the large proportion of mortality attributable to failures of immunisation will be a focus of attention. Nearly half of the mortality is attributable to under-nutrition[20] which has an affect on the development of undernourished children. In addition to environment-related diseases(e.g. air pollution, Unsafe drinking water and food, Poor hygiene practices, second hand smoking, etc.), it caused nearly 3 million death and may increase the possibility of chronic diseases in the future[21].

To save these children, the WHO Millennium Development Goal 4 (MDG 4) called for a two-thirds reduction in the under-five mortality rate. Many programmes aiming at the health care integration approach took actions. For example, The National Programme for Information Technology (NPfIT) in NHS established in 2002, aiming at conneting over 30,000 GPs in England to almost 300 hospitals and patient access to

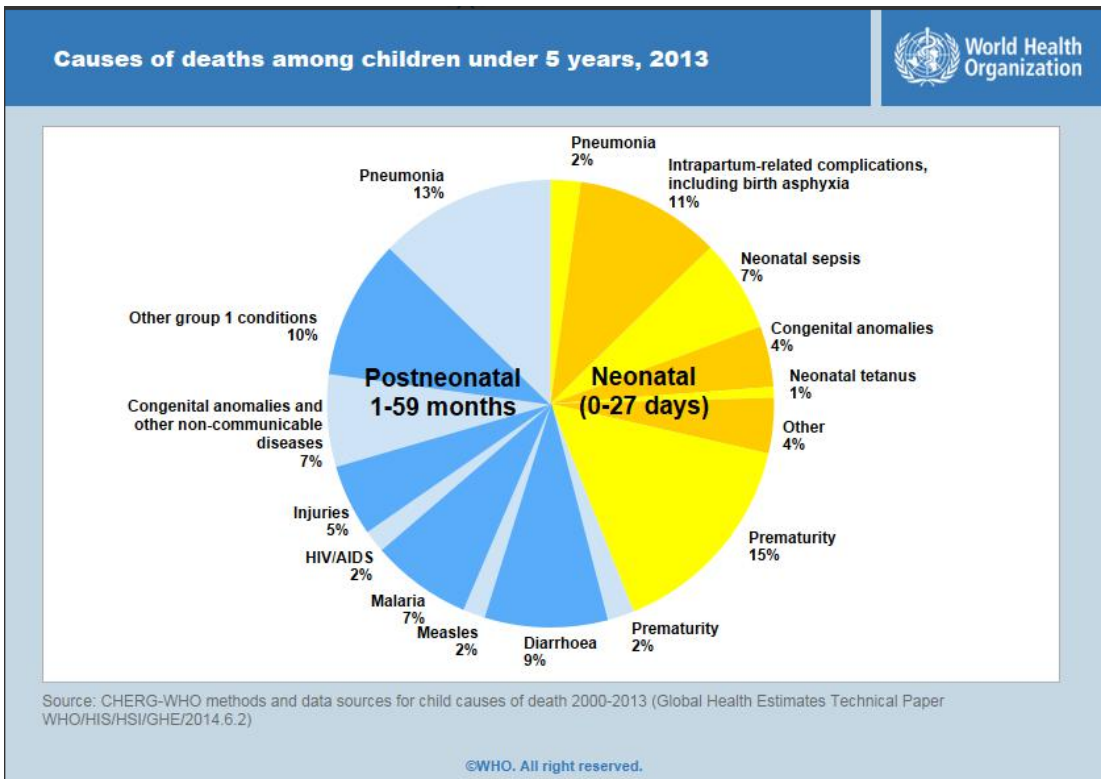


Figure 2.5: Leading Death Causes of Chidren in the 2013.

their personal health care information[22]. At the same time, Scottish Care Information (SCI) programme aims at increasing clinical communication and electronic health care record development[40]. The eRedbook is also a good example to show the intention on improving child health.

These actions resulted in a 3 percent decline in mortality (about 100 million) over the past 25 years. All regions except Sub-Saharan Africa and Oceania have reduced the rate by at least 52 percent. However, only 12 of the 60 countries are on the track to the MDG 4. There, we need to put more effort on saving the young by reducing the risk on environment-related diseases, immunisation and under-nutrition at first.

2.2.3 Related Work on CHR

There is not enough work on Child Health Risk. Slagel et al[46] is related to Child Health Record, it reports on a working prototype of a scheduling system, a text-message-based alert and reminder system, and a medication administration record based on web-entered patient data. There are plenty of topics or researches on child risk[**?**][2], but child risk clinical scores and web application have not been designed and implemented. In the later chapter of algorithm design, existing functions and re-

vised algorithms will be described in detail.

Chapter 3

Technology

The purpose of this chapter is to offer readers some background on the technology used in the development of CHRQ system. It covers the architecture, database, mode, and programming language of the system.

3.1 Architecture-MVC

Modelviewcontroller (MVC) is a software architectural pattern for implementing user interfaces. Such a kind of interactive system is arranged around a model of the core functionality which is independent of the style of input/output. The view components present views of the model to the user while the controller components receive user input and deal with these requests to response on the same view again. This architecture supports different views controlled by a model that can retrieve data from the model and display it. However, this complex pattern is not suitable for simple interface problems[33]. To take advantage of MVC, the CHRQ uses jsps to get inputs and send request to corresponding servlets which import necessary interfaces packaged in Dao and the implements of interfaces in DaoImpl.

3.2 Database-MySQL

MySQL is a relational database management system (RDBMS). [23] it was the world's second most widely used RDBMS, and the most widely used open-source RDBMS[37]. The SQL acronym stands for Structured Query Language. The MySQL development project has made its source code available under the terms of the GNU General Public License, as well as under a variety of proprietary agreements. MySQL is famous for its

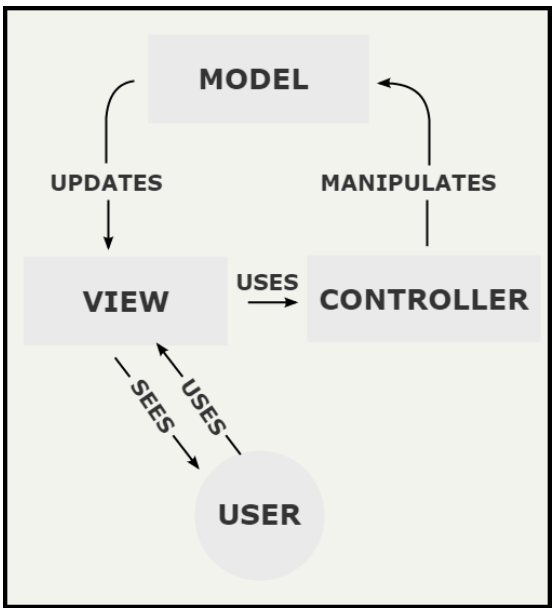


Figure 3.1: MVC pattern

strong performance in the average case and its interface is appreciated by most developers. It has also been evaluated to be a ”fast, stable and true multi-user, multi-threaded sql database server”[5]. To operate MySQL easily, we use the Navicat for MySQL-a GUI tool to administer MySQL databases and manage data within the database.

3.3 Mode-Browser/Server

Browser/Server mode client need to install a browser, such as Internet Explorer, Apple’s Safari, open-source Firefox. With the installation of database server, the browser can interact with Web Server and database server. User can operate server everywhere without need to install any special software. Nevertheless, its response time may be longer than Client/Server mode which pass workload to the server-side[45].

3.4 Web application programming

The interactivity of the web is enhanced by web-based applications. A web application is always called as a dynamic extension of the web server more oriented to individual user needs. Web applications offer distributed and concurrent access over heterogeneous execution environments leading to a high degree of client ubiquity. With larger numbers of users, applications are required to enjoy higher reliability, usability, inter-

operability and security.

3.4.1 J2EE

The J2EE is Oracle's enterprise Java computing platform using a standard of functionality to develop web application on multitier architectures which defines a client tier that handles the presentation, a middle tier that handles the server-side functionality, and a data tier that provides database management capabilities. With an API for object-relational mapping and runtime environment, these developing and running enterprise softwares, including network and web services, and other large-scale, distributed and multi-tier, scalable, reliable, and secure network applications. Java EE extends the Java Platform, Standard Edition (Java SE)[7].

3.4.2 JSP

JavaServer Pages technology provides a way to generate dynamic content for a web client based on HTML, XML, or other document types. It is a text-based file that describes the way that addresses a request and response to. To deploy and run JSP, a compatible web server with a servlet container (e.g. Apache Tomcat, Jetty) is necessary. This JSP seems as a high-level abstraction of Java servlet, and it can be translated into servlets at runtime, because it also uses java programming language. JSP allows Java code and certain pre-defined actions to be interleaved with static web markup content, such as HTML, with the resulting page being compiled and executed on the server to deliver a document.This process occurs on a Java virtual machine (JVM) providing an abstract, platform-neutral environemnt. Additionaly, each JSP servlet is cached and cen be reused when the original JSP is modified[12]. As for the data type that JSP can carry on, JSPs are usually deliver HTML and XML documents, and other types of data are support with the OutputStream.

As how the JSP can be viewed as a view component for a server-side MVC pattern, the figure below shows their relationship. We usually use JavaBeans as the model and Java servlet as controller to achieve the communication.

3.4.3 CSS

Cascading Style Sheets (CSS) is a style sheet language used for describing the look and formatting of a document written in a markup language [14]. Usually, we use CSS

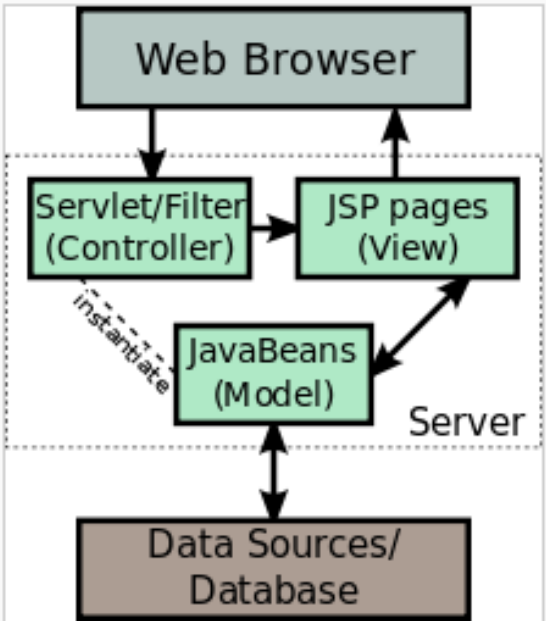


Figure 3.2: JSP in MVC pattern

to change the style of web pages, because it can actually separate the interfaces and content. It can arrange the position of the object in web pages exactly, and supports most of the styles of Font size. These operations are written in HTML and XHTML which can be applied to any kind of XML document, such as plain XML, SVG and XUL. CSS is wildely used in creating visually web pages, user interfaces for web applications or mobile applications.

3.4.4 Ajax

Ajax is outstanding for its asynchronous display mechanism. This mechanism allows web applications communicate with a server asynchronously and does not need to interfering with the display and behavior of the current web page. It is achieved by the XMLHttpRequest object, which will package the user input to a servlet by using a url attached with the packaged id. Although this process is asynchronous, the requests are not need to be asynchronous. Exactly, Ajax is not a single technology, but a group of interrelated web development techniques used on the client-side[26].

3.5 Development Environment

(*) Operating System: Windows 7

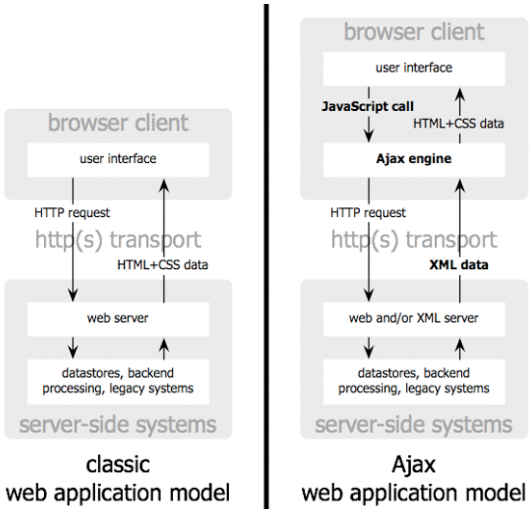


Figure 3.3: Ajax architecture comparing with MVC

(*) Database Platform: MySQL 6.0

(*) Application Platform: Apache Tomcat-MyEclipse Tomcat

(*) Developmental tool: MyEclipse 10.0

Chapter 4

Child Health Risk Query

In this section, I will introduce my system, Child Health Risk Query system (CHRQ) in detail. Section 4.1 introduces the functions of each module and the algorithm and implementation details of these modules are introduced in Section 4.2. Some of the modules need data. For example, the module, called Growth and Development Risk, needs statistics of heights, weights of children. Section 4.3 introduces how these data are collected.

4.1 Overview of Child Health Risk Query

Child Health Risk Query (CHRQ) is a web application aiming to evaluate child development and their environment, in order to alert parents to latent risks to their children. These risks can be categorized into four aspects (i.e. growth and development, top 5 chronic disease, environment-related mortality and travel-related disease, calorie imbalance and sleep inadequacy). These aspects are parallel but relate to each other closely. They not only consider the risk of children selves, but also the risk from the outside and the problems in their habits. As for risk inside their body, it can be categorised to the current risk on growth and approaching diseases. These aspects combine effort on child health care. Each aspect has several detailed functions and corresponding alerts. These alerts are personalized based on child profile (e.g. birth weight, family disease history, height, weight, age, gender, ethnicity, addresses, etc.) and easy understanding with different facial expressions. In addition to obvious diagnosed result, the web-based CHRQ provides personalized advice to these result. The following list is a summary of each aspect (in practice, called module).

(a) Growth & Development Module: This module has three sub-modules for evaluat-

ing growth and development, testing psychological trauma, query the behavioral milestones respectively.

(1) Growth and Development Risk: points out the child in the crowd. By comparing the arm circumference, head circumference, height, weight, BMI with the measured values of most children (a standard value), the function will alert parents whether their children are growing faster or slower than their peers.

(2) Psychological Trauma Test: tests for latent psychological trauma. Many children may experience some psychological trauma or serious scare in their early life more or less[52]. Parents may not be aware of these psychological problems or overlook some diseases. Therefore, online questionnaire is designed to remind parents these potential psychological trauma or diseases.

