

Analysis of the Clinical Nutrition Information System and the Medication Reconciliation Application

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Endorsement

This report has been written by me and has not received any previous academic credit at this or any other institution.

Manar Alsaleh

Executive Summary

Health organizations are in continuing need for up-to-date health information systems that are needed to assist healthcare professionals in order to deliver good quality patient care. This report presents the work done by the author during her internship period at the Information and Informatics Department (ISID) of King Abdulaziz Medical City (KAMC). The ISID is responsible for the development and the improvement of the medical information management systems and sub-systems required for ensuring the best quality healthcare in KAMC.

Medical program analysis is a crucial part of any health informatics project due to the importance of ensuring the interoperability between the different medical information systems and sub systems at a hospital. The author has worked with medical sub system division of ISID where she was responsible for analyzing the new clinical nutrition information system. She contributed in the workflow design and solution introduction for the problems faced during the testing period of the project.

The clinical nutrition department at KAMC requested a health information system that is specially customized to fit the clinical and non-clinical tasks performed at the hospital by the clinical nutrition department as a part of the hospital's core workflow. The objective of this project is to automate these tasks in order to eliminate the use of papers during the day-to-day work of the department. Also, this project aims to insure the integration of the new system with the main hospital information system: QuadraMed® Computerized- Patient Record System (QCPR).

The main problem faced during the testing period of the clinical nutrition information system was the integration between the new system (VersaSuite) and QCPR. To insure interoperability, the new system should fully integrate with QCPR via the HL7 integration engine. The problem was in a segment of the HL7 observation message sent from QCPR to VersaSuite. The author joined the team in solving this problem by modifying the message to delete the segment during transfer via the integration engine due to the fact that the segment is not needed in the nutritional assessment therefore, not needed to be received by the VersaSuite system.

The author also had the opportunity to participate in the project of medication reconciliation application operated by the clinical information management system division of ISID. She developed workflows and helped in solving problems found during the planning stage of the project.

Medication reconciliation has become a routine duty of any physician. Medication reconciliation is essential to decrease medication errors that could happen during patient admission or discharge. The goal of the project of medication reconciliation application is to computerize the medication reconciliation process using the tools provided by the main hospital information system (QCPR).

The author took part in solving the problems faced during the planning of the medication reconciliation project. These problems included change resistance and integration barriers. The change resistance was solved by using change management concepts. The out-patient pharmacy legacy system created an integration barrier. This integration barrier was overcome by modifying the workflow to capture the medication dispensed to patients in order to properly track medication history.

The author concludes this report with recommendations that could be used to improve the clinical nutrition information system and the medication reconciliation application. These recommendations include ideas to increase efficiency of the medication reconciliation application and of the clinical nutrition information system.

The author achieved her tasks during the internship by applying the principles and knowledge that she acquired while taking the Masters of Health Informatics (MHI) academic courses at Dalhousie University.

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List of Acronyms

KAMC	King Abdulaziz Medical City
EHR	Electronic Health Record
CPOE	Computerized Provider Order Entry
MSS	Medical Sub-System
CIMS	Clinical Information Management System
NGHA	National Guard Health Affairs
JCI	Joint Commission International
ISID	Information System and Informatics Department
EMS	Enterprise Medical Systems
OA	Office Automation
LIS	Laboratory Information System
CMII	Corporate Medical Imaging Informatics
QCPR	QuadraMed® Computerized- Patient Record System
ADT	Admission Discharge Transfer
HL7	Health Level 7
NPO	Nil per os
CC	Carbohydrate Counting
ORU	Observation Result Unsolicited
OBX	Observation/ Result HL7 segment
BMI	Body Mass Index
TPN	Total Parenteral Nutrition

1. Introduction

Health informatics is an integral part of any health organization due to the need for up-to-date health information systems and applications in order to eventually improve patient care. At King Abdulaziz Medical City (KAMC), the Information Systems and Informatics Division (ISID) is always trying to improve and ensure ideal health information transmission, storage, management and visualizing in order to assisting health care providers in their daily tasks.

Since medical and any related paramedical information is very essential in providing optimal patient care, electronic health record is needed to facilitate and improve the quality of healthcare. At KAMC, the Electronic Health Record (EHR) software used at the facility is provided by QuadraMed® this software provides the health care professionals with the needed tools to enter patient information, modify information, view and print this information. In addition to the mentioned tools of the EMR used at KAMC, QuadraMed® has a Computerized Provider Order Entry (CPOE) feature where a clinical provider can order procedures, medications and supplement electronically through a secured access.

