ELECTRONIC DATA CAPTURE SYSTEM FOR HEART FAILURE DISEASE
MANAGEMENT PROGRAM IN SKILLED NURSING FACILITY

by

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Electronic Data Capture System for Heart Failure Disease Management Program in Skilled Nursing Facility

Abstract

by

TARUN JAIN

Skilled Nursing Facilities (SNF) provides extensive care to patients and helps them in their rehabilitation. Disease Management Programs (DMP), conducted in SNF, can be vital and helpful in solving critical healthcare problems. SNF Connect study is a clinical study, funded by the National Heart, Lung and Blood Institute, to determine whether application of Heart Failure Disease Management Program (HF-DMP) can reduce rehospitalization rate among older adults for the first 60 days of post admission. HF-DMP includes proactive and weekly observation, assessment, and management by following the National Heart Failure Guidelines and gathers a wide variety of data. This data, if analyzed and examined carefully has the potential to help researchers, doctors and nurses in evaluating the impact of prescribed medication on HF patients in a profound manner. It can also help them to come up with new cost-effective, efficient and reliable treatment for HF patients. The patient population for this HF-DMP is targeted to be 1404. This thesis presents a SNF Electronic Data Capture (SNF-EDC) system for HF-DMP data management. SNF-EDC is
implemented and enriches the existing ONWARD [1] framework. SNF-EDC is one of its kind as there is no similar Data Management System for SNF. It will help in the storage, management and analysis of the data gathered from HF-DMP. SNF-EDC provides useful basic features such as dynamic form generation, flexible backend database selection, input validation and skip patterns. In addition to these functionalities, this system is bundled with various new features and attributes to meet the needs of this specific HF-DMP like auto-completion of drug names, graphs/charts and auto-computation of clinical scores. This thesis presents the main features of the SNF-EDC system, including its design, implementation and deployment.
Chapter 1

Introduction

1.1 Motivation

Clinical trial for Heart Failure Disease Management Program (HF-DMP) in Skilled Nursing Facility (SNF), a study funded by the National Heart, Lung, and Blood Institute (NHLBI) collects diverse and wide range of patient data including left ventricular ejection fraction, patient symptom and activity assessment, daily weights, dietary surveillance, medication titration, patient and caregiver education, discharge and follow up questionnaire. This kind of extensive and large-scale clinical trials entails the need for a scalable, robust and economical data capturing tool which can not only store and manage the data but can also help in analyzing this wide variety of data. While the Research Electronic Data Capture (REDCap) project was developed to provide scientific research teams intuitive and reusable tools for collecting, storing and disseminating project-specific clinical and translational research data [39], there remains a need for tools which support backend databases like mysql. This not only helps in handling the complex relationship between different data attributes but also make it readily available for research and analysis. In such
a scenario ONWARD [1], a framework which has been deployed successfully on similar settings such as the Heart Biomarker Evaluation in Apnea Treatment trial (HeartBEAT, 1RC2HL101417), a multi-institution Phase II clinical trial funded through the American Recovery and Revitalization Act (ARRA) can be utilized perfectly to meet the requirements in hand. Apart from the great features that ONWARD offers, we can add some novel features and functionalities to further enhance the tool. Two of the many additional features are automating the computation of clinical score and graph generation. In this era of technology, using human time and power to accomplish daily mundane tasks is not very efficient and most of the times it proves to be futile. One such task in this DMP is recording patient scores on various studies manually. Automating this can save a lot of time for nurses, which they can use in some productive and meaningful work. Likewise plotting graphs like patient weight over time and tabular representation of patient condition on various symptoms over time can be really helpful. This not only saves some crucial time for doctors and researchers but can also help them understand and analyze the patient condition in a better way.

1.2 Related Work

Data Capturing systems has been around for quite sometime now. Traditionally data was collected on paper-based forms for a long period of time. While initially this idea may have sufficed the needs, but with the growing size, complexity and variety of data, this appeared less scalable and durable. This is when Electronic Data Capture (EDC) came
EDC systems are used by life sciences organizations, broadly defined as the pharmaceutical, medical device and biotechnology industries in all aspects of clinical research [2]. EDC proved to be cost efficient, more durable and scalable and ensured data consistency over paper based approach [3]. With the growing popularity of EDC, people started developing EDC tools which provides automated support for data collection, reporting, query resolution, randomization, and validation, among other features, for clinical trials [4]. One of many such tools is Overture EDC. Efficient workflows and an intuitive design make Overture an easy-to-use EDC solution for all research staff, it streamlines data collection and review at a fraction of the cost of the big vendors [10]. ClinPlus Data Management Software (CPDM) [16] is another great EDC tool. Moreover Entrypoint i4 is another useful tool which provides powerful security options, full audit trial, comprehensive field checking, remote data entry and data export [24]. Few similar tools are AcqKnowledge by Biopac Systems [27], mEDC [5], BioClinica Express [40] and clincase [8]. OPIC is another patient information capturing system, it uses a domain-specific epilepsy and seizure ontology (EpSO) [32].

With the growing data size, potential to draw some useful conclusion from it also increases. Therefore just like data capturing systems, data analysis tools are also becoming increasingly popular. In reality, there is not much use of so much data or information if we cant make sense out of it. One such data analysis tool was used to assess the relevance of genes on the clinical outcome both in treated and untreated breast cancer [6]. Another
example is BRB-ArrayTools which was developed in an attempt to broadly share the knowledge gained by biostatisticians of the Biometric Research Branch of the National Cancer Institute in a decade of involvement in collaborative microarray investigations and in the development of statistical methodology for microarray data [9]. Likewise graphs and charts can also help significantly in analyzing data. Receiver-operating characteristic (ROC) plots demonstrates the limits of a test’s ability to discriminate between alternative states of health over the complete spectrum of operating conditions [7]. Nowadays huge medical problems are solved and understood better through Clinical Data Analytics. Clinical Data Analytics is nothing but applying data mining techniques to clinical data. Hence we can appreciate the usefulness and importance of Clinical Data Analysis and data analysis tools.

Hence keeping the above discussion in mind, we wish to develop an Electronic Data Capture (EDC) tool for Heart Failure Disease Management Program (HF-DMP) in Skilled Nursing Facilities. It will not only serve economical, robust, scalable and flexible data management but will also provide data analysis and profound insight on clinical data. In the next we discuss the features of this tool.

1.3 SNF EDC System

This thesis presents a SNF EDC System which provides flexible relational database selection which users can upload and create. It also has features like dynamic form generation, input validation and skip patterns. Besides these great features which are inherited from its predecessor ONWARD, this system is loaded with many additional functionalities.
It has an auto-complete feature for complex drug names which comes in handy for nurses who have a hard time memorizing all the drug names. Clinicians can retrieve previous medication and edit or update them which can also save a lot of time and energy. This system also computes clinical scores automatically with no effort which also adds to its efficiency. Furthermore, tabular or list view of forms, easy modification of medications, interactive charts and tables makes this system unique and one of its kind.

1.4 Organization of This Thesis

Henceforth, this thesis is organized as follows:

1. Chapter 2 gives the Background knowledge in order to better understand this thesis. Also, In this chapter, I will discuss the impact of Cardiac disease in recent times and why Heart Failure Disease Management Program is crucial. I will also discuss ONWARD tool in this section.

2. Chapter 3 gives the brief overview of the SNF EDC system. I will go in-depth of SNF connect study in this chapter. I will also layout the main features of the system.

3. In Chapter 4, I will discuss the auto-computation of Clinical Scores for various Clinical Studies. First I will discuss the questions on which the score is dependent, then I will list possible options with their values. I will conclude by giving the formulae to calculate the score.
4. Chapter 5, I discuss the graphs and tables implemented in the SNF EDC system. I will talk about advantages of implementing graphs and will discuss the algorithm I used to implement the same.

5. Chapter 6 gives the System Design for SNF EDC system. Here I will discuss the possible use cases, I conclude this section by demonstrating the system architecture.

6. Chapter 7 gives the System Implementation and deployment. I will talk about the development environment and how I implemented the graphs and figures for the SNF EDC system in this chapter.

7. Chapter 8, we conclude by discussing Results and Impact of the SNF EDC system.
Chapter 2

Background

Heart failure is a syndrome with symptoms and signs caused by cardiac dysfunction, resulting in reduced longevity [11]. The number of hospitalizations with any mention of heart failure tripled from 1,274,000 in 1979 to 3,860,000 in 2004; 65% to 70% of admissions were patients with additional diagnoses of heart failure [23]. Heart Failure is a pandemic all over the world, especially in United States of America. In 2009, a total of 2,437,163 resident deaths were registered in the United States with the leading cause of death being heart diseases (24.6%) [12]. As we can see, heart diseases are widespread but it greatly varies with age. The crude prevalence (unadjusted for age) ranges from 3 to 20 individuals per 1000, with a prevalence of 30 to 130 individuals per 1000 for those aged over 65 years [13]. Therefore we can conclude that Heart Diseases are prevalent and one of the major concerns for healthcare around the world.
2.1 What is a Disease Management Program (DMP)?

Disease Management Program (DMP) is nothing but collecting a specific group of patients suffering from a common medical condition and providing them with standardized systematic treatment with a common goal of improving patients quality of life, making the treatment economical and reducing hospitalization rate. In addition to providing the
mentioned benefits, DMP’s exposes researchers and doctors with a huge amount of useful patient data which they can use to find new treatments and understand that particular medical condition in a better way, as a result, improving healthcare as a whole. Five traits seemed to be the most important in ensuring that DMPs meet their goals: program size, simplicity of design, a focus on patients’ needs, the ability to collect data easily and analyze results, and the presence of incentives that encourage all stakeholders to comply with the program [15].

2.2 Why Heart Failure Disease Management Program (HF-DMP) is critical?

Although 4.6 million Americans suffer from heart failure only $28.7 million is committed in research dollars annually [14] which makes Heart Failure Disease Management Program (HF-DMP) all the more important. The Duke Heart Failure Program (DHFP) implemented a congestive heart failure (CHF) disease management program which decreased hospitalization rate and treatment cost resulting in improved medication for CHF [17]. The Coordinating Study Evaluating Outcomes of Advising and Counseling in Heart Failure (COACH) was a multicenter, randomized, controlled trial in which 1023 patients were enrolled after hospitalization because of HF [25]. This study also shows how DMP’s can effect patients with heart failure problem. Hence HF-DMP is indeed pivotal and can be really useful in many ways.
2.3 HF-DMP in Skilled Nursing Facilities (SNF)

Skilled nursing facilities (SNF), often times referred to as nursing homes, are residential facilities where patients can receive skilled nursing services 24 hours a day by licensed nurses [18]. In the United States, heart failure has emerged as the leading first-listed diagnosis among hospitalized older adults and it is expected to grow further in the next decade [19]. Almost one-fourth of older adults hospitalized with heart failure (HF) are discharged to skilled nursing facilities (SNFs) [21]. Patients discharged to SNFs had an alarming 53.5% mortality rate compared with 29.1% for patients discharged to home [20]. Although SNF are a major site of transitional care and serves a huge population, variations in the use of SNF and clinical outcomes of patients discharged to SNF after HF hospitalization are relatively unknown [22]. Consequently, efforts to learn more about the discharge status and related outcomes of patients after HF hospitalization are needed [22]. Hence application of HF-DMP in SNF is of significant importance. The goal of this HF-DMP is not only to improve HF patient’s outcome but also to increase medication affordability.

2.4 OnWARD: Ontology-driven Web-based EDC Framework

OnWARD is a framework which supports the entire clinical research data life-cycle: data specification, data collection, and data reviewing, reporting and analysis in a secure web-based environment well suited for multi-site trials and multi-institution studies. [1]. After collecting the requirements and specifications from the clients which in most cases are researchers or clinicians, this framework converts it into web-based input forms. Thus,
OnWARD can be quickly deployed and customized for any clinical study. Following are the basic features of the OnWARD framework:

1. Flexible Backend Database Selection — This framework has great support for relational databases. Each clinical study has its own backend database chosen and selected by the clients. One can also import the existing databases into this framework even in a cross-platform environment.

2. Dynamic form generation — Each clinical research form has many fields. Associated with these fields are data types, data ranges and data distribution like text boxes, drop down list, text fields and so on. All this information is stored in excel sheets from which meaningful xml files are generated which are then converted to web-based forms by OnWARD framework.

3. Input Validation — This framework checks the user input for data types, hard and soft range of numeric fields. This reduces errors and ensure data quality and integrity.

4. Skip Patterns — Many a times answer to one question is contingent upon answers to other questions. This framework has a capability to skip questions if answer to them is not applicable in the current context of the form. This saves time and improves efficiency.
Chapter 3

Overview of SNF EDC tool

In this chapter we give a detailed overview of the SNF Connect study (1R01HL113387-01). We will explain what kind of data is collected in the study and what forms are generated. We also discuss the unique data capturing needs for HF-DMP in SNF. We will conclude by listing the features of SNF EDC tool.

3.1 SNF Connect Study

The purpose of the SNF connect study is to determine whether application of HF-DMP in SNF can reduce rehospitalization rate among older adults for the first 60 days of post SNF admission [28]. This clinical study was conducted in 12 profitable SNF in greater Cleveland area. Average estimated stay of the patients at SNF is 21 days and they are accessed both during the SNF period and the 60 day post SNF admission period. Heart Failure Nurse Advocates (HFNA) are responsible to co-ordinate with SNF staff and ensure that HF-DMP move forward at a suitable rate. There are two components of SNF HF care which HF-DMP mainly emphasizes on - clinical management and care-giver self efficacy at discharge. Figure 3.1 shows the 7 measures for the two components of SNF HF care.
3.1.1 Clinical Care Measures and Discharge Care Measures.

1. Documentation of Left Ventricle Ejection Fraction (LVEF) — HFNA assures that acquire LVEF for all admitted patients which gives the physicians ability to medicate the patients appropriately.