(3) Behavioral Milestone Query: retrieves what new skill the child should exhibit at a particular developmental stage, what behaviors will occur in future, what vaccination is needed, etc. at that age stage.

(b) Environmental Risk Module: This module has four sub-modules for retrieving vaccination coverage rate, infectious rate, environment-related mortality, and traveling diseases around children' addresses respectively.

(1) Vaccination Coverage: retrieve what percent children have been vaccinated based on the name of the vaccination and the addresses, and show how to interpret the result.

(2) Infectious Rate: retrieve mortality or infectious rate based on the name of the epidemic diseases and the addresses, and show how to interpret the result.

(3) Environment-related mortality: retrieve mortality caused by environment-related problems based on the name of problems and addresses, and show whether the result is optimistic.

(4) Traveling Disease: retrieve epidemic diseases at travel destination and show what vaccination a child should be given before traveling and other preventable tips.

(c) Clinical Risk Module: This module has five sub-modules for predicting likelihood of getting cardiovascular disease, childhood obesity, diabetes type I, cancer, hypertension respectively.

(1) Cardiovascular Disease Likelihood: predict the likelihood of getting cardiovascular disease in 30 years later according to the child information.

(2) Child Obesity Likelihood: predict the likelihood of getting child obesity in childhood, teenage-hood, adulthood according to the child information.

(3) Diabetes type I Likelihood: predict the likelihood of getting diabetes type I in 5 years later according to the child information.

(4) Cancer Likelihood: predict the likelihood of getting cancer in 30 years later according to the child information.

(5) Hypertension Likelihood: predict the likelihood of getting hypertension in 30 years later according to the child information.

(d) Lifestyle Risk Module: This module has three sub-modules for evaluating the calories intake, calories consumption and sleepy time respectively.

(1) Calories Intake: evaluate the calories intake calculating based on what kind of meal.

(2) Calories Consumption: evaluate the calories consume calculating by multiplying activity strength and exercise time.

(3) Sleepy Time: evaluate the sleepy quality of the child according to his or her sleepy time.

4.2 Differences from Existing Applications

In general, the topic of CHRQ is novel owing to its research object is under-five children, and its focus is what kinds of risks the child will experience and how to evaluate these personal latent risk and alert parents. Compared with PHRs and their web applications (e.g. eRedBook), a list of differences of CHRQ are highlighted as below.

(a) Clinical Scores Design for Under-five Children: up to present, there is nearly no clinical risk scores being designed for under-five children. As we all know it is a small probability event few young children get serious diseases, such as cardiovascular disease, child obesity, diabetes type I, cancer and hypertension. However these 5 relatively wide chronic diseases actually start from the early childhood. It is necessary for parents to understand latent risks in next 10-30 years. These proposed predictable algorithms are designed at first time according to the child'

personal information (e.g. birth weight, pregnant smoking, blood pressure, family history, address, etc.), and will be proved in the further. These algorithm designs will be described later.

(b) Online Evaluation of Growth and Development: Many health handbooks (e.g. RedBook) and websites (e.g. eRedBook) offers weight and height comparison result to average values by giving growth charts and description. Unfortunately, these existing growth and development functions do not have the capability to locate a particular child in the growth chart or the capacity to illustrate the difference from normal growth. Moreover, the result has not been evaluated and many users may be confused by the chart or calculated value. What parents want is whether the result is positive or negative and is the child growth faster or slower than children of similar age. Additionally, parents will find a personalized solution useful. Driven by these problems, CHRQ provides parents with an online evaluation function. It provides a easily understandable facial expression that summarises experts' attitudes toward the result, and informs parents of the difference compared to the normal value. It also gives personalized advice on exercise, sleep, and eating to parents who can help adjust the child's behaviour.

(c) Online Evaluation of environmental and infectious risk for the young: existing related work focuses on what kind of environmental problem will lead to disease or mortality, and gives a view of environmental problems (e.g. air pollution, unsafe water, hygiene condition, second hand smoking, climate change, etc.) based on countries. However, general environmental problems make a minor contribution to child mortality. Epidemic infectious diseases with inadequate vaccination coverage cause more deaths in a short time, like SARS. Additionally, each country has different risks, so parents need to know which recommended vaccinations are necessary to protect their child before traveling. For these reasons, an online environmental and infectious risk calculator is important. This module provides risk values and facial expression icons to evaluate the risk at particular locations (e.g. home address, school address, often stay address and travel destination.). Besides, these problems include the low coverage of 7 kinds of vaccination, the mortality caused by 3 infectious diseases, environmental problems, epidemic diseases at travel destinations.

(d) Online Evaluation of diet, activity and sleep for children from birth to age five: many health websites offer calorie calculators and activity calculators for adults

rather than children. To cater to children, the evaluated standard should be based on an age-related calorie intake to build a personal solution that is suitable for children instead of adults. In addition almost no website provides a sleep time query based on age this is important because adequate sleeping time improves the immunity of children. Therefore, CHRQ not only offers a calories intake/consumption calculator, but also a sleep time query with corresponding personalized solutions.

(e) Automatic Form Fill Out: modern clinical websites or web applications require registration before using the functions of the site. Users have to fill out a form that includes their personal information and clinical information. However, this information has to be typed again when they make each test. Considering the inconvenience, CHRQ uses a session to store users' information and fill out field areas with known information. Once the user logs on, his or her registered information will be retrieved and stored in a session, then each form will automatically get the content form that session until logging out.

(f) Asynchronous Information Verification: plenty of websites will reload web page when prompting error password or user name. CHRQ use Ajax asynchronous request without interfering user view.

4.3 Module Specification

4.3.1 User Module

The user module is used to store valid user information which gets from registry and is used in the log on and risk queries. A new user can access the registry by clicking the link of register on the log on interface. This registry ask for the following information (e.g. age, gender, birthday, birth weight, country, the clinical family history, etc.). (note: the birthday is restricted to range from the past 5 years to now, because this CHRQ is not suitable for children over 5.). Having finished, the profile will show and link parents to log on interface. After typing their own user name and password, the CHRQ will use Ajax to verify the correctness. The correctness means both user name and user password are matched with registered information in database respectively. Usually, the user name and password is submitted by a form and output on another web page. However, user usually want to watch the error prompt on the same web page without interfering the current view. For this reason, Ajax uses XMLHttpRequest

object to package user name and password as parameter and redirect to another web page. Then the response will be shown on the special position on the current web page without interfering. This important part of code will be shown as below.

```
1)<input type="text" name="UserPassword"  onkeyup="doReg()"id="
    UserPassword" /><span id="check" style="color:white; border;0;"
    ></span>
```

```
2)var  myXmlHttpRequest;
  function $(id){
      return document.getElementById(id);
    }

  function  getXmlHttpRequest(){
      if(window.ActiveXObject){
      myXmlHttpRequest=new ActiveXObject("Microsoft.XMLHTTP");}else{
      myXmlHttpRequest=new XMLHttpRequest();
        }
    return myXmlHttpRequest;  }
```

```
3)function doReg()
  {
    var UserNameId=$("UserName");
    var UserPasswordId=$("UserPassword");
    myXmlHttpRequest=getXmlHttpRequest();
    if(myXmlHttpRequest){
    var url="AjaxLoginVerify?UserNameId="+UserNameId.value+"&
        UserPasswordId="+UserPasswordId.value;
    myXmlHttpRequest.open("get", url, true);
    myXmlHttpRequest.onreadystatechange=chuli;
    myXmlHttpRequest.send(null);
        }
      }
```

```
4)  function  chuli(){
  if(myXmlHttpRequest.readyState==4){
  $("check").innerHTML=myXmlHttpRequest.responseText;
  }
```

This part of javascript and jsp describes how Ajax sends request and response on the special position on current web page. At first, we need to get the value of username and password, which are stored in ids. At the same time, output position is given based on the position of tag ¡span¿. As for the action of submit, it can be listened on finishing

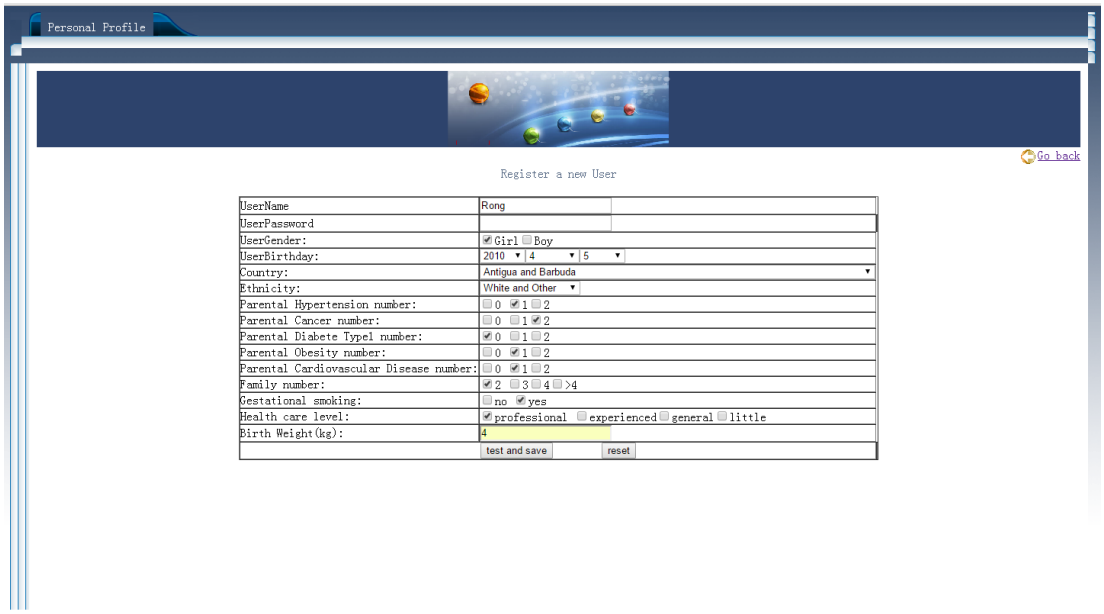


Figure 4.1: Registry

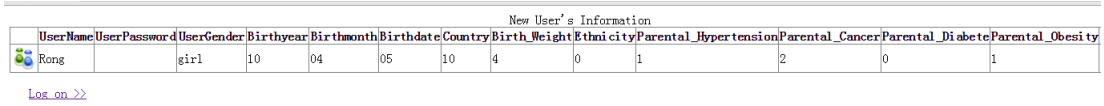


Figure 4.2: Registered user's information

typing password. Next, doReg() will be actived and request will be send to sever by URL including the value of ids. When responsing, Chuli() will be actived and show the prompt content on the current web page.

Such a kind of Ajax verification has some differences from traditional verification by submitting form.

(1) These parameters need to be packed into ids and use the value of ids as parameter to transmit by URL instead of using the parameter directly.

(2) Ajax used for prompting while the other aims to redirect to next web page.

(3) Ajax only retrieve password rather than the whole information according to user name. It also does not need to set these gained attributes into a session.

4.3.2 Growth and Development Risk Module

Function Description:

Growth and Development Risk Module focuses on evaluating the results of physical measurements, including head circumference, arm circumference, height, weight,

Figure 4.3: Verified result of user information by using Ajax

BMI. For example, if the child's height is close to the average height coming from WHO, the child is developing well. Otherwise, he or she grows faster or slower than most children of the same age. According to the difference between the user input and the average, it can show how much faster or slower by using directly different facial expression, like a crying face or a scary face and give the difference. Such a kind of result visualisation is easyier to understand than an informative growth chart. When parents see a smiling face, they know its a optimistic result and do not need to worry about their children. Otherwise, they are given some personalized advice on adjusting the child's habits on eating, activity and sleep, etc. This advice is displayed below the test form frame which is under the test results frame.

Besides the physical evaluation, it also has a psychological evaluation based on the test result of questionnaire. If the user agrees their child has at least one of the behaviors described in the questionnaire. They will be told that the child may be experiencing some psychological issue. This function is important when the child has not been checked out any physical problem for his or her unusual behavior. With the online-evaluated result, parents can be aware of latent psychological issues that may be affecting the child and discuss possible reasons and solutions with a psychologist.

In addition, the behavioral milestone function provides an overview of possible behavior changes, body development and skill acquisition for the child at that age stage. In detail, changes occur in vision, hip, hearing, sleep time, and social skill

development. A part fromm that, what kinds of vaccination are recommended at that age is included in the growth milestone. All these behavioral changes are retrieved by age. With the behavioral milestone, parents can keep better track of their child's development and protect their children with timelyt vaccination.

If parents want more detailed information on how to help their child's development, often the most reasonable way is to change their lifestyle. If they want to know what kinds of lifestyle changes are necessary to understand and reduce latent risk, the link to Lifestyle Risk module will help provide the answer.

Automatic Form Fill Out with Session:
Automatic form fill out is one of the feature of CHRQ, it is achieved by using Session. Session could be used to store users' information and it is available to set/get at anytime from log on to log out. In verifying user stage, we select all the information of the user according to the user name, and set each attribute of user into the session. When the form is needed to be fill out, these attributes will get from the session and show on the special field of the form.

Each form may has special restriction on the typed number, and part of restriction are expect to be automatic addressed. For example, arm circumference form asks the age around of month, while other forms need year or half of month. It causes some inconvenience for users and they want the CHRQ can automatic calculate the suitable age. Age in CHRQ is calculated by current log on time minus the birthday, and represented in several format, such as week, month, half month, year, etc. This function is achieved thanks to import the Date().

In addition to form initialization, the average value will be fill out according the age and gender as a initial value when user do not want to fill out.

Input and Output Design:
This CHRQ asks the user fill out a form including age, gender, head circumference/arm circumference/height/weight/BMI, but age and gender already have been automatically filled in at successful log in. The output includes the evaluated result in facial expression and a short description shown on the result frames, and corresponding personalized advice on the solution frame.