To successfully apply a health informatics solution, one needs to combine information technology knowledge with health knowledge. Health informatics was developed in order to fill the gap between information technology and health information.

As an intern, the first core responsibility of the author was to address several tasks in the Clinical Nutrition Information System Project carried by the Medical Sub-System (MSS) department. The author's knowledge as a registered clinical dietitian in Saudi Arabia was a pivotal part of assigning her to this project. One task was to design the workflows of the various processes at the clinical nutrition department, then analyzing the features and tabs used in the system to ensure interoperability.

The second core responsibility of the author was to participate in the Medication Reconciliation Application Project operated under the Clinical Information Management System (CIMS) department. In this project the problem of manual medication reconciliation was being solved by connecting an application to the hospital's EHR to be used to automate the medication reconciliation process.

2. Description of Organization

King Abdulaziz Medical City (KAMC) in Riyadh is one of five medical cities in the Kingdom under the National Guard Health Affairs (NGHA). KAMC started in May 1983 as a hospital that provided patients with various healthcare services. It has continued growing and today KAMC has become one of the most prominent tertiary care centers in the Middle East. It has a bed capacity of 690 beds. In addition, there are 25 beds allocated for possible surgical operations and 132 beds for emergency admission (National Guard Health Affairs, 2008-2014).

As part of insuring the healthcare quality on international standards, NGHA was accredited by the Joint Commission International standards (JCI) with excellent performance in 2006. This accreditation included all of NGHA hospitals and medical cities distributed across the major cities in Saudi Arabia (National Guard Health Affairs, 2008-2014).

The Information System and Informatics Division (ISID) is one of the administrative divisions in NGHA. ISID develops and supports all computer devices and information technologies in NGHA facilities across the kingdom. ISID is the umbrella of five main divisions one of these divisions is the Enterprise Medical Systems (EMS). The EMS has five departments operating under its supervision namely Clinical Information Management System (CIMS), Medical Sub-system (MSS), Office Automation (OA), Laboratory Information System (LIS), and Corporate Medical Imaging Informatics (CMII). The CIMS is in charge of the support and development of the hospital's information system: QuadraMed® Computerized- Patient Record System (QCPR) while MSS is responsible for the development and support of medical sub-systems that are not covered by the CIMS and/or not part of QCPR and connected to QCPR through an interface engine (National Guard Health Affairs, 2008-2014).

The author was trained under the CIMS and the MSS ISID departments due to their relevance to the job description of the author and availability of the projects that the author participated in.

3. Job Description

As defined by Enrico Coiera, Health Informatics is “the study of information and communication systems in healthcare” (Coiera, 2003, p. xxii). The author's core internship responsibility was studying and analyzing the clinical nutrition information system in the MSS department, and the medication reconciliation application in the CIMS department at KAMC.

As a health informatics intern, the author was assigned several tasks and rotations during the internship period. On January 7th the author started orientation period of two weeks at the EMS's different departments to recognize the departments' responsibilities and to find the right department for the nature of the author's internship.

On January 22nd, the author underwent a 5-week-rotation at the MSS department. During the rotation at the MSS department, the author participated in the project of Clinical Nutrition Information System. This project was one of the many projects operated under the MSS department. The core responsibilities of the author in this project were as follows:

- Developing the workflows diagrams of the various workflows of the clinical nutrition and food service department.
- Meeting end-users to understand requirements.
- Providing support to dietitians on using the system.
- Ensuring quality of data flow.
- As a health informatician with clinical nutrition background, the author provided testing of the system and support for the technical team in understanding the main requirements of the clinical nutrition practitioners.

Lastly, after the MSS rotation, the author went to the CIMS department. The rotation was from February 27th until April 8th. During the CIMS rotation, the author participated in the project of Medication Reconciliation Application and was assigned several tasks to be performed under the supervision of the project manager. The core responsibilities of the author in this project were as follows:

- Meeting the project manager and pharmacists to understand the requirement of this application.
- Developing workflow diagrams.
- Assisting in understanding the required modification of QCPR and solving problems faced in the project.

The following sections depict the overview of the projects and the work performed by the author in detail.

3.1 Clinical Nutrition Information System Project

3.1.1 Project Objective

The project main objective is to deliver an information system specifically designed for the clinical nutrition departments in NGHHA kingdom-wide. This information system should connect to the main hospital information system: QCPR, via an interface engine to enable the clinical dietitians and technicians to fulfill the clinical and non-clinical tasks at the NGHHA domain and scope of work.