2. Symptom and Activity Assessment — HFNA records various symptoms of HF patients like dyspnea, orthopnea, paroxysmal, nocturnal dyspnea, jugular venous distention, edema, abdominal bloating and assigns New York Heart Association (NYHA) functional class weekly 3 times.

3. Daily Weights and Dietary Surveillance — HFNA records patients weight daily and also monitors their diet. HFNA instructs patients on specific food items to avoid and consume. For instance a lower sodium diet is highly recommended.

Figure 3.1: Measures and Components of HF-DMP in SNF [28]
4. Medication Titration — Older adults are first under-medicated for HF as they are less tolerant to medicine than middle-aged men. Medication Titration plays a very critical role and helps to reduce the side effects of medicine especially amongst older patients.

5. Patients and Caregiver Education — 5 lessons are given to patients and caregivers in which teaching points for self-management of HF are taught and in the end they are given 5-page instructions focusing on HF care.

6. Discharge Instructions — All the patients are given discharge instructions so that they can identify symptoms of HF and know when to call. They are also advised to monitor their weight and maintain a low sodium diet.

7. Follow Up Appointment in 7 days Post SNF Discharge — HFNA schedules interview with patients after a week when they are discharged. Shifting from SNF care to home care is a crucial time and patients need attention to reduce rehospitalization.

3.1.2 Critical Data Retrieval in Usual Care (UC) and HF-DMP

Clinical researchers have developed a wide variety of forms to collect patient data in both UC and HF-DMP. HFNA collects data in HF-DMP through forms which are broadly divided into 3 categories.
1. Baseline Forms — These provide baseline information about the patients and it includes forms like Medication History and Patient Demographics. While former provides details about patients medical history which helps physicians to understand patients condition well, later provide patients personal information.

2. These include forms like Kansas City Cardiomyopathy Questionnaire (KCCQ) and Self-Care Management of Heart Failure. These monitor changes in patients condition from baseline to 60-day period.

3. These forms collects patient data 3 times in a week and monitors patients weight, signs and symptoms for HF. This data helps HFNA to manage patients medication.

UC also collects the same data but HFNA is not involved in it. UC also collects data from various forms like:

1. Baseline forms like patient Demographics which includes patients age, sex, race, ethnicity and Medical History. Information in this form is constant and does not change with time.

2. Confusion Assessment Model (CAM) — Information collected in this form helps in measuring Delirium.

3. Fraility Measure/Walk Test — Data collected in these forms helps to identify patients ability to cope up with physiological stress and they also collect data to access non-ambulatory patients as they also measure hand-grip strength.
4. Charlson Commodity Index (CCI) — Data collected in this form is used to measure Comorbidity. The CCI is associated with rehospitalization, duration of stay and mortality.

5. Brief Interview for Mental Status (BIMS) – Information collected in this form is used to measure cognitive impairment.

6. KCCQ — It is a 23 item questionnaire which focuses on physical and social function, self-efficacy and quality of life. It is measured at the time of admission to SNF and 60 day post admission.

7. SCHFI — Self Care HF index is a 23 item form which collects information regarding self care management, self care maintenance and confidence to manage symptoms. This is also recorded in a same way as KCCQ.

8. Forms which records adverse events, baseline weights and dietary surveillance data are also critical. Information in these forms are collected weekly.

All the data collected in this trial is very critical and has the potential to improve HF treatment. It also helps in clinical decision making. This data helps HFNA to identify whether patient condition suffering from HF is improving or not. Thus SNF connect study is one of its kind to actually measure the patients outcome through HF-DMP. The findings and results from this clinical trial will play a crucial role in care and treatment of older patients with HF.
3.2 Features of SNF EDC tool

Besides the features offered by ONWARD tool, we have added some additional features to this tool which are:

1. Auto Completion of Drug Names — To reduce errors and save time, we provided a feature that will auto complete the drug name in context. Since drug names are often complicated, this increased user experience significantly.

2. Auto retrieval of previous medication — Instead of inputting the entire medication every time, clinicians can retrieve the previous medication and edit that. This saves a lot of time and increases simplicity of the tool.

3. Easy Modification of Medication — After loading the previous day medication, clinicians can easily change dosage frequency by choosing options from drop down buttons. They can also discontinue some drugs or add new drugs to an existing medication.

4. Tabular Form — The forms which are generated have two views, list and tabular. One can switch between them conveniently. This also increases user experience of the tool.

5. Auto Computation of Clinical Scores — Nurses and Clinicians would not have to worry about calculating patient scores manually. This is automated in our tool.
6. Graphs and Tables — In order to quickly understand the patient condition, we have implemented graphs and tables. This not only saves time but also helps researchers to gain profound view of the data captured.
Chapter 4

Auto Computation of Clinical Scores

Patient data collected by various forms of UC and HF-DMP generates various clinical scores which helps researchers and physicians in a critical manner.

1. Physicians use these scores to have a better understanding of the patient condition and make important clinical decisions.

2. Medication varies based on these scores for individual patients.

3. Researchers use these scores to learn more about the dynamics of different disease.

4. These scores summarize patient condition in an intelligent way and save a lot of time for physicians.

Scores are generated in several forms like KCCQ, SCHFI, CCI, BIMS, Fraility or Walk test measure and Health Literacy Score. Calculation of these scores relied on excel sheets. Nurses had to manually enter the patient information in these excel sheets. These excel sheets will have pre-defined formulae which would calculate the scores. This can be a tedious and time consuming task, automating this can save a lot of time.
4.1 KCCQ Questionnaire scores

Kansas City Cardiomyopathy Questionnaire (KCCQ) is a 23-item questionnaire and various scores like Physical Limitation, Symptom Stability, Symptom Frequency, Symptom Burden, Total Symptom, Self Efficacy, Quality of Life, Social Limitation, Overall Summary and Clinical Summary are calculated. Figure 4.1 shows one instance of that form.

4.1.1 Physical Limitation Score

Calculation of this score depends on the answers to Question 1a-1f which are “Dressing yourself,” “Showering or Bathing,” “Walking 1 block on level ground,” “Doing yard work, housework, or carrying groceries,” “Climbing a flight of stairs without stopping” and “Hurrying or jogging (as if to catch a bus)”. There is a drop down list in front of each question from which user can select one option. These options with their appropriate values can be seen in Table 4.1.
<table>
<thead>
<tr>
<th>Study ID</th>
<th>1002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of visit</td>
<td>08/28/2014</td>
</tr>
</tbody>
</table>

**Kansas City Cardiomyopathy Questionnaire**

1. Heart failure affects different people in different ways. Some feel shortness of breath while others feel fatigue. Please indicate how much you are limited by heart failure (shortness of breath or fatigue) in your ability to do the following activities:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Dressing yourself</td>
<td>2: Quite a bit limited</td>
</tr>
<tr>
<td>1b. Showering or bathing</td>
<td>4: Slightly limited</td>
</tr>
<tr>
<td>1c. Walking 1 block on level ground</td>
<td>1: Extremely limited</td>
</tr>
<tr>
<td>1d. Doing yard work, housework, or carrying groceries</td>
<td>3: Moderately limited</td>
</tr>
<tr>
<td>1e. Climbing a flight of stairs without stopping</td>
<td>3: Not at all limited</td>
</tr>
<tr>
<td>1f. Hurrying or jogging (as if to catch a bus)</td>
<td>1: Extremely limited</td>
</tr>
</tbody>
</table>

2. Compared with 2 weeks ago, my symptoms of heart failure have become:

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>5: Much better</td>
</tr>
</tbody>
</table>

3. Over the past 2 weeks, how many times did you have swelling in your feet, ankles or legs when you woke up in the morning?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4: Less than once a week</td>
</tr>
</tbody>
</table>

4. Over the past 2 weeks, how much has swelling in your feet, ankles or legs bothered you?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2: Moderately bothersome</td>
</tr>
</tbody>
</table>

5. Over the past 2 weeks, on average, how many times has fatigue limited your ability to do what you wanted?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4: 3 or more times per week</td>
</tr>
</tbody>
</table>

6. Over the past 2 weeks, how much has your fatigue bothered you?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>3: Moderately bothersome</td>
</tr>
</tbody>
</table>

7. Over the past 2 weeks, on average, how many times has shortness of breath limited your ability to do what you wanted?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: All of the time</td>
</tr>
</tbody>
</table>

8. Over the past 2 weeks, how much has your shortness of breath bothered you?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2: Quite a bit bothered</td>
</tr>
</tbody>
</table>

9. Over the past 2 weeks, on average, how many times have you been forced to stop or slow down when you were doing something because of shortness of breath?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>5: Never over the past 2 weeks</td>
</tr>
</tbody>
</table>

10. Heart failure symptoms can worsen for a number of reasons. How sure are you that you know what to do, or whom to call, if your heart failure gets worse?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4: Mostly sure</td>
</tr>
</tbody>
</table>

11. How well do you understand what things you are able to do to keep your heart failure symptoms from getting worse (for example, weighing yourself, eating a low salt diet, etc.)?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2: Do not understand very well</td>
</tr>
</tbody>
</table>

12. Over the past 2 weeks, how much has your heart failure limited your enjoyment of life?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4: It has slightly limited</td>
</tr>
</tbody>
</table>

13. If you had to spend the rest of your life with your heart failure the way it is right now, how would you feel about this?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2: Mostly dissatisfied</td>
</tr>
</tbody>
</table>

14. Over the past 2 weeks, how often have you felt discouraged or down in the dumps because of your heart failure?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4: I rarely felt that way</td>
</tr>
</tbody>
</table>

15. How much does your heart failure affect your lifestyle? Please indicate how your heart failure may have limited your participation in the following activities over the past 2 weeks:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>15a. Hobbies, recreational activities</td>
<td>2: Limited quite a bit</td>
</tr>
<tr>
<td>15b. Working or doing household chores</td>
<td>3: Moderately limited</td>
</tr>
<tr>
<td>15c. Visiting family or friends out of your home</td>
<td>4: Slightly limited</td>
</tr>
<tr>
<td>15d. Intimate relationships with loved ones</td>
<td>1: Severely limited</td>
</tr>
</tbody>
</table>

**Total Symptom Score** 48.96
**Overall Summary Score** 46.61
**Clinical Summary Score** 43.31
**Physical Limitation Score** 41.67
**Symptom Stability Score** 1.00
**Symptom Frequency Score** 56.25
**Symptom Burden Score** 41.67
**Quality of Life Score** 58.33
**Social Limitation Score** 37.5
**Self-Efficacy Score** 50

Figure 4.1: Instance of KCCQ form of HF-DMP in SNF
<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Limited</td>
<td>1</td>
</tr>
<tr>
<td>Quite a bit Limited</td>
<td>2</td>
</tr>
<tr>
<td>Moderately Limited</td>
<td>3</td>
</tr>
<tr>
<td>Slightly Limited</td>
<td>4</td>
</tr>
<tr>
<td>Not at all Limited</td>
<td>5</td>
</tr>
<tr>
<td>Limited for other reasons or did not do</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 4.1: KCCQ Question 1a-1f options with their value

The score should only be calculated if at least 3 questions are answered out of the 6. Once we have the above questions answered, we use the Equation 4.1 to calculate the Physical Limitation Score.

\[ Physical Limitation Score = 100 \times (\text{Mean} - 1)/4 \]  

(4.1)

where,

\[ \text{Mean} = \frac{\text{SumOfTheValuesOfAnsweredQuestions}}{\text{NumberOfQuestionsAnswered}} \]  

(4.2)

### 4.1.2 Symptom Stability Score

Calculation of this score is based on the answer to question 2 which is “Compared with 2 weeks ago, have your symptoms of heart failure (shortness of breath, fatigue, or ankle swelling) changed?”. For this question also their is a drop down list with different options and each has different value. Options with their appropriate values are listed in Table 4.2:
Symptom Stability Score is only calculated if the above question is answered. Once we have the answer to the above question, we use Equation 4.3 to calculate Symptom Stability Score.

\[ \text{Symptom Stability Score} = 100 \times \frac{(\text{Value of Question 2} - 1)}{4} \]  

(4.3)

### 4.1.3 Symptom Frequency Score

This score depends on answers to questions 3, 5, 7 and 9 which are listed in the figure. The possible options for these questions with their respective value is shown in Table 4.3, 4.4 and 4.5.
<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every Morning</td>
<td>1</td>
</tr>
<tr>
<td>3 or more times a week but not everyday</td>
<td>2</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>3</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>4</td>
</tr>
<tr>
<td>Never over the past two weeks</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.3: KCCQ Question 3 options with their values

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All of the time</td>
<td>1</td>
</tr>
<tr>
<td>Several times a day</td>
<td>2</td>
</tr>
<tr>
<td>At least once a day</td>
<td>3</td>
</tr>
<tr>
<td>3 or more times a week but not every day</td>
<td>4</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>5</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>6</td>
</tr>
<tr>
<td>Never over the past 2 weeks</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.4: KCCQ Question 5 and 7 options with their values
<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every night</td>
<td>1</td>
</tr>
<tr>
<td>3 or more times a week but not every day</td>
<td>2</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>3</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>4</td>
</tr>
<tr>
<td>1-2 times a week</td>
<td>5</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>6</td>
</tr>
<tr>
<td>Never over the past 2 weeks</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.5: KCCQ Question 9 options with their values

If at least two of the four questions are answered then we should calculate this score. 

In order to calculate it, we compute:

\[
S_3 = \frac{(ValueOfQuestion_3) - 1}{4} 
\]  \hspace{1cm} (4.4)

\[
S_5 = \frac{(ValueOfQuestion_5) - 1}{6} 
\]  \hspace{1cm} (4.5)

\[
S_7 = \frac{(ValueOfQuestion_7) - 1}{6} 
\]  \hspace{1cm} (4.6)

\[
S_9 = \frac{(ValueOfQuestion_9) - 1}{4} 
\]  \hspace{1cm} (4.7)

Then we calculate Symptom Frequency Score using the Equation 4.8:

\[
SymptomFrequencyScore = 100 \times (mean of S_3, S_5, S_7, and S_9) 
\]  \hspace{1cm} (4.8)
4.1.4 Symptom Burden Score

In order to calculate this score, we need answers from at least one question out of questions 4, 6 and 8. These questions are shown in figure 4.1. Possible options for these questions with their values are shown in Table 4.6.