Interface Design:
The interface to this module is embedded on the main operation interface, and it con-

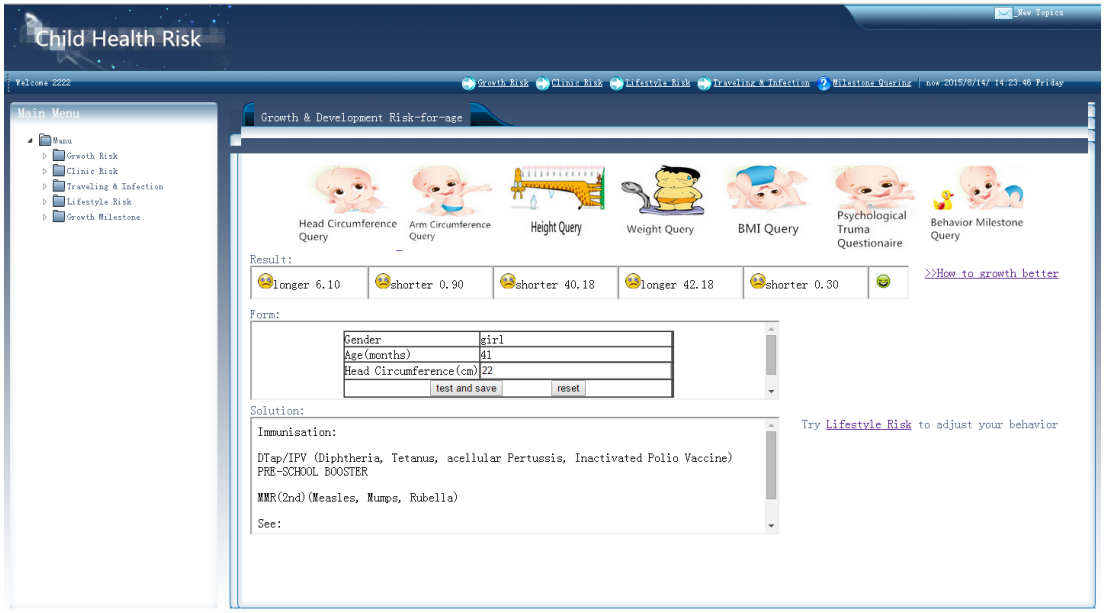


Figure 4.4: The Interface of Growth Risk Module

sists of a series of functional buttons, a series of tested result, a frame of test form, a frame for showing personalized solution from top to bottom. These buttons and content of frames showed on the same web page are more obvious for parents to operate and look over respectively. Users can operate these buttons in one view without the need to redirect to the next page and go back again for operating next function. They also can get a overview of all the evaluated result in a series of result frames on the same view.

For how to match the content to special frame, CHRQ uses different names of target and corresponding ids of frames to make difference. An example of result of arm circumference can shed light on the point. In the form of Arm.jsp, its target name is ”Arm result” matching the id of the frame on the grow and development interface, so the result will be return to the same web page. Such a kind of target also not only can be added into the form, but also inside the link tag. Thus, each clicking event will respond on the targeted frame. Additionally, many test forms have the same target name means one of them will be shown on the frame each time according to the action of the button.

4.3.3 Environmental Risk Module

Function Description: The environmental risk module aims at evaluating the environment-related risk of under five child mortality and infection rate. Infectious diseases usually

cause more deaths in a short period than common environment-related problem. For example the SARS epidemic had the potential to overwhelm health services. Most governments try to control the outbreak of infectious disease. In an outbreak, often children suffer most because they have relatively unprepared immune systems. We can not always stop epidemics in a short time but we can protect children with vaccination and parental awareness. Infection rate retrieval is such a function that attempts to improve parental awareness by showing the incidence and vaccination coverage rate at different locations. These addresses almost cover the areas where children spend significant amounts of time, such as home, school, p[lay areas, and travel destinations. The infectious diseases we consider include flu, cholera and meningitis. CHRQ will evaluate whether the location is safe for children to stay. If the disease coverage is beyond the control line set by WHO, a negative face expression will be shown, otherwise, there is a smiley face. Along with the result shown on the frame, there are personalized vaccination recommendation according to the location and the particular disease.

Apart from enhanced awareness, CHRQ recommends vaccination for children by evaluating the coverage of vaccination based on their chosen locations. If the coverage is already over 90 percent, the child is relatively safe when playing with other children even without getting vaccinated. Otherwise, parents should be alert to give vaccination (e.g. Bgg, DTP3, HepB3, Hib3, Measles,Tetanus, Polio, etc.) to their children and take advice. The evaluated result is also illustrated using a facial expression.

The travel risk function considers two aspects (epidemic diseases and vaccination recommendation) according to the travel destination. Parents can retrieve the situation of these two aspects at the travel destination before travelling with under-five children. With recommended vaccinations for the young, they can discuss it with doctor and get the child vaccinated.

As for environment-related mortality evaluation, CHRQ covers the following widely leading causes: poor sanitation, unsafe water, hygiene inadequacy, air pollution, second hand smoke, climate change, household air pollution. With the evaluated result illustrated by a facial expression, parents are made aware of the environmental risk around their children and so can take personalized solutions, such as changing location, cleaning, avoiding the use of unsafe water, etc. CHRQ cannot address these environmental problems, but can evaluate environmental quality to some degree and alert parents of potential risk.

Input/output designs are the drop-down menu and facial expression with advice

respectively. As for interface design, operating drop-down menu for choosing four addresses and checkbooks for choosing functions are on the left, and all result and personalized advice is inside the right frame. To reduce repeated step in choosing addresses in each function, the interface uses two step description to guide users choose the addresses at first and then what functions wanted next. As a result, users just need to operate one interface and can look through all query result on the right if all locations and functions are selected. However these environment-related problems are difficult to display clearly so drawTable() has been used to mange all results into different tables and print out in java. The following code helps a lot in output design.

```
1  void drawTable(PrintWriter out, String riskPicName, double []values,
       double h1thres, double h2thres)
2    {
3      out.println("<tr>");
4      out.printf("<td><img src = \"%s\" width=50px, height=50px></td>\
         n", riskPicName);
5      for(double v : values)
6        if (v > h1thres)
7          out.println("<td><img src = \"images/commonsick/good.jpg
             \"></td>");
8        else if (v > h2thres)
9          out.println("<td><img src = \"images/commonsick/middle.jpg
             \"></td>");
10       else
11         out.println("<td><img src = \"images/commonsick/bad.jpg\"></
             td>");
12     out.println("</tr>");
13   }
```

4.3.4 Clinical Risk Module

Clinic risk module is an innovative disease prediction tool which can calculate the likelihood of top 5 chronic diseases (e.g. cardiovascular disease, child obesity, diabetes type I, cancer, hypertension, etc.) for under-five children even in 30 years later. Existing work are focus on adult over 20 rather than the young, so there are 5 algorithms are proposed for the CHRQ. These predicted result may be too small to alert parents, because most children stay in health without unappreciated habits (e.g. smoking, drinking), overpressure or sedentary lifestyle. However, it is still important to design these algorithms against serious chronic diseases which starts from childhood.

Figure 4.5: The vaccination coverage retrieval on the interface of Environmental Risk Module

Figure 4.6: The infectious rate retrieval on the interface of Environmental Risk Module

Figure 4.7: The environmental risk retrieval on the interface of Environmental Risk Module

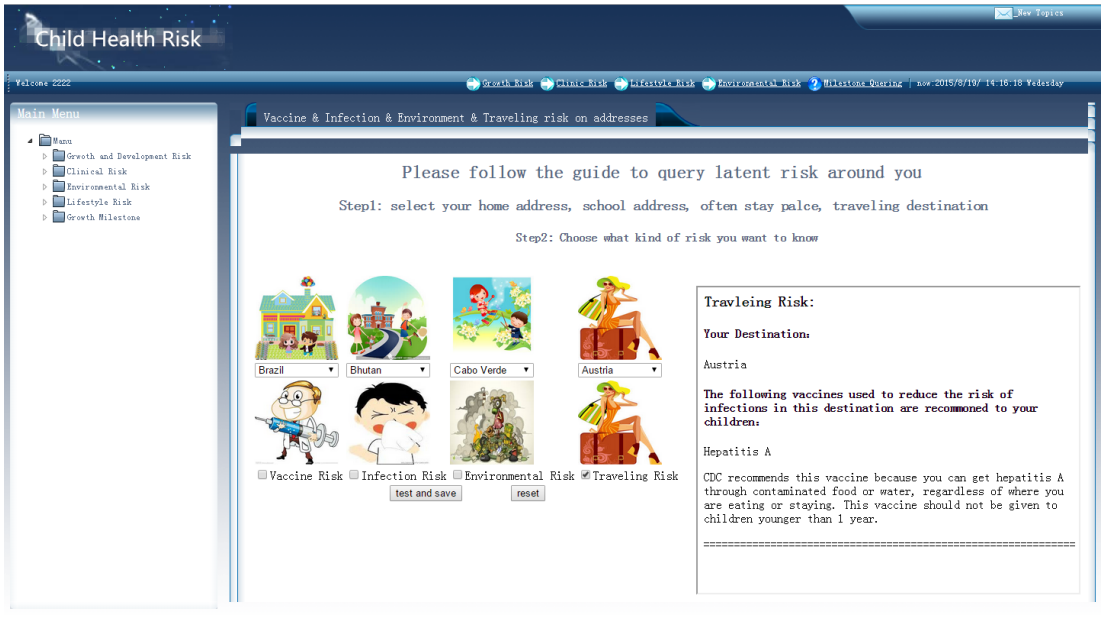


Figure 4.8: The traveling risk retrieval on the interface of Environmental Risk Module

Next, the thesis will discuss the top 5 chronic diseases and gives leading risk factors ranging by the hazard ratio. Based on existing work, five algorithms (e.g. cardiovascular disease score (CDS), child obesity score (COS), diabetes type I (DTS), child cancer score (CCS), hypertension score (CHS)) are proposed.

4.3.4.0.1 Cardiovascular Disease Score (CDS) Cardiovascular disease (CVD) is a group of diseases that involve the heart or blood vessels, including coronary artery diseases, stroke, hypertensive heart disease, rheumatic heart disease, cardiomyopathy, atrial fibrillation, congenital heart disease, endocarditis, aortic aneurysms, and peripheral artery disease. This kind of disease is one of leading causes of death globally, and the its impact has become more serious recently, resulting in 17.3 million deaths (31.5 percent) in 2013 up from 12.3 million (25.8 percent) in 1990[38], and mortality increases with age[41]. According to the report from WHO in 2011, 5 risk factors take up most of the mortality (e.g.High blood pressure (13 percent), smoking (9 percent), diabete (6 percent), lack of exercise (6 percent), obesity (5 percent)). Based on these statistics, the earliest cardiovascular Disease Score (called Framingham Risk Score) can date back to 1998, which estimates the 10 year cardiovascular risk of an individual. In recent years, Hippisley-Cox et al.[31] pointed out that Framingham algorithm over-predicted cardiovascular disease risk at 10 years by 35 percent, and had tracked 1.28 million patients for 17 years to adjust risk factors and corresponding hazard ratios again[57] for its QRISK2 algorithm. However, both of them have not consider to make prediction for under-five children and their researched patients are over 20 years UK/US residents. Inspired by these reports and researches, I reselect these child-related risk factors, and adjust the age range to 5 and under 5. The corresponding scores are also modified. The proposed Cardiovascular Disease Score (CDS) consists of three small algorithms (e.g. Fscore, Vscore, Qscore), and each of them share one third weight in the final CDS score.

Fscore:
Fscore is actually the sum of scores on five dimensions (i.e. systolic blood pressure, total cholesterol, HDL, treated, smoker) (see Table Fscore of CDS for details). For each dimension, different intervals of scores on that dimension corresponds to different scores. For example, if the subject is a girl and her systolic blood pressure is 115 (between 60 and 120), then she gets a score of -2 on systolic blood pressure. Similar

	systolic_blood_pressure		total cholesterol		HDL	treated			smoker		Total Score			
	girl	boy	girl	boy	girl/boy	girl	boy	boy	girl	boy	girl		boy	
0-40	-2	-1	0	0	2						range	result	range	result
40-49	-2	-1	0	0	1						7-16	0.5	0.5-3.5	1
50-59	-2	-1	0	0	0						17-19	1	4.5-5.5	2
60-120	-2	-1	0	0	-1						20-21	2	6.5	3
120-129	1	0	0	0	-1						22	3	7.5	4
130-139	2	1	0	0	-1						23	4	8.5	5
140-159	3	1	0	0	-1						24	5	9.5	6
160-199	4	2	4	4	-1						25	6	10.5	8
200-239	4	2	8	7	-1						26	8	11.5	10
240-279	4	2	11	9	-1						27	11	12.5	12
280-560	4	2	13	11	-1						28	14	13.5	16
Yes						2	1	1	9	8	29	17	14.5	20
											30	22	15.5	25
											31	27	16.5-24.5	30
											32-57	30		

Figure 4.9: Fscore of CDS

	smoler	pregnant smoking	family history	ethnicity	treated	family care	BMI
Yes	1	1	1	1	1	1	
<15 or >18							1
	girl	total_score * 0.067					
V score	boy	(total_score+1) *0.063					

Figure 4.10: Vscore of CDS

cases for boy and other dimensions. After getting the total score, we can easily get the probability of risk in 30 years later according the last column (total score) in table Fscore of CDS. These data are obtained from Framingham Heart Study and tested items is based on prior Framingham algorithm. Different from Framingham algorithm, Fscore resets the age range to 0-5 and age score is -7 for girl and 0.5 for boy (these initial values are calculated into range of total score and are not shown on table independently). Additionally, the predictable time is changed from 10 years to 30 years based on range of data.

Vscore:

Vscore is the sum of scores on 7 dimensions (i.e. smoker, pregnant smoking, family history, ethnicity in black or south Asian, treated, family care level (1 for general, 2 for poor health knowledge), BMI)(see Table Vscore of CDS for details). These tested items are related to child health and easy answered by parents. Whether the child is boy or girl, they use the same tested table to calculate their total score, but they will get probability of risk in 30 years based on gender. The last row shows the two Vscore calculating methods for girl and boy in table Vscore of CDS.