The Clinical Nutrition department is one of the paramedical departments in KAMC and in continuous need for solutions for the information and communication management of their department within NGHHA.

Accordingly, the project aims to achieve the underlined aims:

- Help to identify patients who are at risk of protein and calorie malnutrition.
- Evaluate and establish the nutrition status of patients.
- Evaluate the intake of the patient and post information about the patient.
- Modify protocol formulated by the clinical nutrition department.

3.1.2 Project Scope

This project will present a customized information system for the clinical nutrition departments in all of the medical cities of NGHHA in Saudi Arabia.

3.1.3 Workflows

The Clinical Nutrition Department provides services to in-patients and out-patients in KAMC. Below is detailed account of in-patient workflow:

When a patient is admitted to the hospital, a physician or a nurse orders a diet for the patient. A nursing nutritional screening that is not similar to Dietitian Nutritional Assessment is done. This is performed by a nurse and depending on the results from this assessment; the nurse may order a dietitian referral. All patients who are admitted to the hospital will be automatically seen by the dietitian within one week. The patients' expected discharge dates can be seen in the QCPR's patient chart review. A physician working in the QCPR may send a referral from QCPR via interface

engine to the proposed system to be received by the Dietitian. Upon receiving this referral, afterwards dietitian carries out a thorough analysis. The physician has to agree and cosign the dietitian orders. Those patient put on tube feeding are reexamined each week, those patients not on tube feeding are reexamined when they there is need or if they request to be reexamined.

The out-patient workflow depends on the underlined points:

When the Physician requests for nutritional referral, the patient is screened by the nurse. Assessment is carried out by the dietitian after this screening has been performed. Depending on the dietitian's assessment, it may be necessary to do follow-up for the patient.

3.1.4 Interface Engine Used

Integration is a very pivotal part in any health information system development due to the importance of information security, redundancy reduction, and manual entry error avoidance. VersaSuite as the clinical nutrition information system should be integrated with the hospital information system (QCPR) in order to receive and send patient information, requests, and results. Orion Health Rhapsody Integration Engine is used to interface between the clinical Nutrition Information System (VersaSuite) and the hospital's information system (QCPR). This interface is built with HL7 messaging standards (Orion Health, 2013). There is an integration team in NGHA that is responsible for integrating QCPR with any other information system.

3.1.5 Expectations

The project of clinical nutrition information system is expected to achieve the following:

- All patients' ADT (Admission, Discharge, Transfer) information is sent from QCPR to VersaSuite through the interface engine to be viewed by the clinical dietitian.
- VersaSuite must substitute QCPR in terms of clinical nutrition tasks e.g. nutritional assessment and tube feeding orders. This information will be entered on VersaSuite by dietitians then sent to QCPR via interface engine to be viewed by clinicians other than dietitians.
- VersaSuite will also substitute the legacy system used in the food services department for the tasks of food services such as diet label printing and report generating.

3.1.6 Software Overview

After studying proposals received by various vendors, VersaSuite was chosen to provide multi-user, multitier, graphical user interface-based application that represents the clinical nutrition

information system. VersaSuite is a software company that provides integrated solutions for healthcare in medical institutions (VersaSuite, 2014).

3.1.7 Modifications to the Hospital Main Workflows and QCPR

There were several modifications implemented on the main clinical and non-clinical task workflows. By using Microsoft Visio, the author drew the new workflow diagrams to be easily understood by project's stakeholders. Figures in Appendix A illustrate the new additions and modifications done to the workflows of the clinical nutrition department to meet the requirements of the new project and to be compatible with QCPR tasks.

In order to successfully capture all of the tasks done daily at the Clinical Nutrition department, the project team needed to breakdown both in and out patient workflows into more detailed workflows as follows:

1. New diet or Dietitian consultation:

The new diet workflow starts with the physician or the nurse enters the diet order as per physician instruction on QCPR upon patient admission. As a hospital rule, a dietitian must see all new patients within a week of their date of admission; however, upon admission if the physician asks for a dietitian referral, the dietitian should visit the patients within 24 hours instead of one week. Referrals are entered by the physician on QCPR then sent from QCPR to VersaSuite via the interface engine. Figure 1 and Figure 2 depict the dietitian view on VersaSuite and consults (referrals) in the dashboard of dietitian window respectively. Figures (A1) and (A2) in Appendix A illustrate the main points in the new diet and the dietitian consultation workflows. The patient information is sent from QCPR to VersaSuite upon admission or as per physician referral. Referrals can be for in- or out- patients. For out-patients, the physician can send a dietitian consultation on QCPR during the clinic visit. Then the patient will take a request to the registration as dietitian appointment request to be booked depending on time availability in the dietitians' clinic and on the patient status (adult, pediatrics or diabetic patients). The dietitian will view the patients on VersaSuite and can filter the patients by choosing her/his assigned ward or clinic.