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely bothersome</td>
<td>1</td>
</tr>
<tr>
<td>Quite a bit bothersome</td>
<td>2</td>
</tr>
<tr>
<td>Moderately bothersome</td>
<td>3</td>
</tr>
<tr>
<td>Slightly bothersome</td>
<td>4</td>
</tr>
<tr>
<td>Not at all bothersome</td>
<td>5</td>
</tr>
<tr>
<td>I’ve had no swelling/fatigue/shortness of breath</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.6: KCCQ Question 4, 6 and 8 options with their values

When we answer to at least one question, we calculate the Symptom Burden Score using Equation 4.9.

\[
Symptom\ Burden\ Score = 100 \times \left((\text{Mean of Questions } 4, 6, \text{ and } 8) - 1\right)/4 \quad (4.9)
\]
4.1.5 Total Symptom Score

This is the average of Symptom Frequency Score and Symptom Burden Score. We use the scores calculated from Equation 4.8 and 4.9.

\[
Total\ Symptom\ Score = \frac{Symptom\ Burden\ Score + Symptom\ Frequency\ Score}{2}
\]  

(4.10)

4.1.6 Self Efficiency Score

Response to question 10 and 11 [see figure 4.1] are used to calculate this score. Options for both the question with their appropriate possible values are shown in Table 4.7 and 4.8.

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all sure</td>
<td>1</td>
</tr>
<tr>
<td>Not very sure</td>
<td>2</td>
</tr>
<tr>
<td>Somewhat sure</td>
<td>3</td>
</tr>
<tr>
<td>Mostly sure</td>
<td>4</td>
</tr>
<tr>
<td>Completely sure</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.7: KCCQ Question 10 options with their values
<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not understand at all</td>
<td>1</td>
</tr>
<tr>
<td>Do not understand very well</td>
<td>2</td>
</tr>
<tr>
<td>Somewhat understand</td>
<td>3</td>
</tr>
<tr>
<td>Mostly understand</td>
<td>4</td>
</tr>
<tr>
<td>Completely understand</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.8: KCCQ Question 11 options with their values

Once we have answer to at least one of the two question, we can calculate Self Efficiency Score using Equation 4.11.

\[
SelfEfficiencyScore = 100 \times ((\text{MeanOfQuestions10and11ActuallyAnswered}) - 1)/4
\]

(4.11)

4.1.7 Quality Of Life Score

Calculation of this score depends on answers to questions 12, 13 and 14[see figure 4.1].

Options to these question with their possible values are shown in Table 4.9, 4.10 and 4.11.
It has extremely limited my enjoyment of life | 1
---|---
It has limited my enjoyment of life quite a bit | 2
It has moderately limited my enjoyment of life | 3
It has slightly limited my enjoyment of life | 4
It has not limited my enjoyment of life | 5

Table 4.9: KCCQ Question 12 options with their values

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all satisfied</td>
<td>1</td>
</tr>
<tr>
<td>Mostly Dissatisfied</td>
<td>2</td>
</tr>
<tr>
<td>Somewhat satisfied</td>
<td>3</td>
</tr>
<tr>
<td>Mostly satisfied</td>
<td>4</td>
</tr>
<tr>
<td>Completely satisfied</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.10: KCCQ Question 13 options with their values
<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt that way all of the time</td>
<td>1</td>
</tr>
<tr>
<td>I felt that way most of the time</td>
<td>2</td>
</tr>
<tr>
<td>I occasionally felt that way</td>
<td>3</td>
</tr>
<tr>
<td>I rarely felt that way</td>
<td>4</td>
</tr>
<tr>
<td>I never felt that way</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.11: KCCQ Question 14 options with their values

If at least one of the three questions is answered, then we calculate Quality of Life score using Equation 4.12.

\[
\text{QualityOfLifeScore} = 100 \times \left( \frac{\text{MeanOfQuestions}_{12, 13, \text{and14ActuallyAnswered}} - 1}{4} \right)
\]  

(4.12)

4.1.8 Social Limitation Score

This score depends on question 15a, 15b, 15c, 15d[See Figure 4.1]. Possible values to these questions are shown in Table 4.12.
<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severely limited</td>
<td>1</td>
</tr>
<tr>
<td>Limited quite a bit</td>
<td>2</td>
</tr>
<tr>
<td>Moderately limited</td>
<td>3</td>
</tr>
<tr>
<td>Slightly limited</td>
<td>4</td>
</tr>
<tr>
<td>Did not limit at all</td>
<td>5</td>
</tr>
<tr>
<td>Does not apply or did not do for other reason</td>
<td>&lt;missing value&gt;</td>
</tr>
</tbody>
</table>

Table 4.12: KCCQ Question 15a-d options with their values

If at least two out of four questions is answered, then we calculate Social Limitation Score using Equation 4.13.

\[
SocialLimitationScore = 100 \times \left( \frac{\text{MeanOfQuestions15a-dActuallyAnswered} - 1}{4} \right)
\]  

(4.13)

4.1.9 Overall Summary Score

Overall Summary Score is the mean of Physical Limitation score, Total Symptom score, Quality of Life score and Social Limitation score. We use the values from Equation 4.1, 4.10, 4.12, 4.13 and calculate this score using Equation 4.14.

\[
OverallSummaryScore = \frac{\text{SumOfScoresFrom4.1, 4.10, 4.12, 4.13}}{4}
\]  

(4.14)
4.1.10 Clinical Summary Score

This score is the average of Physical Limitation score and Total Symptom score. Again we use the values from Equation 4.1 and 4.10 to calculate Clinical Summary score using Equation 4.15.

\[ \text{ClinicalSummaryScore} = \frac{\text{SumOfScoresFrom4.1, 4.10}}{2} \]  (4.15)

4.2 SCHFI Score Calculations

Initially Self Care HF Index use to generate a single total score but soon researchers found the need of further dividing this total score into three categories and thus generating three scores listed below instead of one.

1. Maintenance Score
2. Management Score
3. Confidence Score

Figure 4.2 shows the instance of a SCHFI form.
Figure 4.2: Instance of SCHFI form of HF-DMP in SNF

<table>
<thead>
<tr>
<th>Subject ID Number</th>
<th>1002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date SCHFI Completed (mm/dd/yyyy)</td>
<td>08/28/2014</td>
</tr>
<tr>
<td>Self Care in Heart Failure Index (SCHFI)</td>
<td></td>
</tr>
</tbody>
</table>

**Section A. Think about how you have been feeling in the last month or since we last spoke as you complete these items. Listed below are common instructions given to persons with heart failure. How routinely do you do the following?**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weigh Yourself?</td>
<td>2. Sometimes</td>
</tr>
<tr>
<td>Check your ankles for swelling?</td>
<td>1. Never or Rarely</td>
</tr>
<tr>
<td>Try to avoid getting sick (e.g., flu shot, avoid ill people)?</td>
<td>4. Always or Daily</td>
</tr>
<tr>
<td>Do some physical activity?</td>
<td>2. Sometimes</td>
</tr>
<tr>
<td>Keep doctor or nurse appointments?</td>
<td>4. Always or Daily</td>
</tr>
<tr>
<td>Eat a low salt diet?</td>
<td>1. Never or Rarely</td>
</tr>
<tr>
<td>Exercise for at least 30 minutes?</td>
<td>1. Never or Rarely</td>
</tr>
<tr>
<td>Forget to take one of your medicines?</td>
<td>1. Never or Rarely</td>
</tr>
<tr>
<td>Ask for low salt items when eating out or visiting others?</td>
<td>1. Never or Rarely</td>
</tr>
<tr>
<td>Use a system (pill box, reminders) to help you remember your medicines?</td>
<td>4. Always or Daily</td>
</tr>
</tbody>
</table>

**Section B. Many patients have symptoms due to their heart failure. Trouble breathing and ankle swelling are common symptoms of heart failure.**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the past month, have you had trouble breathing or ankle swelling?</td>
<td>1. Yes</td>
</tr>
<tr>
<td>How quickly did you recognize it as a symptom of heart failure?</td>
<td>1. Not Quickly</td>
</tr>
<tr>
<td>Reduce the salt in your diet</td>
<td>3. Likely</td>
</tr>
<tr>
<td>Reduce your fluid intake</td>
<td>3. Likely</td>
</tr>
<tr>
<td>Take an extra water pill</td>
<td>1. Not Likely</td>
</tr>
<tr>
<td>Call your doctor or nurse for guidance</td>
<td>3. Likely</td>
</tr>
<tr>
<td>Think of a remedy you tried the last time you had trouble breathing or ankle swelling. How sure were you that the remedy helped or did not help?</td>
<td>2. Somewhat Sure</td>
</tr>
</tbody>
</table>

**Section C: In general, how confident are you that you can:**

<table>
<thead>
<tr>
<th>Task</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep yourself free of heart failure symptoms?</td>
<td>2. Somewhat Confident</td>
</tr>
<tr>
<td>Follow the treatment advice you have been given?</td>
<td>2. Somewhat Confident</td>
</tr>
<tr>
<td>Evaluate the importance of your symptoms?</td>
<td>3. Very Confident</td>
</tr>
<tr>
<td>Recognize changes in your health if they occur?</td>
<td>1. Not Confident</td>
</tr>
<tr>
<td>Do something that will relieve your symptoms?</td>
<td>2. Somewhat Confident</td>
</tr>
<tr>
<td>Evaluate how well a remedy works?</td>
<td>3. Very Confident</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>46.62</td>
</tr>
<tr>
<td>Management</td>
<td>45</td>
</tr>
<tr>
<td>Confidence</td>
<td>38.92</td>
</tr>
</tbody>
</table>
4.2.1 Maintenance Score

Maintenance Score is contingent to the response from questions 1 to 10 which includes all the questions from section A in figure 4.2. The possible options for all those questions with their respective values are shown in Table 4.13

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never or Rarely</td>
<td>1</td>
</tr>
<tr>
<td>Sometimes</td>
<td>2</td>
</tr>
<tr>
<td>Frequently</td>
<td>3</td>
</tr>
<tr>
<td>Always or Daily</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.13: SCHFI Question from section A options with their values

The options shown in figure 4.13 and their respective value holds true for all ten questions but one. Question number 8 is negatively worded and is needed to recoded with values as shown in Table 4.14.

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never or Rarely</td>
<td>1</td>
</tr>
<tr>
<td>Sometimes</td>
<td>2</td>
</tr>
<tr>
<td>Frequently</td>
<td>3</td>
</tr>
<tr>
<td>Always or Daily</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.14: SCHFI Question from section A options with their values
Once we have the answers to above questions, we calculate Maintenance score by scaling each score between 0-100. We use Equation 4.16 to accomplish this.

\[
MaintenanceScore = \left( \frac{SCHFI1 + SCHFI2 + SCHFI3 + SCHFI4 + SCHFI5 + SCHFI6 + SCHFI7 + SCHFI8 + SCHFI9 + SCHFI10}{10} - 10 \right) \times 3.333
\]

(4.16)

Note that in order for the Maintenance Score to be accurate, it is recommended to have response to at least 5 of the 10 questions. Although it is not necessary for the calculation of the score but it increases precision and accuracy.

### 4.2.2 Management Score

Self Care Management Score is only calculated if the patient had trouble in breathing or has ankle swelling. In simple words this score is only calculated if the answer to the question 11 is yes which is “In the past month, have you had trouble breathing or ankle swelling? ” If the answer is No then we don’t bother to record this score but if the answer is yes then the calculation is dependent on response to questions 12-17 shown in section B of figure 4.2. Options for these question with their respective values are shown in Table 4.15, 4.16 and 4.17.
Table 4.15: SCHFI Form section B Question 12 options with their values

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did not recognize it</td>
<td>0</td>
</tr>
<tr>
<td>Not Quickly</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat quickly</td>
<td>2</td>
</tr>
<tr>
<td>Quickly</td>
<td>3</td>
</tr>
<tr>
<td>Very Quickly</td>
<td>4</td>
</tr>
<tr>
<td>N/A, have not had these</td>
<td>-8</td>
</tr>
</tbody>
</table>

Table 4.16: SCHFI Form section B Question 13-16 options with their values

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Likely</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat quickly</td>
<td>2</td>
</tr>
<tr>
<td>Likely</td>
<td>3</td>
</tr>
<tr>
<td>Very Likely</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 4.17: SCHFI Form section B Question 17 options with their values

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did not try anything</td>
<td>0</td>
</tr>
<tr>
<td>Not Sure</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat Sure</td>
<td>2</td>
</tr>
<tr>
<td>Sure</td>
<td>3</td>
</tr>
<tr>
<td>Very Sure</td>
<td>4</td>
</tr>
</tbody>
</table>

Once we have response to the above questions, we calculate Management score using Equation 4.17.

\[
ManagementScore = \left[\left(SCHFI_{12} + SCHFI_{13} + SCHFI_{14} + \right.ight.
\]
\[
SCHFI_{15} + SCHFI_{16} + SCHFI_{17}) - 4) * 5
\]

It should be noted that at least two of the four possible remedies should be answered by the patient in order for the Management score to be accurate.

### 4.2.3 Confidence Score

Calculation of this score depends on questions 18-23 shown in section C of figure 4.2. These questions can have the multiple options and each option has a unique value. Options along with their values for question 18-23 is shown in Table 4.18.
<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Confident</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat Confident</td>
<td>2</td>
</tr>
<tr>
<td>Very Confident</td>
<td>3</td>
</tr>
<tr>
<td>Extremely Confident</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.18: SCHFI Form section C Question 18-23 options with their values

Once we have the response to the above questions, we calculate the Self Care Confidence score using Equation 4.18.

\[
ManagementScore = \left( \frac{(SCHFI18 + SCHFI19 + SCHFI20 + \right.
\]
\[SCHFI21 + SCHFI22 + SCHFI23) - 6) \ast 5.56}{5}
\]

Note that at least half of the above questions should be answered for an accurate measure of self care confidence score.