Qscore:

	total cholesterol/HDL>3.5	family history		systolic blood pressure(sbp)>120		BMI>18		treaded	
		girl	boy	girl	boy	girl	boy	girl	boy
Yes	(total cholesterol/HD-3.5)*1.001	1.229	1.3	(sbp-120)*1.005	(sbp-120)*1.004	(BMI-18)*1.015	(BMI-18)*1.022	2.73	2.84

Figure 4.11: Qscore of CDS

Qscore is actually the sum of scores on five dimensions (i.e. total choleserol/HDL¿3.5, family history, systolic blood presure¿120, BMI¿18, treated) (see Table Qscore of CDS for details). For each dimension, if comparative result or fact is true, corresponding score of this dimension will be added. For example, if the subject is a girl and her systolic blood pressure is 155 (¿120), then she gets a score of (155-120)*1.004 on systolic blood pressure. Similar cases for boy and other dimensions. With the total score, we can easily get the probability of risk in 30 years later. These data are obtained from QRESEARCH and tested items are selected from QRISK2 that relate to child. Different from QRISK2 algorithm, Qscore resets the age range to 0-5 instead of using log(age/10). Qscore is not directly add hazard ratio for each dimension, but use the interval between the users' and average value to multiply the hazard ratio. For example, QRISK2 adds the hazard ratio of Ratio of total serum cholesterol to high density lipoprotein cholesterol levels into the total score, while the Qscore at first minus the average value of total cholesterol/HDL of children and then multiplies with the hazard ratio as the score of this dimension. Apart from that, the score of treated is the combination of two original treated hazard ratios in QRISK2: Receiving treatment for blood pressure at baseline and Interaction terms for systolic blood pressureblood pressure treatment. Additionally, the predictable time is changed from 10 years to 30 years based on range of data. For final CDS score, CHRQ sets one third as weight for each score:

$$c = 0.33 * f + 0.33 * v + 0.33 * q. \tag{4.1}$$

note: c is CDS score, f is Fscore, v is Vscore, q stands for Qscore.

4.3.4.0.2 Child Obesity Score (COS) Obesity is attributed to excess body fat accumulation, this results in increased of likelihood of various diseases (e.g. heart disease, type 2 diabetes, obstructive sleep apnea, certain types of cancer, and osteoarthritis). It is usually caused by sedentary lifestyle and genetic factors. In recent years, an increasing number of children become obese and the age of these patient is becoming younger. Compared with other chronic disease, the disease occurs earlier even in childhood. The

child obesity score predicts the likelihood of obesity in adulthood, adolescence, and in childhood. All the tested items stands for the values provided when users register, and the score of each item is based on the obesity research. [55].

$$c = (p*0.68 + m*0.74 + n*0.77 + b*0.77 + o*0.77 + s*0.78)/100 \tag{4.2}$$

note: c is childhood obesity score, p is paternal BMI, m is maternal BMI, n stands for the number of family, b is the birth weight, o is maternal Occupation, s refers to Gestational smoking.

$$a = (p*0.70 + m*0.67 + n*0.73 + o*0.74 + s*0.75)/100 \tag{4.3}$$

note: a is adolescent obesity score, p is Paternal BMI, m is maternal BMI, n is stands for the number of family, o is maternal Occupation, s refers to Gestational smoking.

$$a = (p*0.69 + m*0.81 + o*0.84 + b*0.82 + s*0.85)/100 \tag{4.4}$$

note: a is adult obesity score, p is Paternal BMI, m is maternal BMI, o is maternal Occupation, b is the birth weight, s refers to single parenthood.

4.3.4.0.3 Diabetes Type I Score (COS) Patients in diabetes type I have high blood glucose because their pancreas (a small gland behind the stomach) doesn't produce enough insulin to reduce the blood glucose. Type I diabetes can develop at any age, but usually appears before the age of 40 and particularly in childhood. It is most common type of child hood diabetes. Without timely treatment, it will damage the organs of the child. Unfortunately, the cause of the disease is unknown at present. Recently, [47] pointed out the following possible risk factors (e.g. BMI, age, total glucose, fastingC, totalC) and gave corresponding hazard ratio. Driven by these reasons and researches, CHRQ redesigns the prior method and adds 3 possible factors with 0.5 weight for each into the original function and completes the predictable tool. The following function is the calculating method.

	Bruising	Pallor	Lump mass swelling head and neck	Fatigue	Lymphadenopathy	Lump mass swelling	Bleeding	Pain	Musculoskeletal symptoms	Visual symptoms	Abnormal movement	Headache	Parental cancer history
Yes	1	1	1	1	1	1	1	1	1	1	1	1	1

Figure 4.12: cancer score of COS

$$
\begin{aligned}
z = & 1.569 * \log b - 0.056 * a + 0.813 * t + 0.476 * \log f - \\
& 0.848 * c + 0.5 * p + 0.5 * s + 0.5 * l + 0.5 * m - 6.638 \\
& d = 1 - 0.543^{\exp(z)}
\end{aligned}
\tag{4.5}
$$

note d is diabetes type I score, b is BMI, a is Age, t is total glucose, f is fastingC, c is totalC, p is parental history on diabetes, s stands for sugar, l is cold, m is mumps.

4.3.4.0.4 Child Cancer Score (COS)

Cancer is a group of diseases that causes abnormal cell growth with the potential to invade or spread to other parts of the body. These diseases usually cause many symptoms(e.g. a new lump, abnormal bleeding, a prolonged cough, unexplained weight loss, and a change in bowel movements among others, etc.), and each symptoms contributes to 0.0011 to 0.0076 likelihood to form cancer, according to NHS. Therefore, the cancer predictable algorithm selects easy identified child cancer symptoms (e.g. Bruising, Pallor, Lump mass swelling head and neck, Fatigue, Lymphadenopathy, Lump mass swelling, Bleeding, Pain, Musculoskeletal symptoms, Visual symptoms, Abnormal movement, Headache, Parental cancer history), and multiplies the appearing number of symptoms with contributing score as predicted possibility.

$$
\begin{aligned}
i &= t * 0.0011 \\
m &= t * 0.0076
\end{aligned}
\tag{4.6}
$$

note: i is minimal COS, t is total point, m is maximal COS.

4.3.4.0.5 Child Hypertension Score (CHS)

Hypertension is a chronic disease that elevates the blood pressure in the arteries. In the arterial system, systolic pressure (SBP) (maximum pressure) occurs when the left ventricle is most contracted while the diastolic pressure (DBP) (minimum pressures) occurs when the left ventricle is most relaxed prior to the next contraction. Normal blood pressure is within the range of

100140 mmHg systolic and 6090 mmHg diastolic. These two pressures are indicators of latent risk for other diseases (e.g. hypertensive heart disease, coronary artery disease, stroke, aortic aneurysm, peripheral artery disease, and chronic kidney disease). As a result, a child hypertension score is necessary to be designed and used to predict the possibility of getting hypertension.

$$\begin{aligned} z =& 0.156641 * a + 0.20293 + 0.05933 * s + 0.12847 * d \\ &+ 0.19073 * m + 0.16612 * p + 0.033888 * b \\ g =& 1 - 0.543^{\exp(\frac{z}{100} - 6.638)} \end{aligned} \tag{4.7}$$

note: g is CHS for girl, a is age, s is SBP, d is DBP, m refers to smoker, p is parental hypertension, b is BMI.

$$\begin{aligned} z &= 0.156641 * a + 0.05933 * s + 0.12847 * d + 0.19073 * m + 0.16612 * p + 0.033888 * b \\ y &= 1 - 0.543^{\exp(\frac{z}{100} - 6.638)} \end{aligned} \tag{4.8}$$

note: y is CHS for boy, a is age, s is SBP, d is DBP, m refers to smoker, p is parental hypertension, b is BMI.

Interface Design:
Similar to the interface design of Growth and Development Module. This Interface is made up of 5 buttons for operating test, 5 frames for printing the predicted result of corresponding diseases and 1 frame for showing test forms from top to bottom. Beside the frame of form, there is link to personal solutions. All result are shown in facial expressions along with predicted probability. Such a design gives users a sense of integrity for operating buttons and over-viewing the results.

4.3.5 Lifestyle Risk Module

Lifestyle Risk Module is used to evaluate the lifestyle of a child and informs the parents what adjustments are useful for better development. It is an assisted module for growth and development module. The module gives user more detailed personalized solutions on eating, activity and sleep of children.

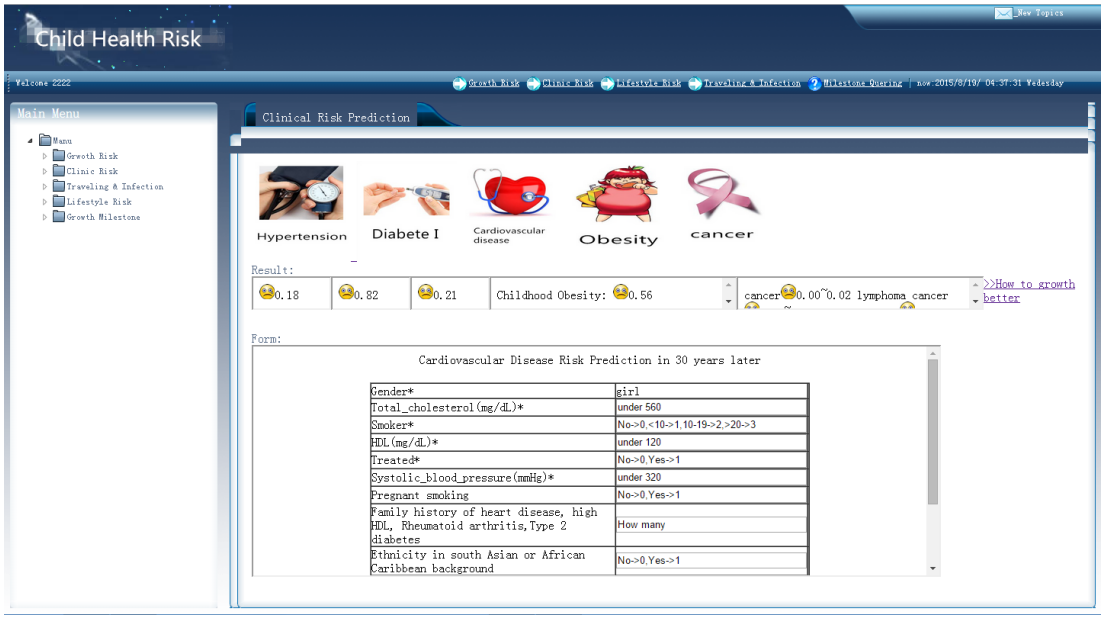


Figure 4.13: Interface of Clinic Risk Module

The first function is calories intake calculating, CHRQ can calculate how many calories have been consumed by the child by checking what kinds of meals (e.g. Chinese food, Italian food, Western food, Indian food) the child have eaten today. Different meals have different numbers of calories. If the amount is over the recommended upper boundary of the child's intake, a crying face will express an uncomfortable feeling for the child, otherwise, there is a smiling face. Excessive intake or insufficient intake will impact the digestive ability of children and nutrition balance. The personalized solution will alert parents to balance the child's diet.

The second function counts calories used in activity, CHRQ will accumulate the multiplied result of consumption per hour of each activity and hours. Different activities have different calories consumption per hour, the user can choose what kinds of exercise their children have taken from a drop down menu, and then type the hours for that activity. Unlike common activity calculators, this calculator is for under-five children whose exercise level is from light to medium. Similarly, facial expressions will stand for the attitudes towards the result, and personalized solution (e.g. how long is fine for children at that age, what kinds of activities are suitable to children, etc.) will be shown on the frame.

The final function is sleep time retrieval. Relaxing time is important for human beings, especially for young children who need more sleep time than adults. By entering the day sleep time and night sleep time CHRQ will compare them with the respective

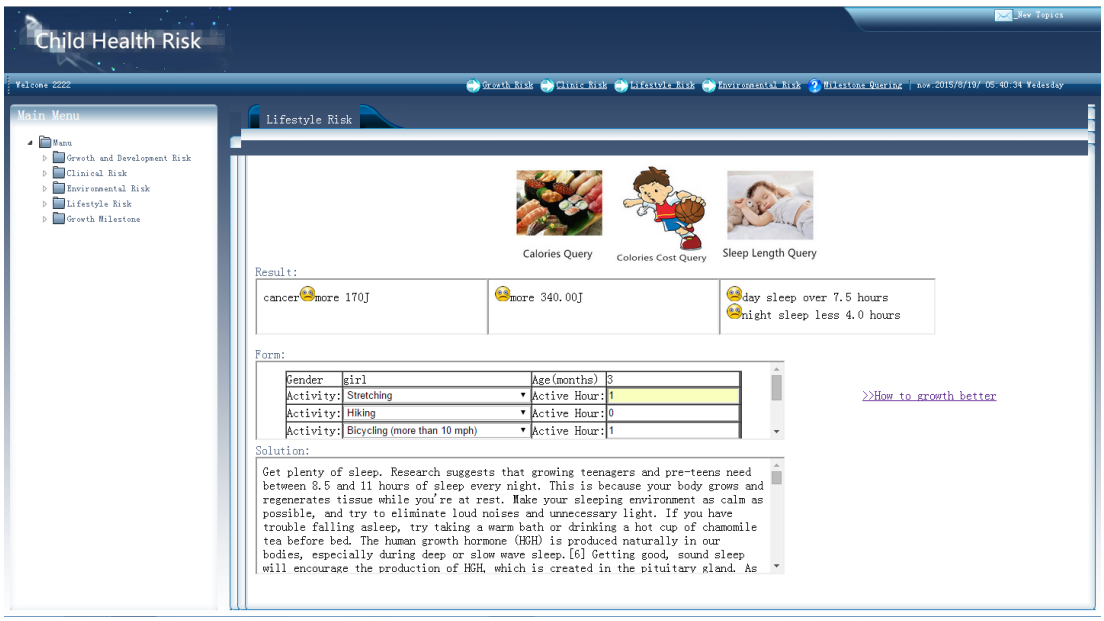


Figure 4.14: The interface of Lifestyle Risk Module

averages at the same age stage and show the facial expression result to users. Similarly, along with the result is the personalize sleepy time advice and how to help children relax.

As for the interface design, from top to bottom, CHRQ arranges 3 operating buttons followed by 3 result frame and then the main frame for test form and solution output. All interfaces have a unified style which makes the web-base CHRQ more user-friendly.