Upon patient admission, all new diet orders will be sent to the food services to be printed (see Figure 3). This procedure happens in order to save time and serve the patient their diet ordered by the physician until the dietitian sees the patient whether as a routine procedure within one week or as per physician referral within 24 hours. After visiting the patient the dietitian will change or keep the diet that the physician ordered for the patient depending on her/his assessment. If the diet is

changed a comment is sent to QCPR through interface engine from VersaSuite to be viewed by the admitting physician then approved by the physician. If the physician approves the updated diet, the physician should enter the new order on QCPR to be sent to food service for the diet label to be updated on VersaSuite through interface engine. If the dietitian does not change the physician diet order there will be no updates or comments sent to QCPR. In terms of dietitians' clinic, the registered patients' information can be viewed in the patient list of the clinic on VersaSuite. The status of the patient (registered or checked in) is updated on QCPR then this update is sent through interface engine to VersaSuite.

Vs, Patient One Age: 34 Sex: M
Allergies: Beans
Pt Loc: 1505-S
Current Meds: Ciprofloxacin HCl 250 mg Tablet; Warfarin 3 mg Tablet
 Follow Up Exam

Dashboard (S) Observations History Objective (O) Assessment (A) Education Goals and Plan (P) Growth Charts

Vitals History

G G G G G G G

Date/Time	Age	Height	Weight	BMI	BP S	BP D	Temp (F)	Pulse	Resp
11/4/2013	33	160	50.0000						

Current Problem List

No active problems

Current Medications

Ciprofloxacin HCl 250 mg Tablet : Administer 2 (500 mg) via po at Q12H (2100,2100,0900).
 Warfarin 3 mg Tablet : Administer 1 (3 mg) via po at OTO (1800). High Alert Med, PO Do Not Crush.

Nutritional Orders

Order	Ordering Physician	Dietician	Date Started	Date Stopped	Status
REGULAR					Assigned
Tube Feeding					Ordered