### 4.3 Charlson Commodity Index (CCI) Total Score

CCI form is a 19 item questionnaire which gives us a total score. Figure 4.3 shows an instance of this form in SNF.
Figure 4.3: Instance of CCI form of HF-DMP in SNF

Calculation of the total score depends on all the questions of this form and each question has an associated weight to it. There are two possible options to all the questions which are “yes” and “no”. Option “Yes” has a value “1” and option “no” has a value “0”. Moreover weight of question 1-9 is “1”, weight of question 10-15 is “2”, weight of question 16 is “3” and weight of question 17-18 is “6”. Once we have the answers to all the above questions,
we calculate Charlson Commodity Index Total score using Equation 4.19.

\[
TotalScore = \sum (Weight \ast Value)ForEachQuestion
\]  

(4.19)

4.4 Brief Interview For Mental Status(BIMS) Score

In the Demographics form, we calculate the BIMS score which is the measurement of impairment and cognition. Figure 4.4 shows an instance of Demographics form in SNF.

![Figure 4.4: Instance of Demographics form of HF-DMP in SNF](image)

Figure 4.4: Instance of Demographics form of HF-DMP in SNF
Calculation of the BIMS score is contingent on 7 questions shown in figure 4.4, each question has a drop down list with appropriate options. Each option has a specific value which is used in the calculation of the score. Option for all 7 questions with their values are shown in Table 4.19

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Options:Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None:0, One:1, Two:2, Three:3</td>
</tr>
<tr>
<td>2</td>
<td>Correct:3, Missed by one year:2, Missed by 2.5 year:1, Missed by &gt;5years or no answer:0</td>
</tr>
<tr>
<td>3</td>
<td>Accurate within 5 days:2, Missed by 6days to 1 month:1, Missed by 1 month or no answer:0</td>
</tr>
<tr>
<td>4</td>
<td>Correct:1, incorrect or no answer:0</td>
</tr>
<tr>
<td>5, 6, 7</td>
<td>Yes, no cue required:2, Yes after cueing(Something to wear):1, No-could not recall:0</td>
</tr>
</tbody>
</table>

Table 4.19: BIMS score questions with their options and values

Once we answers to all the above questions, we use Equation 4.20 to calculate BIMS score.

\[
BIMSScore = \sum (ValueOfEachQuestion) \tag{4.20}
\]

If in case patient is unble to complete this interview, this score becomes 98. Otherwise the value lies somewhere in between 0-15 where 0-7 indicates sever impairment, 8-12 indicates moderate impairment and 12-15 shows that the patient is cognitively intact.
4.5 Frailty or Walktest Measure

In this form, we calculate average grip strength for right hand and left hand. An instance of the Walk Test Form in SNF is shown in figure 4.5.

![Figure 4.5: Instance of WalkTest form of HF-DMP in SNF](image)

Calculation of these scores is very simple. We just record the right hand strength and left hand strength using Dynamometer over three separate instances (right hand 1, right hand 2, right hand 3, left hand 1, left hand 2 and left hand 3). A dynamometer or “dyno" for short, is a device for measuring force, torque, or power [29]. Once we have these
records, we calculate the scores using Equation 4.21 and 4.22.

\[
\text{AverageGripStrengthRight} = \frac{(RightHand1 + RightHand2 + RightHand3)}{3}
\]  
\[
\text{AverageGripStrengthLeft} = \frac{(LeftHand1 + LeftHand2 + LeftHand3)}{3}
\]  

(4.21)  

(4.22)

### 4.6 Health Literacy Score

Health Literacy form is a three question short form which is an indication of patients intelligence and literacy in terms of understanding the medical forms and hospital materials. Figure 4.6 gives an instance of this form in SNF.

![Figure 4.6: Instance of Health Literacy form of HF-DMP in SNF](image)

Calculation of the total health literacy score depends on 3 questions shown in figure 4.6. Each of these three questions with their possible options and corresponding values are shown in Table 4.20.
Once we have response to the above three questions, we calculate Health Literacy Score using Equation 4.23.

\[
TotalHealthLiteracyScore = \sum (ValueOfEachQuestion) 
\] (4.23)
Chapter 5

Graph Generation in SNF EDC tool

Analyzing the data that we capture is critical. With the increasing amount of data, researchers can dig deeply into it and can solve some of the greatest challenges of healthcare in front of us today. It can help us in finding new medication for Heart Failure disease which would be more effective. Also, not only does it saves a lot of time for doctors and clinicians but at the same time give them a profound view of the patients medical condition. It is important to note that healthcare problems which were once considered mysteries are now being solved through the analysis done by the researchers on the data, it helps in determining trends, patterns, forecast diseases and much more. It can lead us to the most cost and time efficient treatment for Heart Failure. Henceforth, we can conclude that healthcare will soon thrive on data analytics as new diseases are coming up and resources are getting limited. Keeping this in mind, we wish to implement couple of graphs in our SNF EDC tool. In this chapter, we would be discussing about these two graphs in depth.
5.1 Weight Over Time Graph

Analysis of Weight over time is a key aspect of SNF study. Doctors use this information to prescribe medication to patient and also to review their progress. Heart Failure patients may suffer from fluid accommodation which results in increasing weight. Therefore checking the patients weight regularly is crucial to identify if their is any fluid accommodation in the patients body. It is proven that increases in body weight are associated with hospitalization for heart failure and begin at least 1 week before admission [30]. Although we know that weight fluctuations is considered to be one of the symptoms for heart failure, very little is known about how exactly weight fluctuations relates to patients with heart failure. Therefore presenting this data on a neat and insightful graph can give researchers and clinicians an opportunity to dig deeper into this relationship and help to improve healthcare for heart failure. Figure 5.1 shows one instance of this graph.

Figure 5.1: Weight over Patients Visit
For the purpose of analysis and research, it is required to make the graph as interactive as possible. Below are some of the key features of this graph:

1. Intelligent Y-axis — The Y-axis of the graph which represents the weight over different time intervals adjusts itself according to the present value range of weight so that small changes in weight can also be seen and analyzed properly. For example in figure 5.1, patients staring weight is around 117 lbs, therefore it is unnecessary to show range 0-115 on the Y-axis because it will not only eat up the majority of the space in the chart and keep the meaningful portion in a very tiny space but it will also make it difficult for researchers and clinicians to clearly see the tiny fluctuations of patients weight over time. Hence starting the Y-axis with the value of 115 makes the graph clear, tidy and easy to understand.

2. Time Interval Adjustment — Some patients are discharged in few days while many are kept for months. As per researchers or clinicians need, sometimes they want to analyze patient weight fluctuation over longer periods of time like months or even years and sometimes they want to monitor patients weight trend during few days or weeks. The time adjustment feature of this tool gives us the comfort to achieve this easily. Graph can be switched between any range from 1 day to 1 year duration based on the length of the period during which patient is under observation. There are direct links on top left side of the graph which switches it from daily mode to 5 day to monthly to quarterly to half-yearly to yearly. Based on the patients scenario,
doctors and researchers can zoom in and out in different time intervals which they want to analyze.

3. Mouse Pointer Value — Often it can be time consuming to look at the exact X-axis value and the corresponding Y-axis value at a certain point especially when the fluctuations are not that significant. In such situation, this feature can come in handy. At any point graph shows the value of the weight with date corresponding to the current position of mouse pointer. This makes the graph easier to read and understand and hence increases user-friendliness.

5.2 Symptoms Over Time Graph

In the SNF connect trial, HF patients are monitored on various symptoms over different patients visit. All these symptoms are shown in table 5.1. Hence monitoring all the above symptoms for HF patients can help clinicians and researchers in many ways. It can help doctors to get a deeper understand of their patients condition. It can also help in measuring the severity of heart failure in a particular patient after-which medication is prescribed to the patients. It can help researchers to find new trends and patterns which relates these symptoms to Heart Failure and create a standard treatment for HF patients. Moreover, If the analysis is advertised properly can create a lot of awareness amongst common people and can help them to identify any signs of Heart Failure patients in their surroundings. Thus we see that this graph is very critical for this HF-DMP. Figure 5.3 shows one instance of this graph.
### Symptom | Explanation
---|---
**Fatigue** | When the heart is not able to pump enough blood required for its proper functioning, the body has a tendency to redirect the blood from other organs to the crucial organs like heart. This results in low blood circulation in the body and increases fatigue. Monitoring this symptom in the HF-DMP can help vitally.

**Activity** | Ability of a body to do any rigorous physical activity drastically decreases in a heart failure patient.

**Shortness of Breath** | When heart failure patients rest or lie on the ground flat, they feel breathlessness. Patients body can’t keep up the blood supply and for this reason only patient often wakes up and complains about having shortness of breath.

**Chest Discomfort** | For the proper functioning of the heart, it is required that it gets enough oxygen rich blood but when it is not able to get it, it causes Angina which is chest pain. Chest discomfort is one of the most common signs of heart failure and it feels as if someone is applying pressure to the patients chest.

**Paroxysmal nocturnal dyspnea** | Paroxysmal" means “sudden attacks that recur,” “nocturnal” means “occurring at night” and “dyspnea” means “difficulty breathing” or “shortness of breath” [31]. This is very common in heart failure patients especially during nights or after some physical activity.

**Orthopnea** | It is a sign of heart failure and is caused by congestion in the lungs and perhaps accompanied by accumulation of excess fluid in the lungs (pulmonary edema) that occurs as a result of left-sided heart failure [33]. This normally occurs when you can’t breath properly while lying flat on the ground.

**Cough** | Coughing which produces white or pink blood-tinged mucus becomes a vital sign for heart failure. HF patients often suffers from sever coughing due to accumulation of the fluid in the lungs.

**Jugular Venous Pressure** | In the presence of congestive heart failure, the right atrial pressure is at least as high and perhaps higher than the jugular venous pressure and hence, if the jugular venous pressure is high, further treatment, especially diuresis, is needed [34].

**Bloat** | HF Patients after eating even small meals feels bloating in their stomach.

**Nausea** | HF patients suffers from nausea and often vomits multiple times in a day.

**Loss Of Appetite** | HF patients don’t feel hungry that often and their appetite also decreases drastically as the digestive system does not receive proper blood which causes a problem in digestion [35].

**Lower Extremity Edema** | When the heart weakens and pumps blood less effectively, fluid can slowly build up, creating leg edema and if fluid buildup occurs rapidly, fluid in the lungs (pulmonary edema) can develop which is a sign of heart failure [37].

**NYHA class** | Doctors and clinicians classify the condition of heart failure patients into different stages based on New York Heart Association (NYHA) functional classification system. These stages are listed in figure 5.2.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue</td>
<td>When the heart is not able to pump enough blood required for its proper functioning, the body has a tendency to redirect the blood from other organs to the crucial organs like heart. This results in low blood circulation in the body and increases fatigue. Monitoring this symptom in the HF-DMP can help vitally.</td>
</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Chest Discomfort</td>
<td>For the proper functioning of the heart, it is required that it gets enough oxygen rich blood but when it is not able to get it, it causes Angina which is chest pain. Chest discomfort is one of the most common signs of heart failure and it feels as if someone is applying pressure to the patients chest.</td>
</tr>
<tr>
<td>Paroxysmal nocturnal dyspnea</td>
<td>Paroxysmal&quot; means “sudden attacks that recur,” “nocturnal” means “occurring at night” and “dyspnea” means “difficulty breathing” or “shortness of breath” [31]. This is very common in heart failure patients especially during nights or after some physical activity.</td>
</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
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<td>HF Patients after eating even small meals feels bloating in their stomach.</td>
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</tr>
<tr>
<td>Lower Extremity Edema</td>
<td>When the heart weakens and pumps blood less effectively, fluid can slowly build up, creating leg edema and if fluid buildup occurs rapidly, fluid in the lungs (pulmonary edema) can develop which is a sign of heart failure [37].</td>
</tr>
<tr>
<td>NYHA class</td>
<td>Doctors and clinicians classify the condition of heart failure patients into different stages based on New York Heart Association (NYHA) functional classification system. These stages are listed in figure 5.2.</td>
</tr>
</tbody>
</table>
Figure 5.2: Heart Failure Stages [38]

<table>
<thead>
<tr>
<th>Class</th>
<th>Patient Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I (Mild)</td>
<td>No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, or dyspnea (shortness of breath).</td>
</tr>
<tr>
<td>Class II (Mild)</td>
<td>Slight limitation of physical activity. Comfortable at rest, but ordinary physical activity results in fatigue, palpitation, or dyspnea.</td>
</tr>
<tr>
<td>Class III (Moderate)</td>
<td>Marked limitation of physical activity. Comfortable at rest, but less than ordinary activity causes fatigue, palpitation, or dyspnea.</td>
</tr>
<tr>
<td>Class IV (Severe)</td>
<td>Unable to carry out any physical activity without discomfort. Symptoms of cardiac insufficiency at rest. If any physical activity is undertaken, discomfort is increased.</td>
</tr>
</tbody>
</table>

Figure 5.3: Symptom Over Patients Visit
Features of the graph shown in figure 5.3:

1. Tabular Form — The main aim of plotting this chart is to save time and give a better and clear picture of patients progression on various symptoms over time. Hence, instead of plotting 12 line/bar charts or 1 line/bar chart with 12 different colors representing different symptoms, we adopted a tabular approach because the former approach was not saving any time and was giving a very unclear picture of patients condition while the later was clear, concise and efficient. As there are about 12 different symptoms for which patient is analyzed. To display all this information in a chart will create confusion with so many lines/bars for different symptoms. Therefore it was required to follow the tabular form approach. It simplified the design and served the purpose beautifully.