4.3.6 Assisted Function Design

The whole interface can be divide into three frames: top, left and right. In the top frame, topics function is on the top right corner and used for giving more links or information on how to care of under-five children. Below the topic button is a series of navigational functions. From the left to right, there is user log on state, Growth Risk Module entry, Clinic Risk Module entry, Lifestyle Risk Module entry, Environmental Risk Module entry, help and current system time. These buttons offers main entries for operating each module. While the left menu provides user detailed entries. Each folder can be extended with several functions, and each function can directly entry corresponding operating web page. For example, if a user only wants to retrieve the vaccine coverage at his or her home address, he or she can click the folder of Traveling and Infection and chose vaccination icon from a series of extended items under this

```
function Tree(rootNode) {
    var $ = this;
    this.root = rootNode;

    this.show = function(container) {
        $.update($.root);
        this.root.expand();

        if(container.tagName)
            container.appendChild($.root.container);
        else if(typeof container == "string")
            document.getElementById(container).appendChild($.root.container);
    }

    this.update = function(parent) {
        parent.indent();
        for (var i = 0; i < parent.children.length; i++) {
            parent.children[i].level = parent.level + 1;
            for (var j = 0; j < parent.ancestor.length; j++) {
                parent.children[i].ancestor.push(parent.ancestor[j]);
            }
            parent.children[i].ancestor.push(parent);
            $.update(parent.children[i]);
        }}}
```

Figure 4.15: The Tree of Menu

folder. This menu is not only for showing user what CHRQ have, but is a fast entry for a special function. In the right frame, it is the main operating interface and all the operations and results will be show on this interface. User puts forward their request and interacts with CHRQ at the same view. In the whole interface design, menu is relatively special part owing to its cascade connection between folder and documents (functions), so a part of core code of menu is showed below.

4.4 Data

Most of data is from the WHO which provides data for the Growth and Development Risk Module (i.e.arm circumference, head circumference, weight, height, BMI for boy and girl under five); Environmental Risk Module on vaccine coverage rate (i.e Bgg, DTP3, HopB3, Hib3, Measles, Tetanus, Polio), infectious disease mortality (i.e. flu, cholera, meningitis), Environment-related mortality (i.e. air pollution, second hand smoking, poor sanitation, unsafe water, hygiene inadequacy, climate change). These data are downloaded in excel format and we use data from the latest year. Travel data in Traveling Risk function comes from the Centers for Diseases Control and Prevention (CDC), and CHRQ selects the name of epidemic diseases for each destination and

```
this.add = function(child) {
    this.container.appendChild(child.container);
    this.children.push(child);
    child.parent = this;
}

this.remove = function(child) {
    child.container.removeNode(true);
    var temp = [];
    for (var i = 0; i < this.children.length; i++) {
        if (this.children[i] != child) {
            temp.push(this.children[i]);
        } else {
            continue;
        }
    }
    this.children = temp;
}
```

heightheight

Figure 4.16: The TreeNode of Menu

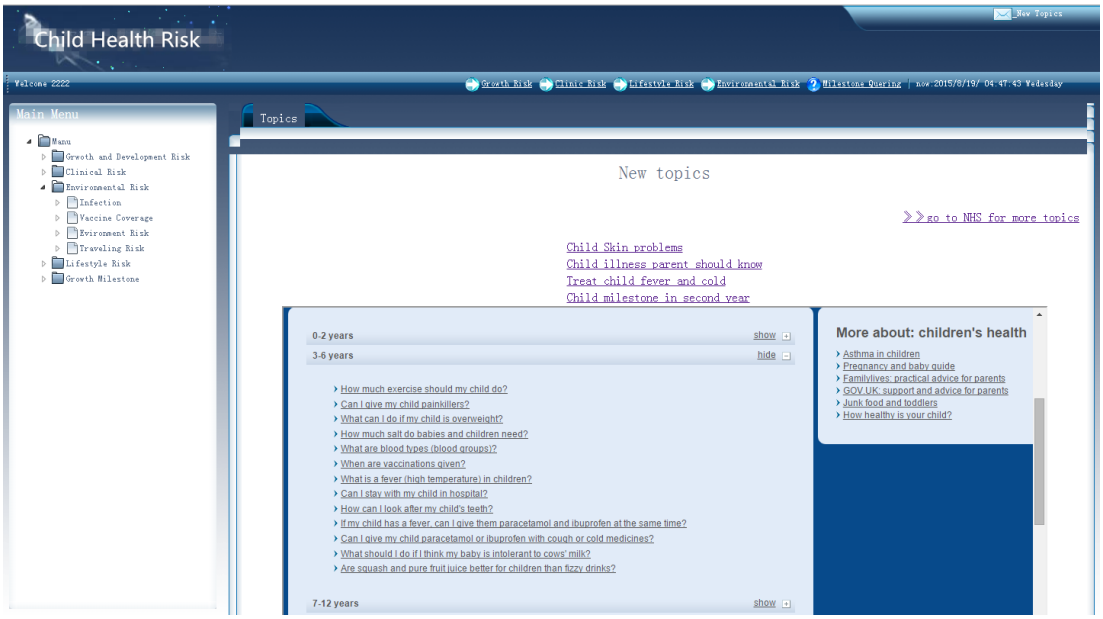


Figure 4.17: The interface of Assisted Funtion

corresponding disease description and vaccination recommendation. As for the child calories requirement of intake and consumption, these data are found in WebMD, a child health website. While NHS, another child health website, offers the child sleep pattern data. These data are also stored in excel format.

Having sourced enough processed data, we need to transfer these excels to sql format and store them in CHRQ database as data tables. This process is completed by Navicat for MySQL, a powerful database management tool which can transfer excels to sql documents in special database. Additionally, this tool supports data table maintenance, field restriction and transfers the sql out in multiple formats. The tool has a GUI operating interface, its foundation lies in the MySQL server 5.5.

As for how to use the data in the database, Myeclipse 10, a full-featured Java IDE for JavaEE and web development tool, provides the database connection service, and reflects these data tables in its own database system (DBS). Then, we can use Java programming language to create connection, statement and retrieve result from database, and then watch the result on the web page after a series of operations on CHRQ web application.

As for other data, these scores, weights or initial data of function are from researchers, reports, lab result, investigation, statistics, even health centres and websites. This part of data do not need to be stored in the database but is used in function implementation as parameters. A part from that, user data shares a large proportion. User data is stored in the user table in the DBS, while the other data does not need to be stored in DBS but is used as parameters in the code.

All data maintenance occurs on the Navicat for MySQL, the updated period usually is one year based on the update rate of WHO. When updating, CHRQ may need to add some sql documents which need data base administrator (DBA) to download from prior data source and use the sql transfer function again to generate the new sql document. Other update and delete operations are also managed by DBA. As for data output, the first way is transfer the sql out in multiple formats and stored on the computer of DBA, while the second way is operating DBS and showing the data or running result on web pages. The web-based output data can be seen above, while a series data tables are shown in the appendix.

Chapter 5

Testing

We should have confidence in the CHRQ if we are to use it to assist in making decisions on children's health. Thus we should consider the potential for errors that may affect the usefulness of the system. In this chapter we briefly consider some key aspects of testing (i.e. function, security, GUI) that should help improve our confidence in the system. Most of testings use black-box method focusing on the functional goals and consider the valid input and invalid input. These testing results verify that the system can identify invalid input and warn user. In fictional testing, I use alert() to check the response to the invalid input in form function, and use Junit to test correctness of a calculating method. In security testing, I focus on log and register and use black-box method to judge whether the system can separate the invalid inputs (e.g. user name is null, user name already exist or un-exist, wrong password, input beyond restriction, etc) from valid inputs. These result reflect the usefulness of the system to some degree.

5.1 Functional testing

Functional testing aims at discovering discrepancies between the behaviour of the system and its external specification. External specification means a precise description of the required behaviour form. We need to test whether the running result as we expected and how the system tolerant to the failure or errors. This testing method also is called black-box testing, one of the software testing that examines the functionality of an application without investigating into its internal structures or workings. With functional testing, we can check whether the function is correct or not, is there any interface error, input and output error, database access error, performance error and initialization and termination errors, etc. Most of these aspects have been tested during

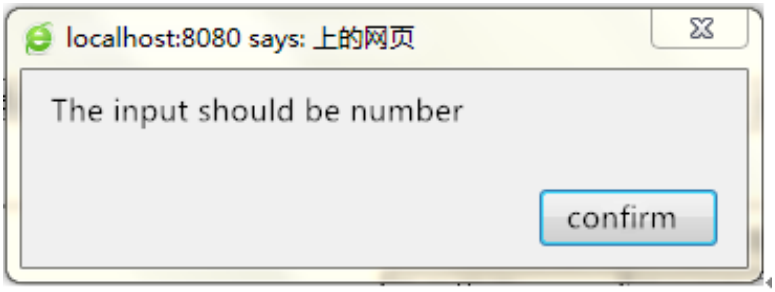


Figure 5.1: The error message of number input restriction

the development. The following example is wrong format of input of height. The typed height (cm) should be number, but we will test whether the system can recognize the typed string and pop the error message.

```
function FormatCheck()
{
   if(!isNum(document.getElementById("height").value)){
   alert("The input should be number");break;
   }
   }
```

I also use white-box method with Junit tool to test some important method in calculation. Here is an example of Junit test case on the getRiskScore().

```
public class Diabete1_inputTest extends TestCase {
private Diabete1_input diabete;
  @Before
  public void setUp() throws Exception {
    super.setUp();
    diabete=new Diabete1_input();
  }
  @After
  public void tearDown() throws Exception {
    super.tearDown();
  }
  @Test
  public void testgetRiskScore() {
    double roundError = 0.00001d;
    assertEquals(diabete.getRiskScore(6.638), 0.457, roundError);
    double score = 6.638d + Math.log(2);
    assertEquals(diabete.getRiskScore(score), 0.705151, roundError);
  }
}
```

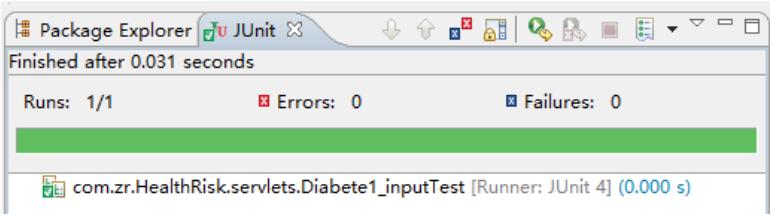


Figure 5.2: The Junit test result on the getRiskScore()

Figure 5.3: The error message of un-exist user in logging

5.2 Security testing

Security testing is defined as external specification. Driven by the goal of developing a security model that constrains the flow of information from one area of the system to another, user log on function has drawn highly attention. CHRQ has 3 restrictions to log on. If the user name cannot be found in the database, the system will reject user to enter main operation interface and show the error message on the view. If user name actually exist but without a correct password, it still rejects users' requirement. Only with correct user name and password, the system agrees the entry and show corresponding prompt information "welcome" on the interface of log on. I still use black-box testing to check the following security problems: user name is null, user name already exist, typed user name beyond the range of restriction in registering, and wrong user name and wrong password with right user name in logging on (correct register and log on are already shown in the prior chapter).