Goals

Date Assigned	Date Completed	Goal

Physical Exam History

No physical exam on file

Figure 1: Snapshot of Dietitian View on VersaSuite

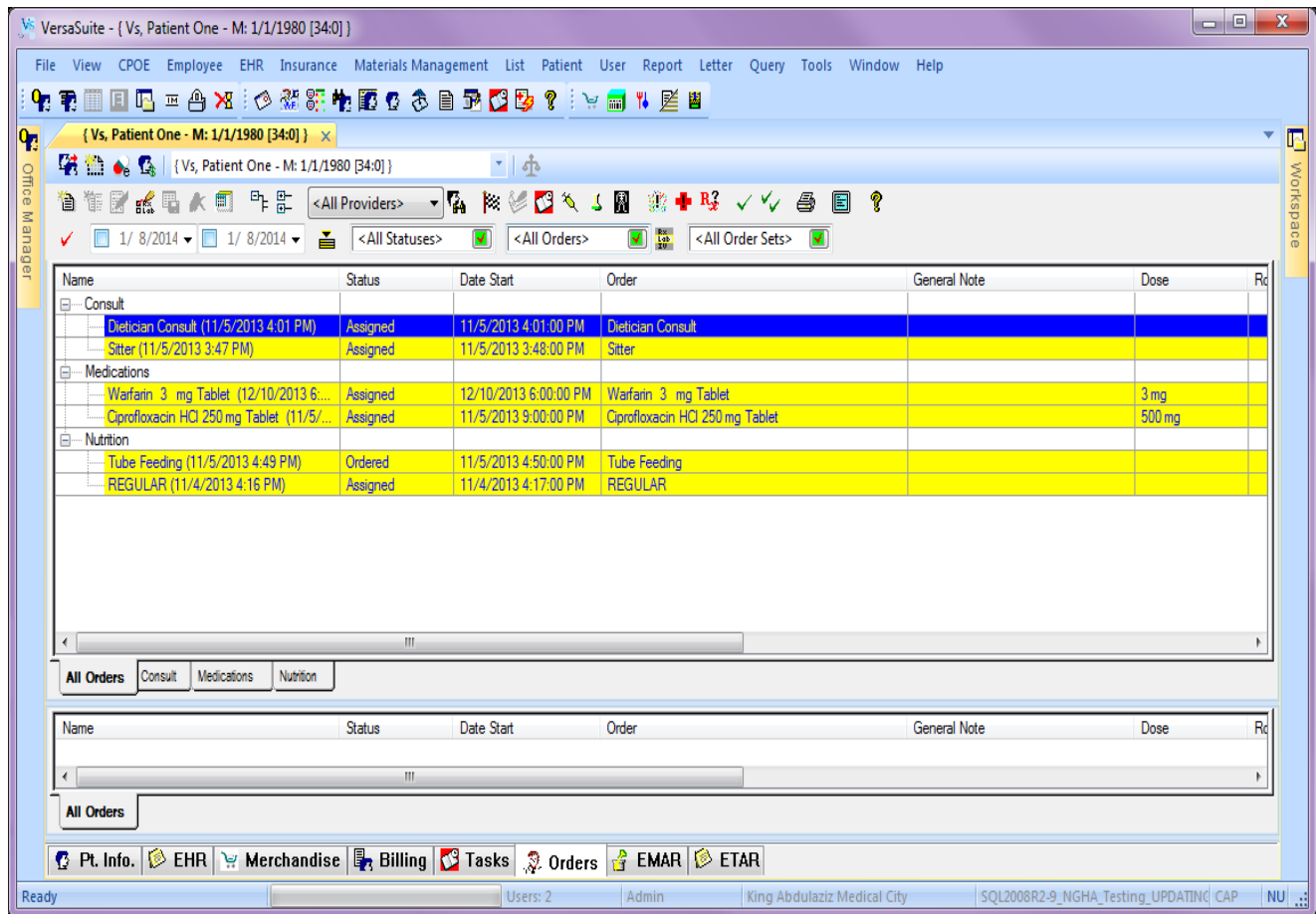


Figure 2: Snapshot of Orders on VersaSuite

King Abdulaziz Medical City										
1/3/2014 8:16:18 AM		Ref #	1065	Page #	1	Card #	3			
1400 CAL ADA LOW SALT Breakfast						Cycle 5				
HBV SKIM MILK HOT 120CC			CJC ORANGE JC 120CC UNSW CBRD ARB THIN BROWN2 CFT GISDHA CBF YOGURT CNO NO SUGAR CNO NO SALT				Deliver			
Time										
Emp #										
Employee Name										
Allergy	<none>									
Special Instructions:										
Additional Items										
MRN							Room	ICA01-S		

Figure 3: Meal Ticket

2. Tube feeding:

Figure (A3) in Appendix A illustrates the tube feeding order workflow. Tube feeding in this context includes all feedings ordered to be administered to patients through nasal or gastric tube, or as oral supplement. The order is entered by physician or by the nurse according to physician request on QCPR. The orders are sent to VersaSuite via interface engine to be viewed by food service staff and dietitians. Figure 4 shows the Tube Feeding view and can be edited by dietitian. If there is a dietitian consultation, the dietitian will assess the patient and the tube feeding order and either recommend new tube feeding order or complete the tube feeding order sent originally by the physician from QCPR. If the dietitian recommends new order, the recommendation will be sent to QCPR as a comment to be viewed and approved by the physician. Then, upon approval, the physician will enter the new tube feeding order according the dietitian's recommendation on QCPR to be sent to VersaSuite to be viewed by food services in order to prepare and print the tube feeding label. Note that all tube feeding orders sent from QCPR to VersaSuite upon physician order entry are not complete in terms of rate and frequency. The tube feeding orders received by the food services staff on VersaSuite have two conditions; first condition, is that there is a predefined tube feeding order entered on VersaSuite by dietitian so the food services staff can choose the predefined order and print the label; and the second condition is that there is no predefined order on VersaSuite so the order is sent automatically as an incomplete order to dietitian to be completed and sent for preparation and label printing. Predefined orders are tube feeding orders entered as a new recommendation by dietitian pending for physician approval or as default tube feeding orders for some patient condition such as the patient is diabetic then the default tube feeding order is diabetic formula (Glucerna) on 240 ml every six hours. Note that the dietitian can send new recommendation anytime that he/she sees that patient needs tube feeding order change or update. Also, all tube feeding patient must be followed up by dietitian every week.

Figure 4 Tube Feeding Window

3. Diet technician referral:

Diet technicians (diet tech) perform several tasks in their daily work in the NGHHA-Clinical Nutrition department. One of their tasks is taking the patients' food preferences and make sure that they are in accordance with the dietitian's diet prescription. The diet tech referral can be requested by dietitians upon patient's order or according to dietitian's view.