2. Symptom Progression — In order to clearly show the patient progression over these symptoms just by seeing this chart, it was required to use different signs and colors. Hence each cell in this tabular chart was a combination of a sign and a background color. Each combination had a different meaning which is shown below:

   ",-" (minus) with a background color of "green" which means that this particular symptom is improving or reducing with time.

   ",+" (plus) with a background color of "red" which means that this particular symptom is degrading or increasing with time.
"="(equal) with a background color of "yellow" which means that this particular symptom is constant or same with time.

"NA"(non-available) with a background color of "white" which means that this record was never taken from the patient.

"X"(cross) with a background color of "grey" which means that the particular symptom does not exist in the patient.

3. Analyzing Patient Condition — Doctors, clinicians and researchers were able to get a good understanding of the patients condition just by looking at this chart.

A series of green towards the end shows that the patient is showing clear signs of improvement over that symptom.

Fluctuations in colors for a single symptom shows that patients health is not getting affected by the medication and something needs to be done.

A series of red towards the end shows that the patients condition is worsening with time and the medication is adversely effecting the patient health.
Chapter 6

System Design

In this chapter I will be discussing the design and architecture of SNF EDC tool. Please note that I will be mainly focussing on generation of clinical scores and graph generation. In order to clearly explain the system design, it is imperative to discuss all the possible use cases and the underlying System Architecture. In this section I will discuss both of these aspects in-depth.

6.1 Use Cases

In this HF-DMP for SNF, we mainly have 4 actors namely Heart Failure Nurse Advocates(HFNA), Doctors, Researchers and Clinicians. Their can be 5 possible use cases shown in figure 6.1, 6.2, 6.3, 6.4 and 6.5.

Figure 6.1: Doctors and HFNA both examines patients.
Figure 6.2: HFNA fills form to capture patient data which automatically generates Clinical Scores and Charts.

Figure 6.3: Doctors, Clinicians, Researchers and HFNA views patients data.

Figure 6.4: Doctors prescribes medication to patients.
When the patient is registered in the SNF. Firstly both the doctors and HFNA will examine the patient which makes our first use case. Then HFNA will store patient information in the forms of the HF-DMP which in turn will automatically generate clinical scores and charts which is our second use case. After that Doctors, HFNA, Clinicians and Doctors can see the patient data which becomes our third use case. Then doctors will prescribe medication to the patients which is our fourth use case. Lastly researchers conduct analysis and research on the data captured which becomes our last and fifth use case.

### 6.2 System Architecture

Based on the above five use cases, I have shown the system architecture in figure 6.6.
System Architecture shown in figure 6.6 can be broken down into the following steps:

1. First step is to build the metadata database for the SNF EDC tool. We got excel files from the clinicians and doctors which had all the information regarding the forms in the HF-DMP. Using these excel files, we generated xml and csv files which contained the following information:

   Variable names, data type, length, question label and description.

   Permissible Values which contains appropriate options and values for each options corresponding to the variable in question. It also contains range for certain variables.
Rules that govern dependent variables, say for instance response to one variable results in hiding of another variable was also captured in these xml and csv files.

Variables that are associated with clinical scores were also stored.

Information about various drugs and headings for the form were also stored.

Form names and their order of display in the SNF EDC tool is also gathered in these xml and csv files. Using all the above information we create a metadata database for SNF EDC tool.

2. Once we have the database setup, we render the forms which patients use to capture patient information.

3. After that the system stores the patient data in the patient database and at the same time calculates clinical scores and displays chart by referring to both metadata and the patient data.

4. Now the patient information along with the clinical scores and charts are viewed by HFNA, doctors, researchers and clinicians.

5. Lastly researchers performs analysis of the data captured and achieves the end goal of this tool which is to improve healthcare for Heart Failure.
Chapter 7

System Implementation

In this chapter I will be illustrating development environment and the implementation of SNF EDC tool. Again I will be mainly focussing on implementation of automation of Clinical scores and chart generation.

7.1 Development Environment

SNF EDC tool is built on the following environment listed below:

7.1.1 Ruby on Rails

While ruby is an object oriented programming language, ruby on rails is an open source web development framework which was written in ruby programming language. For the purpose of developing the SNF EDC tool, we use ruby 1.8.7 and rails 2.3.4. This framework relies on three conventions:

1. Convention over Configuration which means that developers should only have to worry about the unconventional parts of the application.
2. Don’t Repeat Yourself coding methodology which encourages code reuse and efficiency.

3. Models, Views and Controllers (MVC) architecture.

### 7.1.2 MySQL

My Structured Query Language (MySQL) is an open source, secure, cost-efficient relational database management system (RDBMS). It has great compatibility with ruby on rails and for this reason, we use the version 5.6.x for the SNF EDC system.

### 7.1.3 Javascript

It is again an object oriented programming language which mainly used to keep the webpages interactive and responsive. Including javascript in the website significantly improves the websites performance. We heavily use Javascript 1.8 in our system to interact with the server without reloading the whole webpage.

### 7.1.4 Google Chart API

This is a free tool provided by google which helps to create graphs and charts on webpages. It is very simple to use and gives users a large variety of charts to choose from. The graphs created by using this API are very neat and concise. We use this API in our tool to plot weight over time graph.
7.1.5 Red Hat Enterprise Linux Server release 6.5 (Santiago)

This is a linux based Operating System on which we host our SNF EDC System. This OS is fast, reliable, light-weight, secure and stable.

7.1.6 Ruby Version Manager (RVM)

RVM is a command-line tool which allows you to easily install, manage, and work with multiple ruby environments from interpreters to sets of gems [36]. We use version 1.25.27 for this system.

7.1.7 Phusion Passenger

It is a web server and an application server. Designed to be fast, robust and lightweight, it makes web app deployments a lot simpler and less complex, by managing your apps’ processes and resources for you [26]. We use version 4.0.45.

7.2 Implementation of Automation of Clinical Scores

Computation of clinical scores used to be a tedious task and hence its automation was imperative. In this section, I will discuss how I implemented it.

7.2.1 Storing the information in an XML file

I store the information about all the variables in all the forms that are related to any of the clinical scores discussed in this thesis. The xml file contains 3 attributes namely
variable names, Associated Clinical Score to a particular variable and Name of the table which variable belongs to.

7.2.2 Migrating XML data to MySQL server

I developed a Task to process the xml file and migrate all the data to the Scorings table in the mysql server. This table comprises of various columns like variable ID, variable name and related clinical score variable ID. This task read the xml file and exported the retrieved data to the mysql server.

7.2.3 Algorithm to calculate Clinical Scores

This algorithm can be illustrated in few simple steps listed below:

1. First as the user is filling up the form, we check each variable to see if it is present in the Scorings table.

2. If we find a match in the scorings table, we call a javascript function to serialize all the related variables and their values and send it as a parameter to the mean calculate function.

3. Inside the controller function, we check to see the related clinical score for each variable in the serialized parameter.

4. Once we know which clinical score has to be calculated and the associated variables to that score, we calculate the score by using the appropriate formulae.
5. We check to see if it meets the rendering condition, for instance some scores requires certain number of questions to be answered.

6. If everything is satisfied, we display the score otherwise we leave the score field untouched.

The above algorithm can illustrated as shown in figure 7.1.

![Figure 7.1: Algorithm for Computation of Clinical Scores](image)
7.3  Implementation of Charts

There are two charts in the SNF EDC tool. I will be discussing both in this section.

7.3.1  Weight over time Graph

Implementation of this chart can be explained in few steps listed below:

1. Check to see for each variable if it belongs to Heart Failure Disease Management Program Weekly Assessments table.

2. Run an SQL Query to get the weight of the patient over all the visits.

3. Convert the weight in a common scale of either "kilograms" or "pound".

4. Once we have the weights in common scale and the Date-time visits, we plot the weight over time chart.

Please note that this graph comes with a show and hide functionality which is implemented in javascript, this makes the chart more interactive. Figure 7.2 illustrates the above steps.
Figure 7.2: Implementation of Weight over Time graph

7.3.2 Symptom Progression Chart

This chart is implemented in a very similar way as above. Implementation is illustrated below.

1. Check to see for each variable if it belongs to Heart Failure Disease Management Program Weekly Assessments table.
2. Once we know that we are in the right table, we check for a "Symptom and Activity Assessment As compared to baseline" variable heading as this is the place where the symptom progression chart should reside.

3. Run SQL query to get the symptom values for the patient.

4. Assign signs to the values as listed below.

   "1" — "=".

   "2" — "+".

   "3" — ":-".

   ":8" — ":X".

   ":-97" — ":N/A".

5. Checks the rendering condition.

6. Render the chart.

Note that this chart also comes with a show and hide functionality. Above implementation is also shown in figure 7.3.
7.4 Deployment at UC Denver

The SNF EDC system was deployed at University Of Colorado, Denver medicine school. It is deployed as a self-contained VMWare virtual machine containing a standard Linux, Apache, MySQL, Ruby On Rails architecture. An operating user account is created and has ownership of the local Onward SNF code. After that a production
copy of the Onward SNF application is checkout out of the GIT repository into /home-onward/snf. Then a MySQL user account is created according to the configuration in "config/database.yml". Note that Onward SNF is configured to run with the industry standard Apache web server instead of the built-in Rails server. This configuration is achieved using Apache configuration files found in "/etc/http/conf.d". That directory contains two configuration files namely "ruby.conf" is a site wide passenger configuration file to load the "mod_passenger.c" Apache module and "rubysnf.conf" is the SNF specific Apache configuration file. It is extremely simply for end-users to deploy this virtual machine-based solution. All that needs to be done is for the end-user’s local DHCP server to be configured to assign a static IP to the virtual machine and specify a host name corresponding to the IP address in their DNS server.
Chapter 8

Results and Conclusions

The Skilled Nursing Facility (SNF)-Connect Trial is the first of its kind to assess if a Heart Failure Disease Management Program (HF-DMP) will improve outcomes for patients in SNFs will provide evidence on the effectiveness of HF-DMP to improve outcomes for older frail heart failure patients undergoing post-acute rehabilitation [28]. Our SNF Electronic Data Capture (EDC) system will make this process convenient and hassle-free and will provide the following features:

1. Time Efficient — Implementing this system saves a lot of time for HFNAs, Doctors, Clinicians and researchers in the following ways:

   Automation of calculation of clinical scores saves a lot of time for HFNAs as they don’t have to manually calculate that score using excel sheets. They just have to record patient information in the system and the clinical scores will be calculated automatically.

   Features like auto-completion of drug-names saves a lot of time as nurses don’t have to remember the spellings of some complex drug names.
Easy Navigation — Navigating from one form to another with minimal effort makes this system really user-friendly.

Ordering of Forms — This has been done in a way in which the more important forms are kept at the top which again leads to user-friendliness and at the same time saves some precious time.

Hassle-free inserting, updating, editing and deletion of data can be done in this system which makes it really convenient for the users.

2. Easy Data Analysis — Implementing various graphs and storing the data in a structured manner makes data analysis easy rewarding.

Giving a pictorial representation of patients progression on various symptoms and weight over time can give a profound view of the condition of the patient and how he has been reacting to the medication given to him. This detailed and neat information can help researchers and clinicians to come up with patterns and trends and tell us how these symptoms exactly relate to Heart Failure Patients.

Storing data in a relational database management system makes it structured and easy to retrieve in the suitable layout that researchers require.

3. Data security — Patient data collected in this HF-DMP will be stored in a secure and reliable place with back-ups.

4. Data Accessibility — Data will be easily available to the researchers in a structured form which will help them analyze it in a better way.
5. Cost Effective — SNF EDC System is a cost-efficient electronic data capture system.

In summary, I can say that SNF EDC system which is built to carry out the HF-DMP in SNF is a reliable, secure, cost-efficient, time-efficient and a robust system. This aims to improve healthcare for HF patients especially amongst older adults and at the same time gives a convenient and suitable platform for conducting clinical research and data analysis.
APPENDIX
Related Files and Ruby on Rails Code

A.1 Scores.xml File

```xml
<scorings>
  <scoring>
    <variable>KCCQdress</variable>
    <relatedvariable>Physicallimitationscore</relatedvariable>
    <tablename>kccq</tablename>
  </scoring>
  <scoring>
    <variable>KCCQshower</variable>
    <relatedvariable>Physicallimitationscore</relatedvariable>
    <tablename>kccq</tablename>
  </scoring>
  <scoring>
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    <tablename>kccq</tablename>
  </scoring>
  <scoring>
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  <scoring>
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    <tablename>kccq</tablename>
  </scoring>
  <scoring>
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    <relatedvariable>Physicallimitationscore</relatedvariable>
    <tablename>kccq</tablename>
  </scoring>
  <scoring>
    <variable>KCCQcompared2week</variable>
    <relatedvariable>Physicallimitationscore</relatedvariable>
    <tablename>kccq</tablename>
  </scoring>
</scorings>
```
<variable>KCCQhlifewithheartfailure</variable>
<relatedvariable>Physicallimitationscore</relatedvariable>
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</scoring>