Figure 5.4: The error message of wrong password in logging

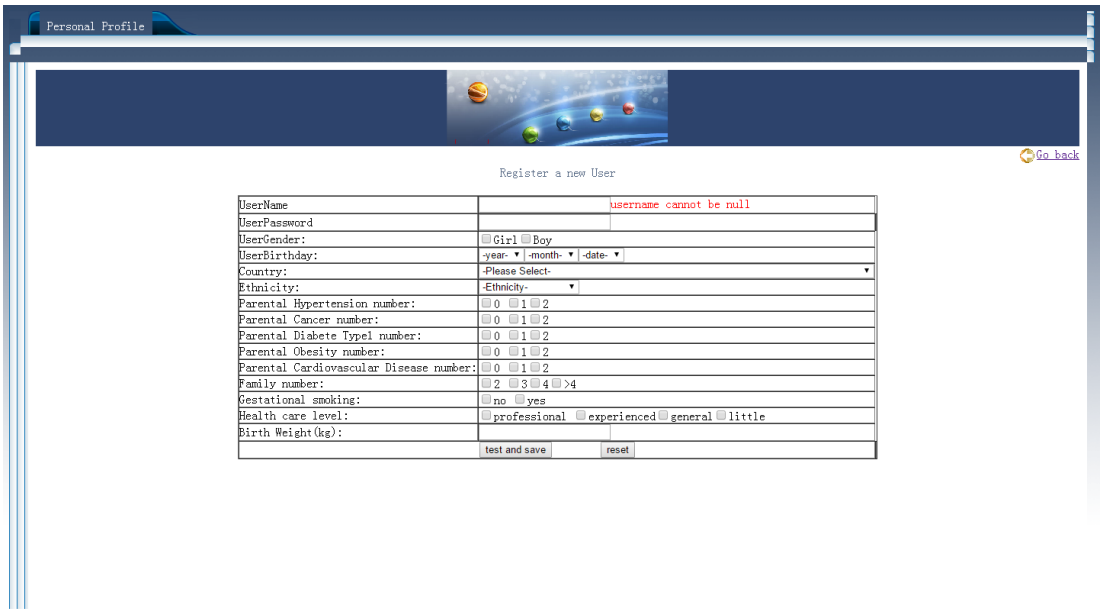


Figure 5.5: The error message of null name in registering

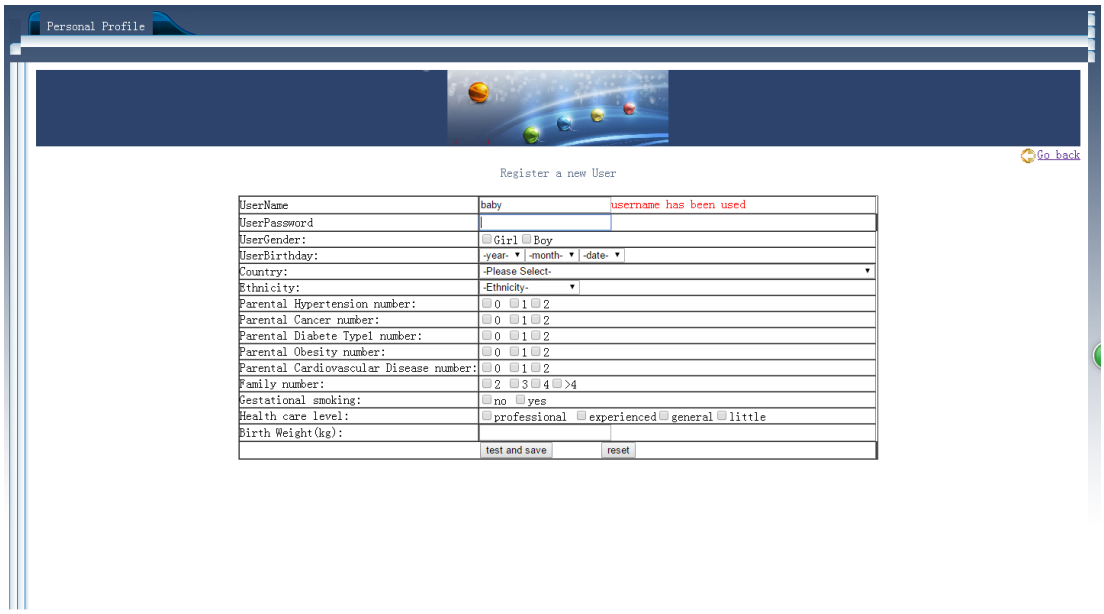


Figure 5.6: The error message of tying exist user name in registering

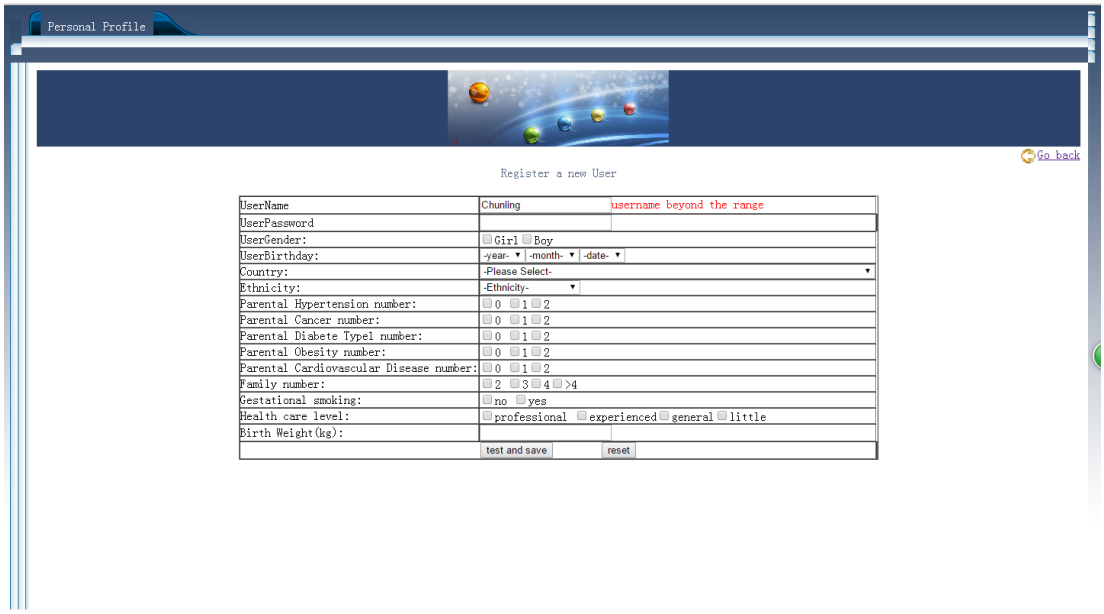


Figure 5.7: The error message of user name is over range in registering

5.3 GUI testing

The GUI testing aims to let these interfaces to be quite dynamic to catch up users' needs. It needs high cost than normal testing in creating code and maintenance. Considering amount of debug work in code fix, we choose manually adjust UI design on the following aspects: location of panels, correctly language tips, local formats (e.g. UK Date format), matching the resolution of the web browser, colour schemes, pictures, fonts, size and position of pop-ups, preferred formats (e.g. how many items organize in one view), etc. The final UI design has been evaluated with a good grade in the chapter of Evaluation.

Chapter 6

Evaluation

To verify the usability of CHRQ system, a small set of volunteers were invited to do the evaluation with no preference. This chapter deploys three traditional evaluation methodologies (i.e. Heuristic Evaluation, Scenario-based Tasks Evaluation, Questionnaires) with detailed evaluation principles. Our results give us some confidence the CHRQ fulfills its intended function.

6.1 Evaluation mythology with result

6.1.1 Heuristic Evaluation

Heuristic evaluation aims to identify and address usability problems in the user interface (UI) design and judge whether the UI follows the recognized usability principles (”heuristics”). In this way, users will make fewer errors in operating the UI and increase the learnability, efficiency, memorability and satisfaction. Compared with other usability testing methods (questionnaires and scenario-based tasks), heuristic evaluation is highly flexible with low cost, and requires a smaller number of evaluators. In this project, we get 17 volunteers, including 3 parents with under-five children, to finish this test by checking the principle proposed by Susan Weinschenk [54] and Dean Barker[43]. The revised test content and result are shown below. The result reflects the high support rate for the usability of CHRQ.

(1) User Control: whether the user has enough control of the interface.

(2) Human Limitations: whether the UI avoid overloading human limitations.

(3) Modal Integrity: whether different tasks have different modality support.

(4) Accommodation: whether the UI satisfy parents with under-five children.

(5) Linguistic Clarity: whether the language is easy understanding in communication.

(6) Aesthetic Integrity: whether the visualization are appreciated.

(7) Simplicity: whether the design will not use unnecessary complexity.

(8) Predictability: whether the system response is efficient.

(9) Interpretation: whether there are codified rules that try to guess the user intentions.

(10) Accuracy: whether the result of user actions correspond to their goals.

(11) Technical Clarity: whether the concepts represented in the interface have the highest possible correspondence to the domain they are modeling.

(12) Flexibility: whether the design can be adjusted according to different needs of users.

(13) Fulfillment: whether the user experience is adequate.

(14) Cultural Propriety: localization.

(15) Suitable Tempo: whether the work pace is adequate.

(16) Consistency: unified style.

(17) User Support: whether the design will support learning and provide the required assistance to usage.

(18) Precision: whether the steps and results of a task will be what the user wants.

(19) Forgiveness: error tolerant.

(20) Responsiveness: whether the interface provides enough feedback information about the system status and the task completion.

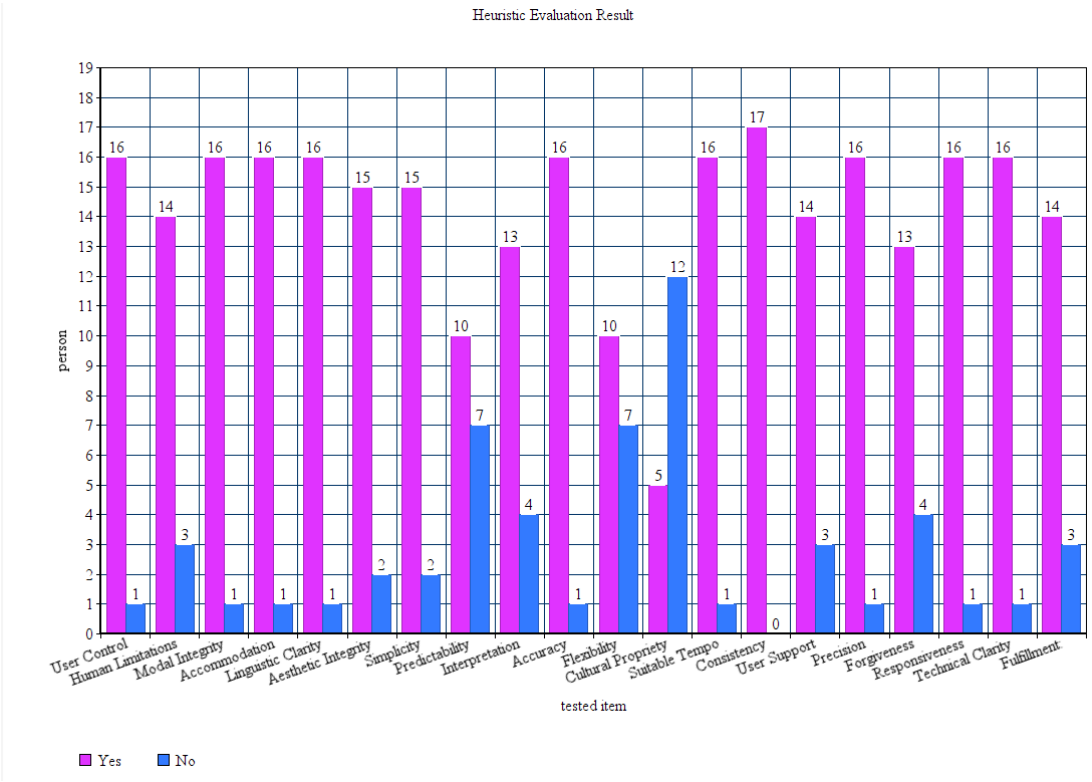


Figure 6.1: Heuristic Evaluation Result

6.1.2 Scenario-based Tasks Evaluation

Scenario-based Tasks Evaluation is used to judge whether users understand how to use a series of actions that the interface provides to achieve some goal. A scenario provides a task that is representative of the intended operation of the system. The design principle of task scenarios are: 1) is realistic and typical for how people actually use the system, when they are on their own time, doing their own activities; 2) encourages users to interact with the interface; and 3) do not give away the answer. Followed by the task scenarios, we record the grades of the task given by 3 parents who have not use this system before respectively to check the feature of the application is easy understanding. As a result, all the 3 evaluators gave good grades on each principle of Nielsen[39] after completing the task.

(1) Start the application and register a new user, and then log on

(2) Enter the Growth and Development Risk to use the height risk query function, and remember your result.

(3) Enter the Clinical Risk to use child obesity prediction function and remember the disease possibility of childhood obesity.

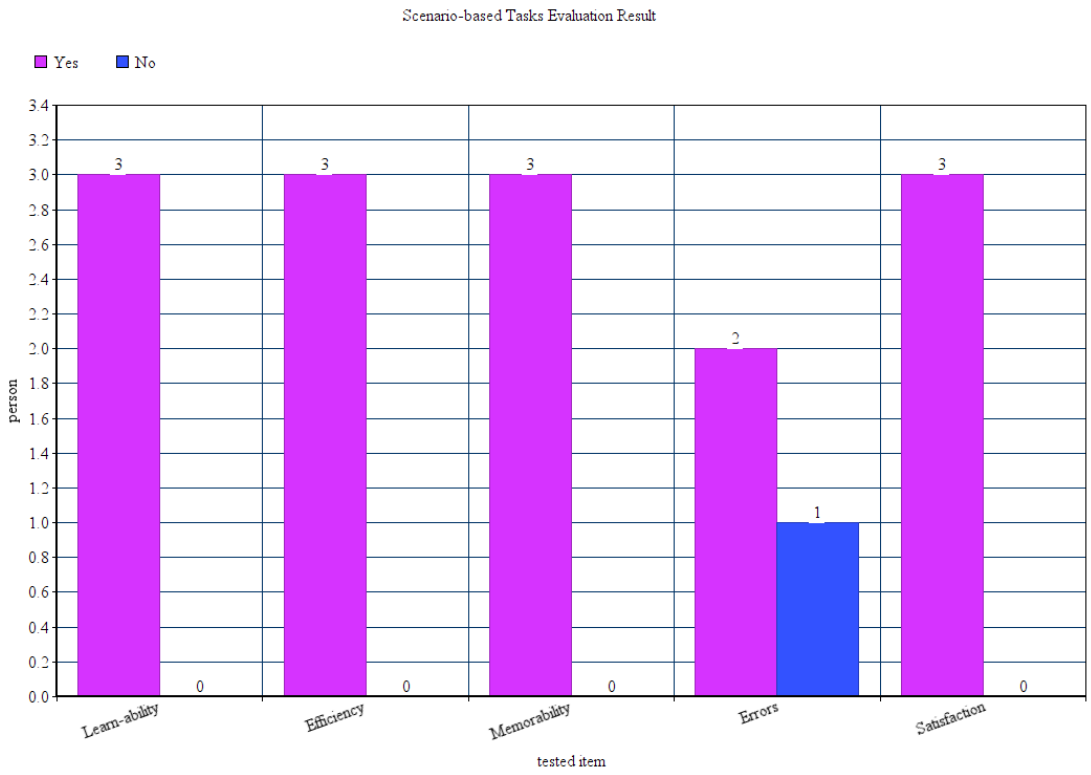


Figure 6.2: Scenario-based Tasks Evaluation Result

(4) Enter the Environmental Risk to use vaccination coverage retrieval function, and record the coverage rate of BGG at your home address.

(5) Enter the Lifestyle Risk to use the calories intake query function and understand evaluated result of the day meals.

(6) Look through other related topics

Nielsens usability evaluation principles are:

(1) Learnability: How easily the user can complete the task without previous experience with the application.

(2) Efficiency: How fast the user can complete a task by using the application.

(3) Memorability: How easily it would be for the user to handle the application.

(4) Errors: The number of mistakes that the user made during using.

(5) Satisfaction: Is the user satisfied in overall with the application.

6.1.3 Questionnaires

Along with scenario-based tasks and Heuristic evaluation, Questionnaires is the last kind of traditional usability evaluation method. Questionnaires are used for collecting and making analysis of responses about the impression for the CHRQ system and identifying possible problems. This questionnaire is finished 17 volunteers, resulting in good comments on the system. The questionnaire is designed based on the following principles[36]:

(1) Tip: Inform the users about system status and the possible operation.

(2) General language: The UI must contain words and phrases familiar to the user.

(3) Easy switch: The user must be able to switch between system functions without too much effort.

(4) Error: The system must be optimized in order to prevent errors.

(5) Recognition: The user must be able to recognize the functionality of every part of the system instead of remembering.

(6) UI optimisation: The system allows the user to optimize the interface in order to complete faster the tasks.

(7) Aesthetic design: The UI of the system should have an aesthetic and minimalist related design.

(8) Interpretation: The system should print error messages in a local language, and suggest a possible solution.