Figure (A4) in Appendix A depicts the workflow of the diet technician consultation or referral. When a dietitian visits a patient, usually there is a standard question of whether the patient has special food preferences. If the patient has food preference, the dietitian send a referral to the diet tech on VersaSuite where the diet tech can review the referral on the VersaSuite's user interface that is access customized (the diet technician can only view the information needed to perform their daily tasks). Then, upon the patient visit by the diet tech, the diet tech documents the food preferences on VersaSuite after making sure that they are appropriate according to the diet prescribed by the dietitian. The diet updates are sent through VersaSuite to the food service department where they can view the information needed to produce the diet order. Then food services staff updates the diet preferences on VersaSuite and print the updated meal ticket. Note that also physicians and nurses can make a food preferences order on QCPR that is sent via the interface engine to VersaSuite and received as a diet tech referral.

4. Nourishment:

Nourishments are any snack ordered for patients by dietitian or diet tech on VersaSuite. These nourishment orders are viewed by food services staff on VersaSuite to schedule the snack and print the nourishment label. See the Nourishment workflow diagram in figure (A5) in Appendix A.

5. Nil per os (NPO) order:

NPO status means that patient is not taking anything by mouth according to physician's order. Figure (A6) in Appendix A shows the NPO order workflwo. Upon physician NPO order on QCPR, a notification is sent to VersaSuite through interface engine that the patient is NPO so the diet will be put on hold automatically on VersaSuite. The dietiain can see that the patient is NPO so there will be no updates to the patient's diet until the phyisician request on QCPR to remove the NPO status from the patient's chart on QCPR.

6. Carbohydrate [Carb] Counting (CC) clinic:

Carb Counting is a technique used by dietitians to manage the diet of diabetic patients. The carb counting has a specialized dietitian at the NGHHA assigned only for diabetic patients. Physicians can refer patients to Carb Counting clinic or to be seen by carb counting dietitian if the patient is an in-

patient. The carb counting referrals are sent from QCPR to VersaSuite to be viewed by the carb counting dietitian. If the patient is an out-patient and is seeing the physician in the diabetes clinic, the physician can send the patient to diabetic educator first before booking an appointment with carb counting clinic. The carb counting appointments are booked on QCPR then sent to VersaSuite to be viewed by carb counting dietitian on the carb counting clinic view. Once the patient is checked-in by the reception clerk on QCPR, an update of the patient status is sent to VersaSuite so the patient status will be changed from registered to checked-in. The carb counting dietitian will see the patient status and call for the patient upon checking in for assessment in the clinic. After completing the carb counting clinic visit, the dietitian will update the patient chart on VersaSuite then, this update is sent to QCPR as recommendation to be viewed in the patient chart view on QCPR.

3.2 Medication Reconciliation Application Project

3.2.1 Project Objective

The main goal of the medication reconciliation process in general is to ensure that the “right medication is being given to the right patient with right doses and on the right time”. Medication Reconciliation was defined by the Joint Commission,

Medication Reconciliation is the process of comparing a patient's medication orders to all of the medications that the patient has been taking. This reconciliation is done to avoid medication errors such as omissions, duplications, dosing errors, or drug interactions. It should be done at every transition of care in which new medications are ordered or existing orders are rewritten. Transitions in care include changes in setting, service, practitioner or level of care. This process comprises five steps: 1)develop a list of current medications; 2) develop a list of medications to be prescribed; 3) compare the medications on the two lists; 4) make clinical decisions based on the comparison; and 5) communicate the new list to appropriate caregivers and to the patient. (Joint Commission, 2006, p.1)

Almost 46% of medication errors happen upon admission or discharge from the hospital. Medication reconciliation is associated with a significant decrease in medication errors (Pronovost, 2003). Taking patient medication history accurately can enhance medication safety during and after hospitalization (Pippins, 2008).

The objectives of this project are:

- To fully computerize the medication reconciliation process.
- To reduce any possible error that can occur when admitting or discharging the patient.

3.2.2 Project Scope

The medication reconciliation application is a service that was provided by QuadraMed® as a built-in application in the QCPR upon CIMS request with specific customization upon CIMS demand. The application of the medication reconciliation will be implemented in the hospital health information system (QCPR) and will include all of the NGHHA facilities kingdom-wide.