<variable>KCCQhoeldiscouraged</variable>
<relatedvariable>Physicallimitationscore</relatedvariable>
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<variable>KCCQhobby</variable>
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<variable>KCCQdohouseholdchores</variable>
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<variable>KCCQvisitouthome</variable>
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A.2 Task to process the xml file

```ruby
require 'hpricot'
task :import_scorings => :environment do
  scoring_data = File.open(ENV['file'], 'r')
doc = Hpricot(scoring_data)
scoring_data.close

doc.get_elements_by_tag_name("scoring").each do |scoring|
  if x=Scoring.find_by_variable_name((scoring/"variable").inner_text)
    x.delete
  end
end

doc.get_elements_by_tag_name("scoring").each do |scoring|
  s = Scoring.create
  tabId=Table.find_by_tablename((scoring/"tablename").inner_text).id
  s.variable_id= Variable.find_by_variablename_and_table_id((scoring/"variable").inner_text, tabId).id
  s.variable_name= (scoring/"variable").inner_text
  s.related_variable_id = Variable.find_by_variablename((scoring/"relatedvariable").inner_text).id
  s.save
```
A.3 Controller Function for Clinical Score Calculation

```python
def mean_calculate:
    right = 0.0
    left = 0.0
    mean = 0.0
    sum, sum1, sum2, sum3, sum4, sum5, sum6, sum7, sum8, sum9 = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
    count, count1, count2, count3, count4, count5 = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
    phylimscore = -1.0
    symstabscore = -1.0
    symfreqscore = -1.0
    symburdscore = -1.0
    seleffscore = -1.0
    qual lifescore = -1.0
    soclimscore = -1.0
    totsymscore = -1.0
    oversumscore = -1.0
    clininsumscore = -1.0
    rightscore = -1.0
    leftscore = -1.0

    value1, available = 0.0, 0.0
    update, update1, update2, update3, update4, update5, update6, update7, update8, update9, update10, update11, update12, update13, update14 = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
    status1, status2, status3, status4 = 0.0, 0.0, 0.0

    variable = Variable.find_by_id(params[:variable_id])
    for params.inspect
        variable.scoring_related_variable_names.each do |vname|
            value = params[vname].to_f

            if (vname == "wtgs" || vname == "wrh2" || vname == "wrh3")
                if (value > 0)
                    right = right + value
                    update9 = update9 + 1
                end
            end

            if (vname == "wlh1" || vname == "wlh2" || vname == "wlh3")
                if (value > 0)
                    left = left + value
                end
            end
        end
    end
```
update10=update10+1
end
end

if (vname=="1repetitionofwords" || vname=="2abletoyear" || vname==
"3abletomonth" || vname=="4abletoday" || vname=="ablesock" || vname
=="ableblue" || vname=="ablebed")
if (value >=0)
  sum6=sum6 + value
  update11=update11+1
end
end

if (vname=="schifwy" || vname=="schifcyas" || vname=="schiftags"
 || vname=="schiffska" || vname=="schifkdna" || vname=="schifelsh" || vname
=="schifealm" || vname=="schiftoym" || vname=="schifalsi" || vname
=="schifushy")
if (value >=0)
  sum7=sum7 + value
  update12=update12+1
end
end

if (vname=="schifhqu" || vname=="schifsyd" || vname=="schifysi"
 || vname=="schiftaewp" || vname=="schifudng" || vname==
"schifartut")
if (value >=0)
  sum8=sum8 + value
  update13=update13+1
end
end

if (vname=="schifkufhf" || vname=="schifta" || vname==
"schifeifs" || vname=="schifrcyh" || vname=="schifdsry" || vname==
"schiferw")
if (value >=0)
  sum9=sum9 + value
  update14=update14+1
end
end

if (vname=="cmimyo" || vname=="cmiconges" || vname=="cmiperivas" || vname
=="cmicva" || vname=="cmidementia" || vname=="cmicopd" || vname
=="cmicontis" || vname=="cmipepulcer" || vname=="cmiliver" || vname
=="cmidiabmild")
if (value >0)
  sum=sum + (value *1)
  update8=update8+1
end
end
if (vname=="cmihemi" || vname=="cmidiabsev" || vname=="cmirenal" || vname=="emitumor" || vname=="cmileuke" || vname=="cmilymph")
    if (value > 0)
        sum = sum + (value * 2)
        update8 = update8 + 1
    end
end
if (vname=="cmiliversev")
    if (value > 0)
        sum = sum + (value * 3)
        update8 = update8 + 1
    end
end
if (vname=="cmiaids" || vname=="cmisolidtum")
    if (value > 0)
        sum = sum + (value * 6)
        update8 = update8 + 1
    end
end
if (vname=="KCCQdress" || vname=="KCCQshower" || vname=="KCCQw1bolg"
           || vname=="KCCQdowork" || vname=="KCCQclimb" || vname=="KCCQhurry"
           || vname=="KCCQcompared2week" || vname=="KCCQwakeupsowellfeet"
           || vname=="KCCQhmtfatiguelimityou" || vname=="KCCQhmtshortbreathlimit"
           || vname=="KCCQhmtforctosleepinchair" || vname=="KCCQhmswellfeet"
           || vname=="KCCQhmfatiguebotherthere" || vname=="KCCQhmsbreathlimit"
           || vname=="KCCQwtoifgetworse" || vname=="KCCQhtfgettingworse"
           || vname=="KCCQhowfailurelimitenjoyment" || vname=="KCCQhlifewithheartfailure"
           || vname=="KCCQhfeeldiscouraged" || vname=="KCCQhobby"
           || vname=="KCCQdohouseholdchores" || vname=="KCCQvisitouthome"
           || vname=="KCCQhowfailurerelaxation"
    if (value > 0)
        count = count + 1.0
        sum = (sum + value)
    end
mean = sum / count
if (count > 2)
    update1 = 1
    phylimscore = 25 * (mean - 1.0)
end
if (phylimscore >= 0 && status1 == 0)
    available = available + 1.0
    status1 = 1
end
end
if (vname=="KCCQcompared2week")
if (value >=0)
  mean = value - 1
  symstabscore = 25*(mean)
  update1=1
end
end

if (vname=="KCCQwakeupswellfeet" || vname=="KCCQhmtfatiguelimityou" || vname=="KCCQhmtshortbreathlimit" || vname =="KCCQhmtforcetosleepchair")
  if (vname=="KCCQwakeupswellfeet" || vname=="KCCQhmtforcetosleepchair")
    if (value >=0)
      count1 = count1 + 1.0
      value1 = (value - 1.0)/4
      sum1 = (sum1 + value1)
    end
  end
  if (vname=="KCCQhmtfatiguelimityou" || vname=="KCCQhmtshortbreathlimit")
    if (value >=0)
      count1 = count1 + 1.0
      value1 = (value - 1.0)/6
      sum1 = (sum1 + value1)
    end
  end
  mean = (sum1 / count1)
  if (count1 >1)
    update2=1
    symfrequescore = 100*(mean)
  end
end
if (vname=="KCCQhmswellfeet" || vname=="KCCQhmfatiguebothere" || vname=="KCCQhmshortbreath")
  if (value >=0)
    count2 = count2 + 1.0
    sum2 = (sum2 + value)
  end
  mean = sum2 / count2
  if (count2>0)
    update3=1
    symburdscore = 25*(mean - 1.0)
  end
end

if (vname=="KCCQwtoifgetworse" || vname=="KCCQhtfgettingworse")
  if (value >=0)
    count3 = count3 + 1.0
sum3 = (sum3 + value)
end
mean = sum3 / count3
if (count3 > 0)
  update4 = 1
  selfffscore = 25*(mean - 1.0)
end
end

if (vname == "KCCQhowfailurelimitenjoyment" || vname == "KCCQhlfewithheartfailure" || vname == "KCCQhfeofdiscouraged")
  if (value >= 0)
    count4 = count4 + 1.0
    sum4 = (sum4 + value)
  end
  mean = sum4 / count4
  if (count4 > 0)
    update5 = 1
    qualllifescore = 25*(mean - 1.0)
  end
  if (qualllifescore >= 0 && status2 == 0)
    available = available + 1.0
    status2 = 1
  end
end
end

if (vname == "KCCQhobby" || vname == "KCCQdohouseholdchores" || vname == "KCCQvisithome" || vname == "KCCQintimate")
  if (value >= 0)
    count5 = count5 + 1.0
    sum5 = (sum5 + value)
  end
  mean = sum5 / count5
  if (count5 > 1)
    update6 = 1
    soclimscore = 25*(mean - 1.0)
    if (soclimscore >= 0 && status3 == 0)
      available = available + 1.0
      status3 = 1
    end
  end
end
end
end

mc = variable.scoring
p "update value"
p update
render :update do |page|
# var = Variable.find_by_table_id_and_id(params["table_id"].to_i, 310)
    if (update1 ==1)
        page["Physicallimitationscore"].value = phylimscore.round(2)
    end
    if (update1 ==1)
        page["symptomstabiltyscore"].value = symstabscore.round(2)
    end
    if (update2 ==1)
        page["symptonfrequenciescore"].value = symfreqscore.round(2)
    end
    if (update3 ==1)
        page["symptonburdenscore"].value = symburdscore.round(2)
    end
    if (update4 ==1)
        page["selfefficacyscore"].value = seleffscore.round(2)
    end
    if (update5 ==1)
        page["qualityoflifescore "]').value = quallifescore.round(2)
    end
    if (update6 ==1)
        page["sociallimitationsscore"].value = soclimscore.round(2)
    end
    if (update8 >0)
        page["cmiscore"].value=sum.round(2)
    end
    if (update9 >0)
        rightscore=right/update9
        page["wagsr"].value=rightscore.round(2)
    end
    if (update11 >0)
        page["bimsscore"].value=sum6.round(2)
    end
    if (update12 >0)
        sum7=(sum7−10)*3.33
        page["schfits "]').value=sum7.round(2)
    end
    if (update13 >0)
        sum8=(sum8−4)*5
        page["schfits2 "]').value=sum8.round(2)
    end
    if (update14 >0)
        sum9=(sum9−6)*5.56
        page["schfits3 "]').value=sum9.round(2)
    end
    if (update10 >0)
        leftscore=left/update10
        page["wagsl"].value=leftscore.round(2)
    end
if (update2==1 || update3==1)
  if (update2==1 && update3==0)
    totsymscore=symfreqscore
  end
  if (update2==0 && update3==1)
    totsymscore=symburdscore
  end
  if (update2==1 && update3==1)
    totsymscore=(symburdscore+symfreqscore)/2
  end
  page["Totsymscore"].value = totsymscore.round(2)
end
if(totsymscore>=0 && status4==0)
  available=available+1.0
  status4=1
end
update7=1
end
if (update==1 || update7==1 || update5==1 || update6==1)
  if (available==1.0)
    oversumscore=phylimscore+quallifescore+soclimscore+totsymscore+3
  end
  if (available==2.0)
    oversumscore=(phylimscore+quallifescore+soclimscore+totsymscore+2)/2.0
  end
  if (available==3.0)
    oversumscore=(phylimscore+quallifescore+soclimscore+totsymscore+1)/3.0
  end
  if (available==4.0)
    oversumscore=(phylimscore+quallifescore+soclimscore+totsymscore)/4.0
  end
  page["Overallsumscore"].value = oversumscore.round(2)
end
if (update==1 || update7==1)
  if (update==1 && update7==0)
    clininsumscore=phylimscore
  end
  if (update7==1 && update==0)
    clininsumscore=totsymscore
  end
  if (update==1 && update7==1)
    clininsumscore=(phylimscore+totsymscore)/2
  end
  page["Clinicalsumscore"].value = clininsumscore.round(2)
end
A.4 Javascript function to serialize variables

```javascript
function serializeAutoCalculationVariableValues(var_names) {
    arr = var_names.split(".");
    params = ";
    for(var i = 0; i < arr.length; i++) {
        var value = arr[i];
        params += "&" + arr[i] + "+" + $(arr[i]).value;
    }
    return params;
}
```