(9) Help: The system should provide help or using guidance to the user so that they can use them successfully.

(10) Goal: the system indeed alerts parents various risk of their children and inspire them to take personalized solution.

The evaluation identified several areas where the interface could be improved. In response to the evaluation results and feedback from evaluators on each stage, we made the following changes to the CHRQ:

(1) Reintegrated several functions of each module into one view so that all operations and results are completed and shown respectively on the same interface.

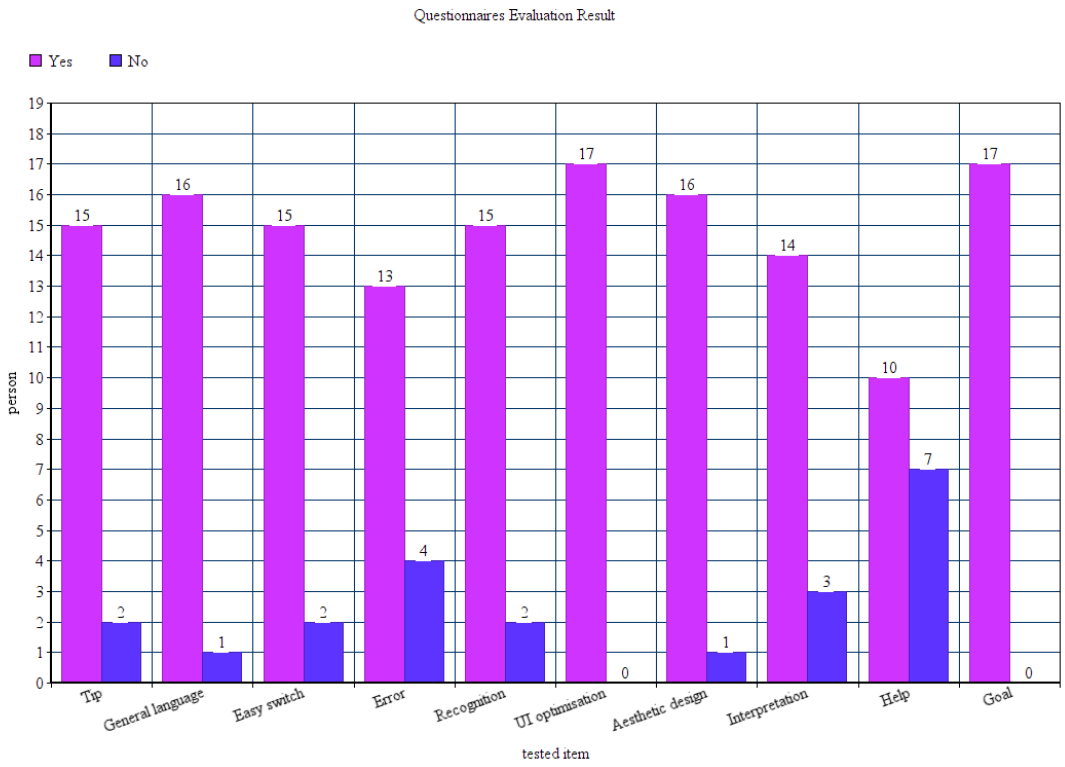


Figure 6.3: Questionnaires Result

(2) Expression result more obvious by using facial expression instead of words.

(3) Added fast entries to each function in left menu.

(4) Added tips on each typed field of forms.

(5) Error prompts without interfering users by using Ajax technology.

(6) Added automatic form fill out function to avoid repeated user information input.

Chapter 7

Conclusion and Future Work

This final chapter summarises the functions, contributions and features of the CHRQ system, and indicates the future direction of CHRQ on visualization, risk factor selection, interaction, date updating, delivery and reminder.

7.1 Conclusion

CHRQ actually achieves the goal of the project. It not only evaluated the existing PHR systems but also addresses the problems proposed at the beginning along the development. Besides, its usefulness and usability have been tested and appreciated respectively for the evaluators. Additionally, CHRQ lights the direction of Child Health Risk in the future.

We developed a web-based Child Health Risk Query system that can evaluate the child growth and development, predict top 5 chronic diseases risk, point out lifestyle problems of child, retrieve environment-related mortality and infectious rate at specified locations. These evaluated result using facial expression will alert parents to take the personalized solutions for protecting their young children as early as possible. CHRQ provides a PHR that focuses on child risk evaluation. Different from existing system, like eRedBook, the CHRQ offers online growth evaluation, diseases prediction, lifestyle problem query, infectious and environment-related mortality retrieval based on different addresses and traveling destinations. The usability of these functions has been evaluated and appreciated by volunteer who made comments with no preference. In comments, they prefer the facial expression result and personalized solutions which contributes to understanding and to motivation to act on the health of the child.

Along with CHRQ, child chronic disease prediction algorithms have been proposed and implemented, including cardiovascular diseases in 30 years later, childhood obesity, teen-hood obesity, adulthood obesity, cancer, hypertension, and diabetes type I. Different algorithms focus on different child clinical information and each risk factor has different weight in different algorithms. These algorithms have theoretical evidences but their validity goes beyond the scope of this dissertation will.

Moreover, the utility of the interface and functionality has been evaluated. The automatic user information fill-out design reduces the workload for users. In addition, multiple entries cater different using habits. If user want to evaluate all growth measurements at once, he/she can use the main Growth and Development interface. If he/she just wants to evaluate child height, the extensible menu offers fast entry for that function. In addition to form hint, input restriction is already show in the text field, and error alerts will show on the web page without interfering with the use of the interface. Apart from that, unified design style and easy access improve work efficiency.

7.2 Future Work

Based on the evaluation of CHRQ and related health risk work, the system could be extended in following aspects: result visualisation, automatic risk factor selection, interaction between professional interface and user interface, automatic data update, and alert delivery and calender reminder.

7.2.1 Visualising Result

Facial expression icons are easy to understand but not informative for users who want to overview the statistics or look back their history risks. For example, a parent may want to mark his/her child's height on a growth chart with a overview comparison. They may also expect these evaluated result are organized in a line chart based on time and look back the risk history at anytime. Therefore, CHRQ can easily be extended to distribute these results on a timeline with each line presenting a series of results of one function. In addition to each button of facial expression on one line, a statistic chart could be unfold by clicking.

7.2.2 Automatic Risk Factor Selection

Existing disease risk factors and corresponding hazard ratios are derived long period statistics. Such a statistical result is expensive for researchers who want to focus on research rather than investigation. Additionally, the statistical data will be scattered when we select on the basis of the main causes of risk. That is to say, when we select some of the top causes, some related risk factors to these causes and their relationship are discarded. However the relationship is important in clustering risk factors and reselection. [50] and [32] used machine learning in automatic clinical feature selection by using training data and updating coefficients of features. Such a method improves the efficiency of automatic selecting risk factor. In the distant future, automatic risk factor selection algorithms are expected to extent the clinical risk module.

7.2.3 Interaction between Professional Interface and User Interface

Few PHRs implement the interaction between the professional interface and user interface, and most of them just focus on one aspect to cater for a particular group. While the interactive design is necessary, because user may want to get online advice from experts or experienced grandmother in time. CHRQ is expected to post parents' question or disease description on the interactive interface, and to show the feed-backs from other users (e.g. experts, PG doctors, grandmother, experienced parents etc.) below the question along with the reliable starts according to the level of their clinical knowledge.

7.2.4 Automatic Data Update

The current data management of CHRQ is operated by the DBA and the updated period is 1 year based on the data update frequency of WHO. Besides, the data cannot transfer from these data sources to CHRQ directly because of technological limitation and accessible restriction. Thus, CHRQ is expected to achieve data source automatic connection and data update regularly.

7.2.5 Alert Delivery and Calender Reminder

All evaluated and predicted results are shown on line instead of delivering to the end devices, like mobile. It may be not convenient for modern parents who want to look

through the child risk at any time and check the personalized solution. For this reason, a email deliver or app support is expected to be added on the CHRQ. As for the vaccination schedule, it is also expected to generate a calender reminder on the end device or sending by email.

Appendix A

Appendix

Here are all data tables in the database of CHRQ.

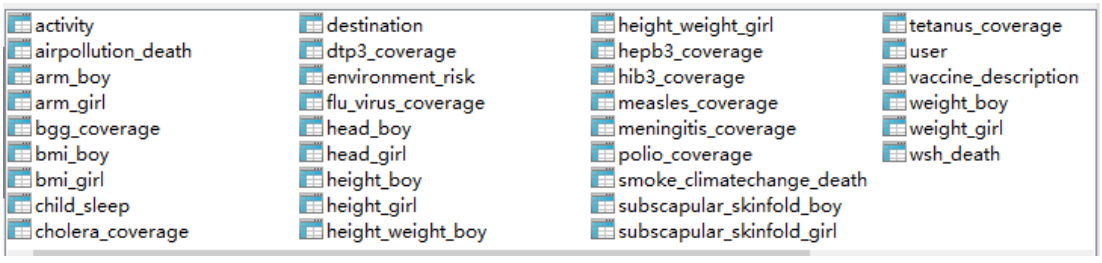


Figure A.1: All tables in the database

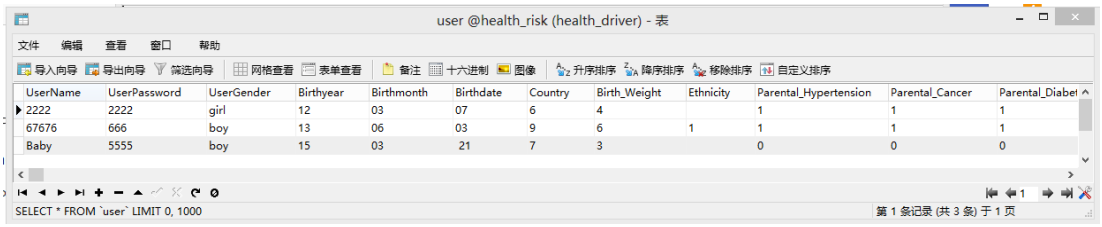


Figure A.2: data table of User's information in register

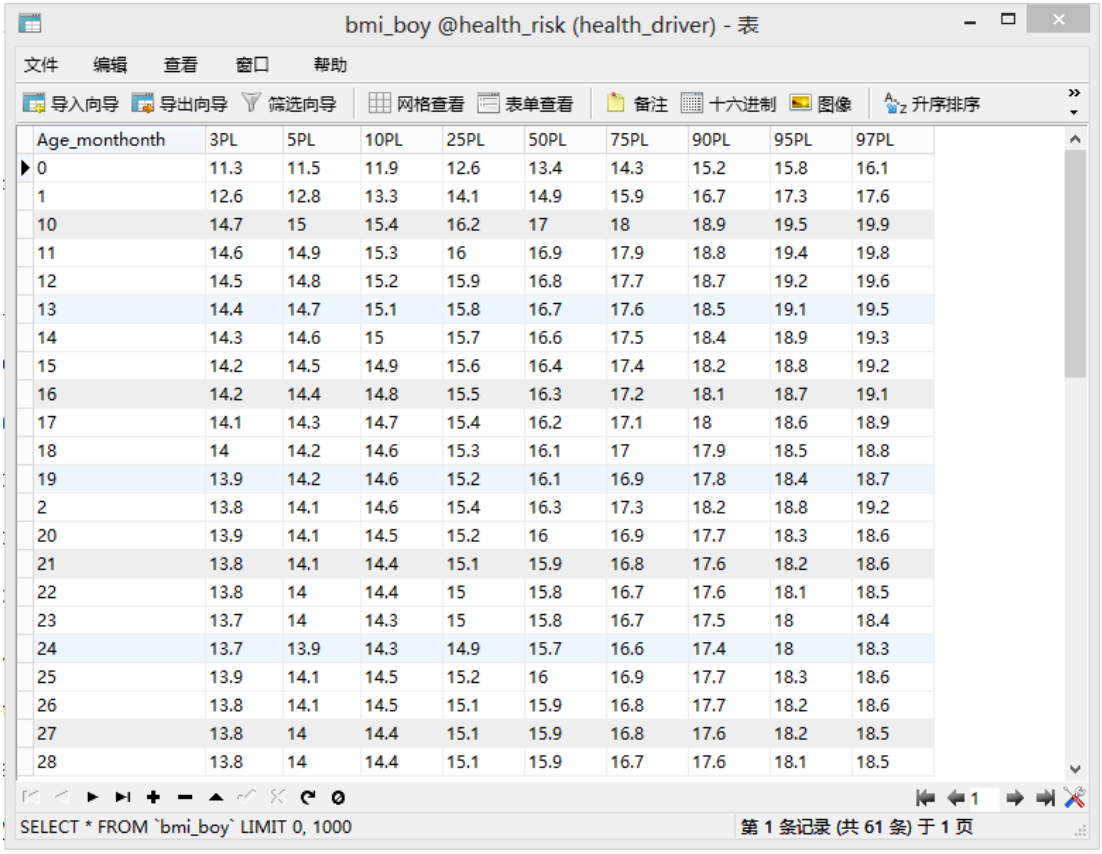
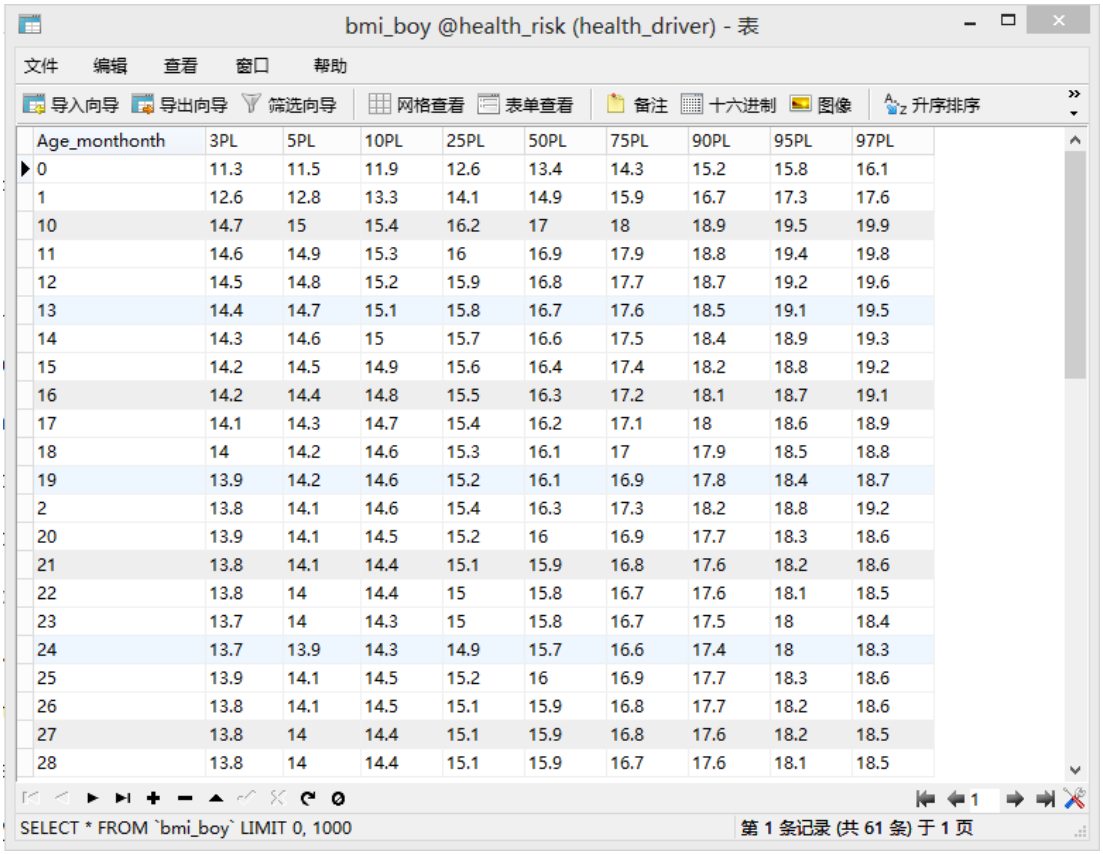
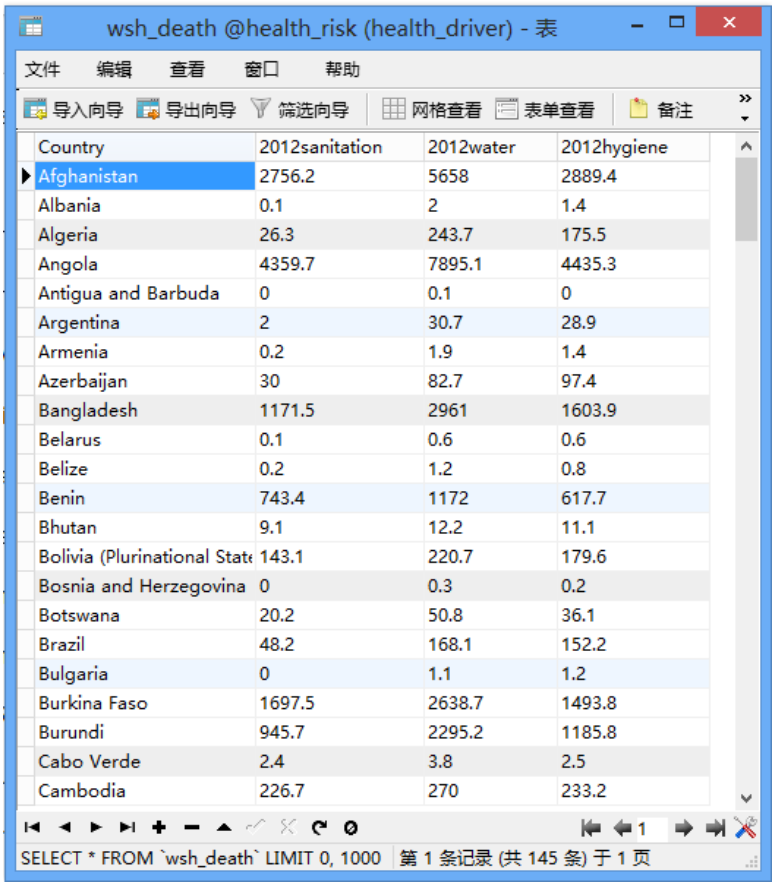