3.2.3 Workflow

Previous to this project, the medication reconciliation process was almost done manually on papers and signed manually by providing physician which produces various errors. One of these errors is the transcript error. Another error is the duplication of medications. The first step in the manual medication reconciliation is the documentation of the medications that the patient brings with upon admission. In this step, the physician writes the medications brought by the patient on paper form as home medication and manually writes if the patient needs to continue, discontinue or hold each medication in the list and write the doses manually. After that the physician puts this list in the paper patient chart. The second step is to order medications as visit medications which is done electronically on QCPR through the CPOE. After documenting the medications from home and entering new medication orders on QCPR both lists (admission medication list and home medication list) are put in the patient chart for comparing and reconciliation. The last step is the discharge medication list, which is done similarly on paper. The physician compare the home and admission medication lists and prescribe manually what should be taken with patient to home as discharge medication. Then, the discharge orders are sent to out-patient pharmacy for medication dispensing.

This project is brought to automate the previous processes. The author used Microsoft Visio to draw the new workflow diagrams in order to make it easier to understand by stakeholders.

3.2.4 Expectations

The project is expected to propose an automation of the medication reconciliation process by modifying the QCPR to fully computerize the process. The main expectations of this solution are the following:

- When the physician admits a patient, the home medication list should be filled by the physician then the same physician will modify and enter orders into the visit medication list on QCPR.
- When the physician discharges a patient, the discharge medication list should be filled by the physician then the same physician will modify and enter orders into the discharge medication list on QCPR.
- Physicians perform the medication reconciliation step by comparing the medication lists and then submit the reconciliation report.

3.2.5 Modifications to QCPR

Due to the importance of medication reconciliation in avoiding many harmful errors, an international rule was issued by the Joint commission that all health information system HIS manufacturers have to put the service of medication reconciliation as meaningful functionality in their HIS that can be requested by the health facility using this HIS (Joint Commission, 2006).

According to the project requirements and scope the following modifications were implemented on the QCPR workflow:

The solution proposes two main workflows in the medication reconciliation process. Figure (C1) in Appendix C shows the first one which is the admission medication reconciliation workflow where the physician documents the home medication on QCPR upon admission. Then, electronically the physician can copy one or more of the home medications to the admission (visit) medication list and modify the doses and the route on QCPR then accept as a new admission order. Figure 5 shows a snapshot of the medication reconciliation tab on QCPR physician view window. Also, if the physician wants to enter a new medication that is not listed in the home medications, the physician can enter the new order in the list of visit medications and then enter the dose and route before accepting the order on QCPR. The last step of the admission medication process is that both of the home and visit medication lists appear on the same window to be compared and edited concurrently (see Figure 6). Figure 7 shows the admission medication reconciliation report where both of the home and visit lists appear for the physician to approve and submit or to edit then approve and submit.

Adult, Test Two Location: P Partum-G Number: 2008126 Gender: Female Attending: Abed, Nuha Primary Insurance: Letter of Exception
 Crit Loc: 2008126-1 Age: 41Y PCP:

Care Management Trends ICU Labs Face Sheet Med Reconciliation

Order Entry Discontinue For Surgery

Data Review Chart Review Lab Review Rad Review Medication Summary

Trends Microbiology VS Trend Chemistry Trend Hematology Trend

Documentation Allergy Documentat... Precautions & Alerts Catheter Settings Edit Admit Diagnosis

Assignment Physician Assignment Provider Register

Patient Cautions

Date/Time	Medication Allergy	Symptom	Miscellaneous Data
21/02/14 1833	No Known Med Allergy		
Date/Time	Other Allergy	Symptom	Miscellaneous Data
21/02/14 1833	No KnownAllergy		
Result Date/Time	Exp Date/Time	Other Cautions	

Inbox

All	Criticals/A...	Review	Orders	ASOOrders	Complete	Sign
Total						

Medication Reconciliation

Date/Time	Procedure	Status
Thu, 20/02/14 0920	Admission Medication Reco...	sched

Interactive Care Grid

Scale	Go to	February 21, 2014	February 24, 2014	February 25, 2014	February 27, 2014	March 3, 2014
Allergy						
Card Services						
Neurology			24-Feb 15:45 com...			
Endoscopy						
Laboratory						0/2
Anatomical Pathology						
Radiology				25-Feb 08:05 sch...		