sectionView for Clinical Score

```html
<% if @table.pages.length > 1%>
<div tabindex="-1">
    <table><tr><td class="pagenumberlink" colspan="2">
        Pages <% @table.pages.each do |p|%>
        <a href="#page <%= p %>" tabindex="-1"><%= p %></a>
        <% end %>
    </td></tr></table>
</div>
<% end %>

<% @table.pages.each do |p|%>
<% if @table.pages.length > 1%>
<tr><td class="pagenumber" colspan="2">
    <a name="page <%= p %>">
    Page <%= p %>
    </a>
</td></tr>
<% end %>
<% end %>
<% for i in 0..@vars.length-1%>
<% if (@varnums.include?(@vars[i].id) and (@vars[i].questionpage==p)) %>
<% headings = Heading.find(:all, :conditions => ["variableid =?", @vars[i].id]).sort_by{|h| h.headingorder} %>
<% if headings.length>0 %>
```
<% headings.each do |heading|%>
  <tr class="heading">
    <td colspan="2"><%=heading.headertext %></td>
  </tr>
<% end %>
<% end %>
<% end %>
<% if ( @vars[i].questionpage == p)%>
<% if ((i%2)==0)%>
  <tr class="even" id="%= "id_"+@vars[i].variablename%>>
    <% else %>
  <tr class="odd" id="%= "id_"+@vars[i].variablename%>>
    <% end %>
    <td width="70%"><%= @vars[i].name%></td>
    <% if @vars[i].active%>
    <% active = false%>
    <% else %>
    <% active = true%>
      <% if @vars[i].distribution == 1 and @vars[i].scoring%>
    <td><%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :disabled => active, :onchange => remote_function(:url => {:controller => :variables, :action=>:mean_calculate, :variable_id=>@vars[i].id}, :with => "'value' + value + '&table_id' + serializeAutocalculationVariableValues('#{@vars[i].scoring_related_variable_names.join(',')}')")%></td>
      <% elsif @vars[i].distribution == 1 and @vars[i].visible%>
    <td><%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :onchange => remote_function(:url => {:controller => :variables, :action=>:skip, :variable_id=>@vars[i].id}, :with => "'value' + value" )%>
      <% else %>
    <%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :disabled => active%>
    <% end %>
    </% if !@vars[i].rules.empty? %>
    </% end %>
  <% elsif @vars[i].distribution == 1 and !@vars[i].visible%>
    <td><%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :disabled => active%></td>
    <% elsif @vars[i].distribution == 3 %>
    <td>
<% if @vars[i].length > 100 %>
  <%= text_area_tag @vars[i].variablename, @res[@vars[i].variablename].disabled => active, :size => "18x5" %>
  <%=#@@vars[i].variablename%>
<% end %>
<%#=@vars[i].variablename%>
<% script %>
$.wtyy().keypress(function(e) {
  if(e.keyCode == 13 && !e.shiftKey) {
    e.preventDefault();
    this.form.submit();
  }
});
</script>
<% else %>
  <%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :disabled => active %>
<% end %></td>
<% elsif @vars[i].distribution == 4 %>
<td>
  <%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :disabled => active %></td>
<% elsif @vars[i].distribution == 2 %>
<% value = {} %>
<% if @pers[i] != nil %>
<% @pers[i].each do |per| %>
  <%= value[per.startvalue.to_i.to_s + ':' + per.valuemeaning.to_s] = per.startvalue %>
<% end %>
<% value = value.sort_by{|a|a[1]} %>
<% value.insert(0,'---1000') %>
<td>
<% if !@vars[i].rules.empty? %>
  <%= select_tag @vars[i].variablename, options_for_select(value, :selected => @res[@vars[i].variablename].to_i), :disabled => active, :onchange => remote_function(': url => {:controller => :variables, :action => :skip, :variable_id => @vars[i].id}, :with => "'value=' + value ") %>
  <%= select_tag @vars[i].variablename, options_for_select(value, :selected => @res[@vars[i].variablename].to_i), :disabled => active, :onchange => remote_function(': url => {:controller => :variables, :action => :mean_calculate, :variable_id => @vars[i].id}, :with => "'value=' + value + '&table_id=#{@table.id}' + serializeAutocalculationVariableValues('#{@vars[i].scoring_related_variable_names.join(",")}')" ) %>
<% elsif %>
<% %>
<%= select_tag @vars[i].variablename, options_for_select(value, :selected => @res[@vars[i].variablename].to_i), :disabled => active %>
</td>
<% end %>
</td>
<% else %>
<td><%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :disabled => active %></td>
<% end %>
<% else %>
<td><%= text_field_tag @vars[i].variablename, @res[@vars[i].variablename], :disabled => active %></td>
<% end %>
<%= observe_field @vars[i].variablename, :frequency => 0.5, :url =>{:controller => :variables, :action => :validate,:variable_id => @vars[i].id }, :with => "'value='+value"%>
<% puts "tarun"%>
<% $mean = 0.0
$count = 0.0
%>
</tr>
<% end %>
<% end %>
<% end %>
</tr>
</table>
</div>
<% for i in 0..@vars.length-1%>
<% if @vars[i].questionpage == -1%>
<tr>
<td width="70%"><%= @vars[i].name%></td>
<% if @vars[i].active%>
<% active = false%>
<% else %>
<% active = true%>
<% end %>
<% if @vars[i].distribution == 1%>
A.5 View for Graphs

```ruby
<%require 'gchart'%>
<%div id = "view_record">
<% if @current_user.can_view_table?(@table_id)%>
  <% if @res >
    <% if @table.format == 1%>
      <div class = "headers" style="margin-bottom:0px; padding-bottom:1px;" >
        <table width="100%">
          <% for i in (0..@vars.length -1)%>
            <% if (@vars[i].questionpage == 0)%>
              <tr>
                <td width="70%"><%= @vars[i].name%></td>
            <%end%>
          <%end%>
        </table>
      </div>
    <% else%>
```
<% if @vars[i].distribution == 2 and @res[@vars[i].variablename] != -1000%>
  <td><%= @res[@vars[i].variablename].to_s + " : " + @vars[i].meaning(@res[i]).to_s %></td>
<% elsif @vars[i].distribution == 2 and @res[@vars[i].variablename] == -1000%>
  <td></td>
<% elsif @vars[i].distribution == 4%>
<% if !@res[@vars[i].variablename].blank?%>
  <td><%= DateTime.parse(@res[@vars[i].variablename].to_s).strftime("%m/%d/%Y") %></td>
<% end %>
<% else %>
  <td><%= @res[@vars[i].variablename] %></td>
<% end %>
</tr>
<% end %>
</table>
</div>
<% if @table.pages.length > 1%>
<div>
<table width="100%"><tr>
<td class="pagenumberlink" colspan="2">
  Pages
</td>
</tr>
<% @table.pages.each do |p|%>
  <a href="# page <%= p %>">Page <%= p %></a>
<% end %>
</table>
</div>
<% end %>
</div>
</div>
<% div class="pages" style="border-top:1px solid rgb(0,0,0); border-bottom:1px solid rgb(0,0,0); overflow:auto; margin-bottom:0px; padding-bottom:1px;"%>
  <table class="questionaire">
    <% @table.pages.each do |p|%>
    <% if @table.pages.length > 1%>
      <tr><td class="pagenumber" colspan="2">
      <a name="page <%= p %>">Page <%= p %></a>
      </tr></td>
    <% end %>
    <% end %>
    <% if for i in (0..@vars.length - 1)%>
    <% if (@varnums.include?(@vars[i].id) and (@vars[i].questionpage == p))%>
      <% headings = Heading.find(:all, :conditions => ["variableid =?", @vars[i].id]).sort_by{|h| h.headingorder} %>
    </% end %>
    </% end %>
  </table>
</div>
<script type='text/javascript' src='http://www.google.com/jsapi'></script>
<%end%>
<%end%>

<script type='text/javascript'>
goog.load('visualization', '1', {'packages':['annotatedtimeline']});
goog.setOnLoadCallback(drawChart);
function drawChart() {
    var data = new goog.visualization.DataTable();
data.addColumn('date', 'Date');
data.addColumn('number', 'Weight');
data.addColumn('string', 'title1');
data.addColumn('string', 'text1');
    var cd=0;
    for c in 0..arr.length-1%
        data.addRows([new Date(%arr5[0]%),%arr6[0]%,%arr7[0]%),%arr[0]%, undefined, undefined]);
    data.addRows([new Date(%arr5[c]%),%arr6[c]%,%arr7[c]%),%arr[c]%, undefined, undefined]);
    chart = new goog.visualization.AnnotatedTimeLine(document.getElementById('chart_div'));
    chart.draw(data, {displayAnnotations: true, scaleType: 'maximized'});
}
function showChart() {
    document.getElementById("chart_div").style.display = "block";
}
function hideChart() {
    document.getElementById("chart_div").style.display = "none";
}</script>
<script>
<input type='button' onClick='javascript:showChart();' value='Show'>
<input type='button' onClick='javascript:hideChart();' value='Hide'>
<div id='chart_div' style='width: 700px; height: 240px; display: block;'> </div>
</script>

<%end%>
</tr>
<%if heading.headingtext == "Symptom and Activity Assessment As compared to baseline"%>
<tr>
<td colspan="2">**Patient Symptom Report:**

```sql
select ifyesfatiguehfdmpasses, ifyesactivityhfdmpasses, ifyesshortnesshfdmpasses, ifyeschesthfdmpasses, ifyesparoxysmhfdmpasses, ifyesorthopneahfdmpasses, ifyescoughhfdmpasses from ", @table.tablename," where studyid=" ,@res["studyid "].to_s.to_i %
```

```sql
select datevisit from ", @table.tablename," where studyid=" ,@res["studyid "].to_s.to_i %
```

```sql
select ifyesjugularhfdmpasses, ifyesbloathfdmpasses, ifyesnauseahfdmpasses, ifyesappetitehfdmpasses, ifyesedemahfdmpasses from ", @table.tablename," where studyid=" ,@res["studyid "].to_s.to_i %
```

```sql
select nyahaclasshfdmpasses from ", @table.tablename," where studyid=" ,@res["studyid "].to_s.to_i %
```

```dbh = @table.connect %
% arr=Array.new()
% arr1=Array.new()
% arr2=Array.new()
% arr3=Array.new()
% symbol=Array.new()
% symbol1=Array.new()
% symbol2= ['Fatigue', 'Activity', 'Shortness of Breath', 'Chest Discomfort', 'Paroxysmal nocturnal dyspnea', 'Orthopnea', 'Cough', 'Jugular Venous Pressure', 'Bloat', 'Nausea', 'Loss of Appetite', 'Lower Extremity Edema', 'NYHA Class'] %
% @resultss = dbh.select_all(sql.to_s) %
% @resultss1 = dbh.select_all(sql1.to_s) %
% @resultss2 = dbh.select_all(sql2.to_s) %
% @resultss3 = dbh.select_all(sql3.to_s) %
```
<% i = 0 %>
<% @results.each do | r |%
<% arr[i] = r.to_s.to_i %>
<% if arr[i] == 1 %>
<% symbol[i] = "=" %>
<% end %>
<% if arr[i] == 2 %>
<% symbol[i] = "+" %>
<% end %>
<% if arr[i] == 3 %>
<% symbol[i] = "-" %>
<% end %>
<% if arr[i] == -8 %>
<% symbol[i] = "X" %>
<% end %>
<% if arr[i] == -97 %>
<% symbol[i] = "N/A" %>
<% end %>
<% end %>
<% i = i + 1 %>
<% end %>
<% end %>

<% j = 0 %>
<% @results1.each do | y |%
<% arr1[j] = y.to_s.split("T").first %>
<% j = j + 1 %>
<% end %>
<% k = 0 %>
<% @results2.each do | z |%
<% arr3[k] = z.to_s.to_i %>
<% if arr3[k] == 1 %>
<% symbol1[k] = "=" %>
<% end %>
<% if arr3[k] == 2 %>
<% symbol1[k] = "+" %>
<% end %>
<% if arr3[k] == 3 %>
<% symbol1[k] = "-" %>
<% end %>
<% if arr3[k] == -8 %>
<% symbol1[k] = "X" %>
<% end %>
<% if arr3[k] == -97 %>
<% symbol1[k] = "N/A" %>
<% end %>
<% k = k + 1 %>
<% end %>
<%end%>

<%count=0%>
<%stat=0%>
<%stat1=0%>

<script type="text/javascript">
  function showTable () {
    document.getElementById("tablediv").style.display = "block";
    document.getElementById('table').style.visibility = "visible";
    document.getElementById('table').style.display = "inline"
  }
  function hideTable () {
    document.getElementById("tablediv").style.display = "none";
    document.getElementById('table').style.visibility = "hidden";
    document.getElementById('table').style.display = "none"
  }
</script>

<input type='button' onClick='javascript:showTable();' value='Show'>
<input type='button' onClick='javascript:hideTable();' value='Hide'>

<div id="tablediv" style="border:1px solid black;width:750px;height:400px;overflow-y: hidden;overflow-x: scroll;display:none;">
  <table id='table' border=5 style="display: none;">
    <tr>
      <th nowrap="nowrap">Symptom</th>
      <% arr1.each do |l|%>
      <%count=count+1%>
      <th nowrap="nowrap">
        <p><%= l %></p>
      </th>
      <%end%>
    </tr>
    <%for i in 0..6%>
    <tr>
      <td nowrap="nowrap">&lt;%=symbol2[stat]%&gt;</td>
      <%stat=stat+1%>
    </tr>
    <%end%>
    <tr>
      <td nowrap="nowrap">&lt;%=symbol2[stat]%&gt;</td>
      <%stat1=i%>
      <%for j in 1..count%>
      &lt;%= if symbol[stat1]=="+" %&gt;
    </tr>
  </table>
</div>
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Red</td>
<td>Positive</td>
</tr>
<tr>
<td>−</td>
<td>Lime</td>
<td>Negative</td>
</tr>
<tr>
<td>%</td>
<td>Gold</td>
<td>Percentage</td>
</tr>
<tr>
<td>N/A</td>
<td>Black</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>X</td>
<td>Grey</td>
<td>Missing Data</td>
</tr>
</tbody>
</table>

Example:

For Symbol 1:
- If symbol[stat1] == "−" %, color Lime.
- If symbol[stat1] == "+", color Red.
- If symbol[stat1] == "+", color Gold.
- If symbol[stat1] == "N/A", color Black.
- If symbol[stat1] == "X", color Grey.