Figure A.3: data table of BMI for Growth Risk



Age_monthonth	3PL	5PL	10PL	25PL	50PL	75PL	90PL	95PL	97PL
0	11.3	11.5	11.9	12.6	13.4	14.3	15.2	15.8	16.1
1	12.6	12.8	13.3	14.1	14.9	15.9	16.7	17.3	17.6
10	14.7	15	15.4	16.2	17	18	18.9	19.5	19.9
11	14.6	14.9	15.3	16	16.9	17.9	18.8	19.4	19.8
12	14.5	14.8	15.2	15.9	16.8	17.7	18.7	19.2	19.6
13	14.4	14.7	15.1	15.8	16.7	17.6	18.5	19.1	19.5
14	14.3	14.6	15	15.7	16.6	17.5	18.4	18.9	19.3
15	14.2	14.5	14.9	15.6	16.4	17.4	18.2	18.8	19.2
16	14.2	14.4	14.8	15.5	16.3	17.2	18.1	18.7	19.1
17	14.1	14.3	14.7	15.4	16.2	17.1	18	18.6	18.9
18	14	14.2	14.6	15.3	16.1	17	17.9	18.5	18.8
19	13.9	14.2	14.6	15.2	16.1	16.9	17.8	18.4	18.7
2	13.8	14.1	14.6	15.4	16.3	17.3	18.2	18.8	19.2
20	13.9	14.1	14.5	15.2	16	16.9	17.7	18.3	18.6
21	13.8	14.1	14.4	15.1	15.9	16.8	17.6	18.2	18.6
22	13.8	14	14.4	15	15.8	16.7	17.6	18.1	18.5
23	13.7	14	14.3	15	15.8	16.7	17.5	18	18.4
24	13.7	13.9	14.3	14.9	15.7	16.6	17.4	18	18.3
25	13.9	14.1	14.5	15.2	16	16.9	17.7	18.3	18.6
26	13.8	14.1	14.5	15.1	15.9	16.8	17.7	18.2	18.6
27	13.8	14	14.4	15.1	15.9	16.8	17.6	18.2	18.5
28	13.8	14	14.4	15.1	15.9	16.7	17.6	18.1	18.5

Figure A.4: data table of BMI for Growth Risk



Country	2012sanitation	2012water	2012hygiene
Afghanistan	2756.2	5658	2889.4
Albania	0.1	2	1.4
Algeria	26.3	243.7	175.5
Angola	4359.7	7895.1	4435.3
Antigua and Barbuda	0	0.1	0
Argentina	2	30.7	28.9
Armenia	0.2	1.9	1.4
Azerbaijan	30	82.7	97.4
Bangladesh	1171.5	2961	1603.9
Belarus	0.1	0.6	0.6
Belize	0.2	1.2	0.8
Benin	743.4	1172	617.7
Bhutan	9.1	12.2	11.1
Bolivia (Plurinational State	143.1	220.7	179.6
Bosnia and Herzegovina	0	0.3	0.2
Botswana	20.2	50.8	36.1
Brazil	48.2	168.1	152.2
Bulgaria	0	1.1	1.2
Burkina Faso	1697.5	2638.7	1493.8
Burundi	945.7	2295.2	1185.8
Cabo Verde	2.4	3.8	2.5
Cambodia	226.7	270	233.2

Figure A.5: data table of water, sanitation, and hygine for Environmental Risk-environment function

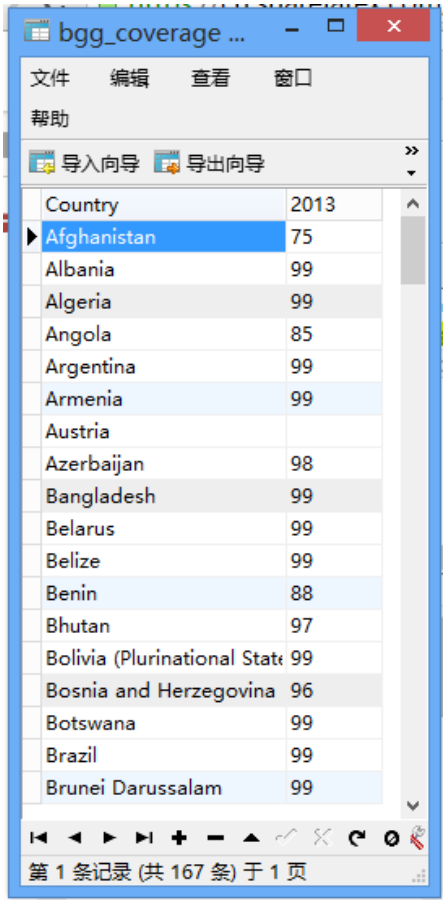


Figure A.6: data table of the coverage of BGG for Environmental Risk-Vaccination

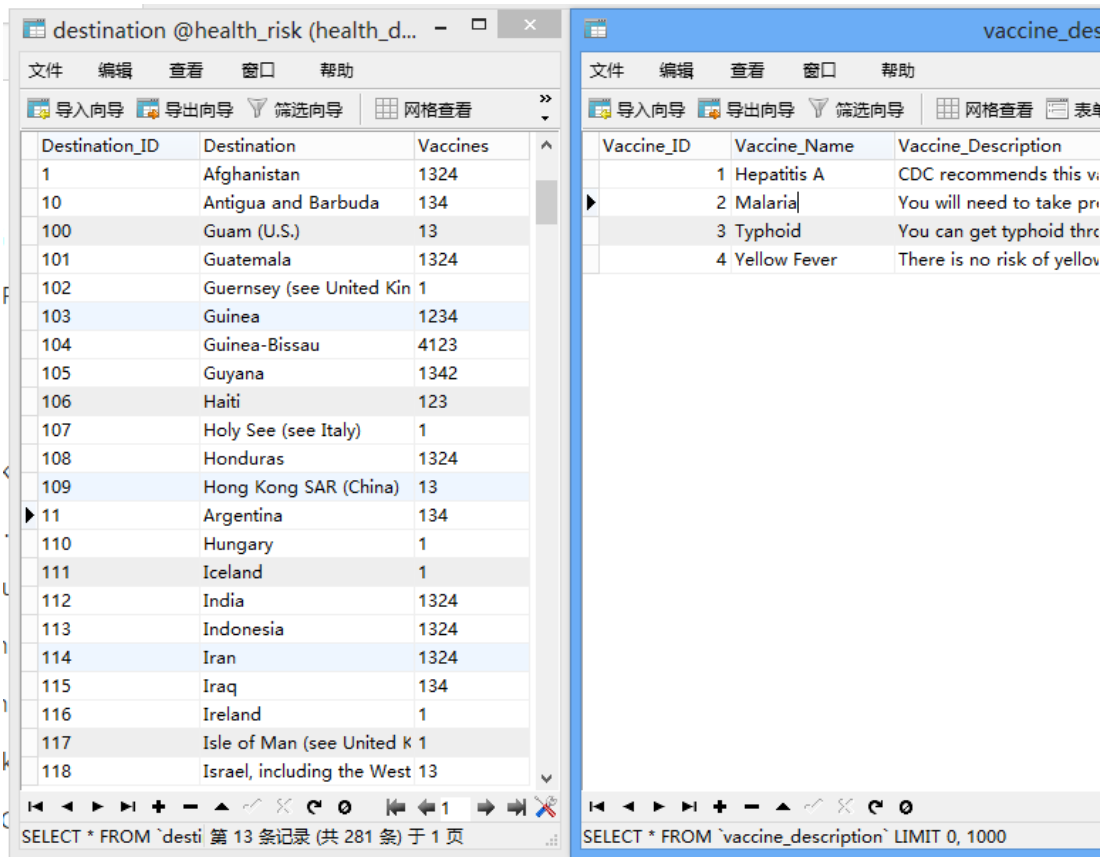


Figure A.7: data table of travelling vaccine category and vaccine description for Environmental Risk-Traveling

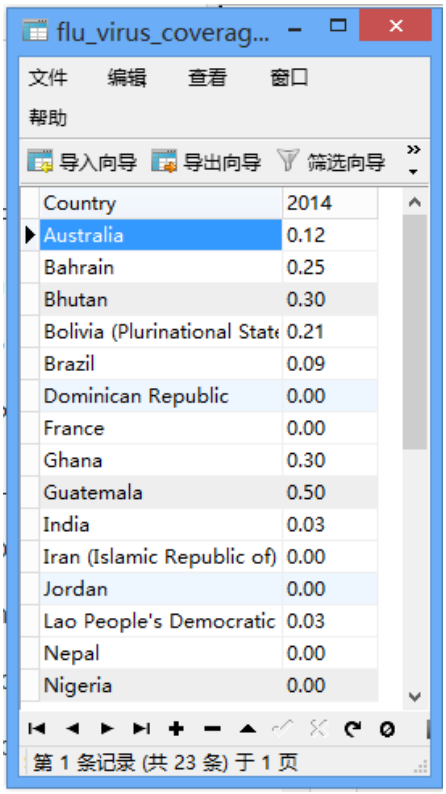


Figure A.8: data table of infectious mortality for Environmental Risk-infection

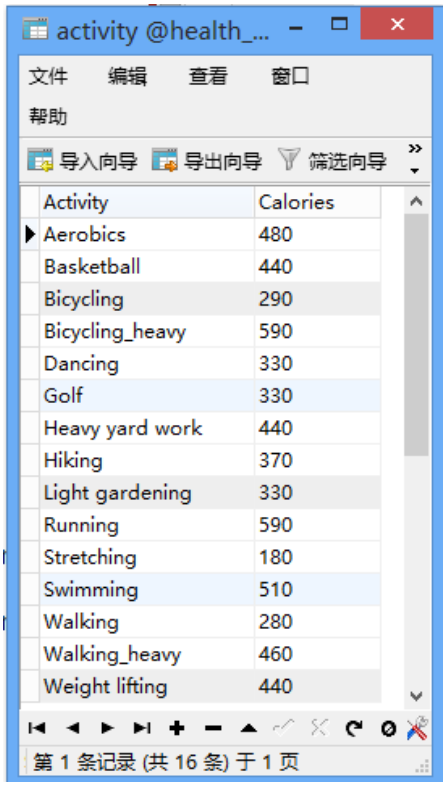


Figure A.9: data table of activity for Lifestyle Risk

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