For Symbol 2:
- If symbol2[stat1], color Red.
- If symbol2[stat1] == "+", color Gold.
- If symbol2[stat1] == "−", color Lime.
- If symbol2[stat1] == "N/A", color Black.
- If symbol2[stat1] == "X", color Grey.
```html
<% if @res[@vars[i].variablename] %>
<tr>
  <td><%= @res[@vars[i].variablename] %></td>
</tr>
<% end %>
</table>
</div>

<% else %>
</div>
<% else %>
</div>
<% end %>
</div>

<% if ( @vars[i].questionpage == -1)%>
<tr>
  <td width="70%"><%= @vars[i].name%></td>
  <% if @vars[i].distribution ==2 and @res[@vars[i].variablename] != -1000%>
  <td><%= @res[@vars[i].variablename].to_s + " + @vars[i].meaning(@res[i].to_s %</td>
  <% elsif @vars[i].distribution == 4%>
  <td><%= DateTime.parse(@res[@vars[i].variablename].to_s).strftime("%m/%d/%Y at %I:%M %p") %</td>
  <% else %>
  <td><%= @res[@vars[i].variablename] %></td>
  <% end %>
</tr>
<% end %>
</table>
</div>
<% else %>
</div>
<% else %>
</div>
<% end %>
</div>
<% else %>
</div>
<% else %>
</div>
<% end %>
</div>
<% else %>
</div>
<% else %>
</div>
<% end %>
</div>
<% else %>
</div>
<% else %>
</div>
<% end %>
</div>
<% for i in (0..@vars.length-1)%>
<% if (@varnums.include?(@vars[i].id)) %>  
<% headings = Heading.find(:all,:conditions => ["variableid ="?,@vars[i].id]).sort_by{|h| h.headingorder}%>
<% if headings.length > 0 %>  
<% headings.each do |heading| %>
      <tr class="heading">
     <td colspan="2"><%= heading.headingtext %>
     <% if @tabletablename="hfdmpweeklyassesments"%>
     <% if heading.headingtext="Weekly Weight Assessment"%>
<% sql1="select datevisit from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit ">
<% sql2="select weighthfdfmpasses ,weightmesurehfdfmpasses from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit "%>
<% dbh = @table.connect %>
<% arr=Array.new() %>
<% arr5=Array.new() %>
<% arr6=Array.new() %>
<% arr7=Array.new() %>
<% @resultss1 = dbh.select_all(sql1.to_s) %>
<% @resultss2 = dbh.select_all(sql2.to_s) %>

<% j=0%>
<% @resultss1.each do |y| %>
<% arr5[j]=y.to_s.split("-").first.to_i%>
<% arr6[j]=y.to_s.split("-").second.to_i-1%>
<% arr7[j]=y.to_s.split("-").third.to_i%>
<% j=j+1%>
<% end%>
<% k=0%>
<% @resultss2.each do |z| %>
<% if z[1].to_s=="1" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% arr[k]=z[0].to_s.to_i%>
<% end%>
<% if z[1].to_s=="2" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% temp=z[0].to_s.to_i%>
<% end%>
<% end%>
<% if @tabletablename="hfdmpweeklyassesments"%>
<% if heading.headingtext="Weekly Weight Assessment"%>
<%sql1="select datevisit from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit ">
<% sql2="select weighthfdfmpasses ,weightmesurehfdfmpasses from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit "%>
<% dbh = @table.connect %>
<% arr=Array.new() %>
<% arr5=Array.new() %>
<% arr6=Array.new() %>
<% arr7=Array.new() %>
<% @resultss1 = dbh.select_all(sql1.to_s) %>
<% @resultss2 = dbh.select_all(sql2.to_s) %>

<% j=0%>
<% @resultss1.each do |y| %>
<% arr5[j]=y.to_s.split("-").first.to_i%>
<% arr6[j]=y.to_s.split("-").second.to_i-1%>
<% arr7[j]=y.to_s.split("-").third.to_i%>
<% j=j+1%>
<% end%>
<% k=0%>
<% @resultss2.each do |z| %>
<% if z[1].to_s=="1" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% arr[k]=z[0].to_s.to_i%>
<% end%>
<% if z[1].to_s=="2" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% temp=z[0].to_s.to_i%>
<% end%>
<% end%>
<% if @tabletablename="hfdmpweeklyassesments"%>
<% if heading.headingtext="Weekly Weight Assessment"%>
<%sql1="select datevisit from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit ">
<% sql2="select weighthfdfmpasses ,weightmesurehfdfmpasses from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit "%>
<% dbh = @table.connect %>
<% arr=Array.new() %>
<% arr5=Array.new() %>
<% arr6=Array.new() %>
<% arr7=Array.new() %>
<% @resultss1 = dbh.select_all(sql1.to_s) %>
<% @resultss2 = dbh.select_all(sql2.to_s) %>

<% j=0%>
<% @resultss1.each do |y| %>
<% arr5[j]=y.to_s.split("-").first.to_i%>
<% arr6[j]=y.to_s.split("-").second.to_i-1%>
<% arr7[j]=y.to_s.split("-").third.to_i%>
<% j=j+1%>
<% end%>
<% k=0%>
<% @resultss2.each do |z| %>
<% if z[1].to_s=="1" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% arr[k]=z[0].to_s.to_i%>
<% end%>
<% if z[1].to_s=="2" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% temp=z[0].to_s.to_i%>
<% end%>
<% end%>
<% if @tabletablename="hfdmpweeklyassesments"%>
<% if heading.headingtext="Weekly Weight Assessment"%>
<%sql1="select datevisit from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit ">
<% sql2="select weighthfdfmpasses ,weightmesurehfdfmpasses from ",@tabletablename," where studyid=",@res.first["studyid"].to_s.to_i," GROUP BY datevisit "%>
<% dbh = @table.connect %>
<% arr=Array.new() %>
<% arr5=Array.new() %>
<% arr6=Array.new() %>
<% arr7=Array.new() %>
<% @resultss1 = dbh.select_all(sql1.to_s) %>
<% @resultss2 = dbh.select_all(sql2.to_s) %>

<% j=0%>
<% @resultss1.each do |y| %>
<% arr5[j]=y.to_s.split("-").first.to_i%>
<% arr6[j]=y.to_s.split("-").second.to_i-1%>
<% arr7[j]=y.to_s.split("-").third.to_i%>
<% j=j+1%>
<% end%>
<% k=0%>
<% @resultss2.each do |z| %>
<% if z[1].to_s=="1" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% arr[k]=z[0].to_s.to_i%>
<% end%>
<% if z[1].to_s=="2" && z[0].to_s.to_i != 0%>
<% z[0]%>
<% temp=z[0].to_s.to_i%>
<% end%>
<% end%>
<% temp=temp*2.20%>
<%arr[k]=temp%>
<%end%>
<% if z[0].to_s.to_i != 0%>
<%k=k+1%>
<%end%>
<%end%>

<script type='text/javascript' src='http://www.google.com/jsapi'></script>
<script type='text/javascript'>
goog.load('visualization', '1', {'packages':['annotationtimeline']});
goog.setOnLoadCallback(drawChart);
function drawChart() {
  var data = new google.visualization.DataTable();
data.addColumn('date', 'Date');
data.addColumn('number', 'Weight');
data.addColumn('string', 'title1');
data.addColumn('string', 'text1');
<%c=0%>
var cd=0;
<%for c in 0..arr.length-1%>

data.addRows([new Date(<%= arr5[c]%>,<%= arr6[c]%>,<%= arr7[c]%>), <%= arr[c]%>, undefined, undefined]);
  }
data.addRows([new Date(<%= arr5[0]%>,<%= arr6[0]%>,<%= arr7[0]%>), <%= arr[0]%>, undefined, undefined]);
<%end%>
var chart = new google.visualization.AnnotatedTimeLine(document.getElementById('chart_div'));
chart.draw(data, {displayAnnotations: true, scaleType: 'maximized'});
}
function showChart(){
document.getElementById("chart_div").style.display = "block";

function hideChart()
    document.getElementById("chart_div").style.display = "none";

</script>
<input type='button' onClick='javascript:
    showChart();' value='Show'>
<input type='button' onClick='javascript:
    hideChart();' value='Hide'>
<div id='chart_div' style='width: 700px; height: 240px; display: block;'>
</div>

</td>
</tr>
</table>

%%%%if heading.headingtext="Symptom and Activity Assessment As compared to baseline"%>
<tr>
  <td colspan="2">Patient Symptom Report:
</td>
</tr>

%%%% sql="select ifyesfatiguehfdmpasses , ifyesactivityhfdmpasses , ifyeshorshtnesshfdmpasses , ifyeshchesthfdmpasses , ifyesparoxyhfdmpasses , ifyesorthopneahfdmpasses , ifyescoughhfdmpasses from ", @table.tablename ,"," where studyid=" , @res.first["studyid"] ,to_s ,to_i ," GROUP BY datevisit" %>
  <% sql1="select datevisit from ", @table.tablename ,"," where studyid=" , @res.first["studyid"] ,to_s ,to_i ," GROUP BY datevisit" %>
  <% sql2="select ifyesjugularhfdmpasses , ifyebloathfdmpasses , ifyesnauseahfdmpasses , ifyesappetitethfdmpasses , ifyesedemahfdmpasses from ", @table.tablename ,"," where studyid=" , @res.first["studyid"] ,to_s ,to_i ," GROUP BY datevisit" %>
  <% sql3="select nyhaclasshfdmpasses from ", @table.tablename ," where studyid=" , @res.first["studyid"] ,to_s ,to_i ," GROUP BY datevisit" %>

%%%% dbh = @table.connect %>
%%%% arr=Array.new() %>
%%%% arr1=Array.new() %>
%%%% arr2=Array.new() %>
%%%% arr3=Array.new() %>
%%%% symbol=Array.new() %>
<% symbol1= Array.new() %>
<% @resultss = dbh.select_all(sql.to_s) %>
<% @resultss1 = dbh.select_all(sql1.to_s) %>
<% @resultss2 = dbh.select_all(sql2.to_s) %>
<% @resultss3 = dbh.select_all(sql3.to_s) %>
<% i=0%>
<% @resultss.each do |x|%>
  <% x.each do |r|%>
    <%- arr[i]= r.to_s.to_i %>
    <%- if arr[i]==1%>
      <%- symbol[i]="\"%>
    <% end%>
    <%- if arr[i]==2%>
      <%- symbol[i]="+"%>
    <% end%>
    <%- if arr[i]==3%>
      <%- symbol[i]="-"%>
    <% end%>
    <%- if arr[i]==-8%>
      <%- symbol[i]="X"%>
    <% end%>
    <%- if arr[i]==-97%>
      <%- symbol[i]="N/A"%>
    <% end%>
  <% end%>
  <% i=i+1%>
<%- end%>
<%- end%>
<%- j=0%>
<% @resultss1.each do |y|%>
  <% arr1[j]=y.to_s.split("T").first%>
  <% j=j+1%>
<%- end%>
<%- k=0%>
<%- @resultss2.each do |z|%>
  <% arr3[k]=q.to_s.to_i%>
  <% if arr3[k]==1%>
    <%- symbol1[k]="\"%>
  <% end%>
  <% if arr3[k]==2%>
    <%- symbol1[k]="+"%>
  <% end%>
  <% if arr3[k]==3%>
    <%- symbol1[k]="-"%>
  <% end%>
  <% k=k+1%>
<%- end%>
<%- @}
<% if arr3[k]==−8%>
  <symbol1[k]="X">%
<%end%>
<% if arr3[k]==−97%>
  <symbol1[k]="N/A">%
<%end%>
<%k=k+1%>
<%end%
<%end%
<%count=0%>
<%stat=0%
<%stat1=0%
<script type="text/javascript">
  function showTable () {
    document.getElementById('tablediv').style.display = "block";
    document.getElementById('table').style.visibility = "visible";
  }
  function hideTable () {
    document.getElementById('tablediv').style.display = "none";
    document.getElementById('table').style.visibility = "hidden";
  }
</script>
<input type='button' onClick='javascript:showTable()'; value='Show'>
<input type='button' onClick='javascript:hideTable()'; value='Hide'>

<div id="tablediv" style="border:1px solid black; width:750px;height:400px;overflow-y:hidden;overflow-x:scroll;display:none;">
  <table id='table' border=5 style="display: none;">
    <tr>
      <th nowrap="nowrap">Symptom</th>
      <% arr1.each do |l|%>
        <%count=count+1%>
        <th nowrap="nowrap">%
        <p><%=l%></p>
      </tr>
    </th>
    <%end%>
<table>
<thead>
<tr>
<th>i</th>
<th>symbol2[stat]</th>
<th>stat</th>
<th>stat1</th>
<th>symbol1[stat1]</th>
<th>symbol1[stat1]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbol 1</td>
<td>Symbol 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;&quot;</td>
<td>&quot;&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;N/A&quot;</td>
<td>&quot;&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;X&quot;</td>
<td>&quot;&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Result Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;&quot;</td>
<td>4</td>
</tr>
</tbody>
</table>

```ruby
<% if symbol1[stat1] == "" %>
  <td bgcolor='Gold'>&lt;center&gt;&lt;FONT COLOR=BLACK FACE="Geneva, Arial" SIZE=3&gt;&lt;%=symbol1[stat1]%&gt;&lt;/FONT&gt;&lt;/center&gt;&lt;/td&gt;
<% end %>
<% if symbol1[stat1] == "N/A" %>
  &lt;td bgcolor='Grey'&gt;&lt;center&gt;&lt;FONT COLOR=WHITE FACE="Geneva, Arial" SIZE=3&gt;&lt;%=symbol1[stat1]%&gt;&lt;/FONT&gt;&lt;/center&gt;&lt;/td&gt;
<% end %>
<% if symbol1[stat1] == "X" %>
  &lt;td bgcolor='Grey'&gt;&lt;center&gt;&lt;FONT COLOR=WHITE FACE="Geneva, Arial" SIZE=3&gt;&lt;%=symbol1[stat1]%&gt;&lt;/FONT&gt;&lt;/center&gt;&lt;/td&gt;
<% end %>
<% stat1 = stat1 + 5 %>
<% end %>
```

```ruby
<% end %>
```

```ruby
</tr>
<% end %>
<% end %>
<% end %>
<% end %>
<% end %>
<% if (@vars[i].questionpage == 0) %>
<% if (((@vars[i].varnum % 2) == 1) %>
<tr class="odd">
<% end %>
<% else %>
<tr class="even">
<% end %>
<% end %>
<% end %>
<% end %>
<% end %>
<% if (@vars[i].questionpage == 0) %>
<% if (@vars[i].distribution == 2 and @res.first[@vars[i].variablename] != -1000) %>
<% td width="70%"&gt;&lt;%= @vars[i].name%&gt;&lt;/td&gt;
<% if (@vars[i].distribution == 2 and @res.first[@vars[i].variablename].to_s != "-") %>
<% @resultss3.each do |tt| %>
<% td>&lt;%= t %&gt;&lt;/td&gt;
<% end %>
</tr>
```

```ruby
<% end %>
```

```ruby
</tr>
<% end %>
<% end %>
<% end %>
<% end %>
<% end %>
<% if (@vars[i].questionpage == 0) %>
<% if (@vars[i].distribution == 2 and @res.first[@vars[i].variablename] == -1000) %>
<% td&gt;&lt;%= DateTime.parse(@res.first[@vars[i].variablename].to_s).strftime("%m/%d/%Y")%&gt;&lt;/td&gt;
<% end %>
```

```ruby
<% end %>
```

```ruby
</tr>
<% end %>
<% end %>
```
<tr>
  <td width="70%"> <%= @vars[i].name%></td>
  <td><%= @res.first[@vars[i].variblename].to_s + " \\
  @vars[i].meaning(@res.first[i]).to_s%></td>
  <td><%= DateTime.parse(@res.first[@vars[i].
  variablename].to_s).strftime("%m/%d/%Y at %I:%M %p")%></td>
</tr>
</table>
</div>
</div>
</div>
</div>
</div>
</div>
</div>
</div>
</div>

</tr>
</table>
</div>
</div>
</div>
</div>
</div>
</div>

You are not allowed to view this page.

</div>
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