Figure 5: Snapshot of the Medication Reconciliation Window on QCPR

Search Consolidated Medication List

H	V	D	Medication	Information	Last Dose	Start	Stop	Source	Order Set
▼ Home Medications									
H			Aspirin	81 mg EC tab po daily					
H			Atorvastatin Calcium	10 mg tab po daily					
H			Simvastatin	40 mg tab po daily					
▼ Visit Orders									
V			Atorvastatin Calcium	10 mg tab po daily at default 0900 ...		06-Mar-14 ...	07-Apr-14 0...	order	

Figure 6: Consolidated Medication List on QCPR

Submit Reset	
C-Riyadh SANG King Abdulaziz Medical City Admission Medication Reconciliation Report March 6, 2014 1523	
For: Adult, Patient Admit Age: 87Y Sex: F Ht: Wt: BSA:	Allergies/Sensitivities Medication - Lisinopril Food/Environment - Latex -
Home Medications Aspirin 81 mg EC tab po daily Atorvastatin Calcium 10 mg tab po daily Simvastatin 40 mg tab po daily	Current Medications Atorvastatin Calcium 10 mg tab po daily scheduled at default 0900 Ordered by: Maha Rph. Mazyad Start: 06/03/14 1522 Stop: 06/04/14
Admission Medication Reconciliation <input checked="" type="checkbox"/> Reconciled	
Name: <input type="text" value="Mazyad, Maha Rph."/> Badge: <input type="text"/> Signature: <input type="text"/>	
Submit Reset	

Figure 7: Admission Medication Reconciliation Report

The second workflow is the discharge medication reconciliation. Figure (C2) in Appendix C shows the workflow of the discharge medication reconciliation process. When the physician discharges a patient, a discharge medication list appears during the process of discharge on QCPR (see Figure 8). The physician is required to copy from the visit or home medication lists and/or enters the new orders in the discharge medication list. After entering orders to the discharge medication list the three lists of medications (home, visit, and discharge) appear on one window on QCPR to be compared and edited then reconciled by the physician. Figure 9 shows the discharge medication reconciliation report as seen by the physician to be approved or reset.

arch Consolidated Medication List									
H	V	D	Medication	Information	Last Dose	Start	Stop	Source	Order Set
▼ Home Medications									
H			Aspirin	81 mg EC tab po daily					
H			Atorvastatin Calcium	10 mg tab po daily					
H			Simvastatin	40 mg tab po daily					
▼ Visit Orders									
	V		Atorvastatin Calcium	10 mg tab po daily at default 0900 ...		06-Mar-14 ...	07-Apr-14 0...	order	
▼ Discharge Medications									
		D	Aspirin	81 mg EC tab po daily					
		D	Simvastatin	40 mg tab po daily					

Figure 8: Consolidated Medication List with Discharge Medication on QCPR

Submit Reset		
C-Riyadh SANG King Abdulaziz Medical City Discharge Medication Reconciliation Report March 6, 2014 1526		
For: Adult_Patient Admit Age: 87Y Ht: BSA:	Sex: F Wt:	Allergies/Sensitivities Medication - Lisinopril Food/Environment - Latex -
Home Medications	Current Medications	Discharge Medications
00099 81 mg EC tab po daily	Atorvastatin Calcium 10 mg tab po daily scheduled at default 0900 Ordered by: Maha Rph. Mazyad Start: 06/03/14 1522 Stop: 06/04/14	Aspirin 81 mg EC tab po daily
08562 10 mg tab po daily		Simvastatin 40 mg tab po daily
31160 40 mg tab po daily		
Admission Medication Reconciliation		
<input checked="" type="checkbox"/> Reconciled		
Name: Mazyad,Maha Rph. Badge: Signature:		
Submit Reset		

Figure 9: Discharge Medication Reconciliation Report

4. Relevance of the Internship to Health Informatics

Health Informatics is the discipline that focuses on two main points; providing solutions for issues related to processing of data, information and knowledge in any health care setting; and studying the essentials of data, information and knowledge processing in healthcare (Hasman, Haux, & Albert, 1996) “The ultimate goal [of Health Informatics] should always be to improve the quality of health care and of research and education in medicine and the health sciences” (Hasman et al., 1996, p.132).

The job description of a health informatician requires several skills; analytical, technical, managerial and communicational skills. All of the academic courses at the Master of Health Informatics (MHI) program at Dalhousie University are valuable for having the knowledge needed to be a health informatician. This internship was a pivotal opportunity for the author to implement the knowledge that she acquired as a student in the MHI program.

Some of the primary responsibilities of the author during her internship were to perform system analysis, design workflows, and perform some project management tasks in the MSS department. The skills needed to analyze the clinical nutrition health information system, and the medication reconciliation application were acquired from the academic MHI course of HINF 6610 - Information systems and Issues where the author learnt how to analyze systems, locate issues and propose possible solutions. During the aforementioned course the author also learned how to design workflows and data flow diagrams where this skill helped greatly in drawing the workflows diagrams and understanding the major work and data flow changes that both of the projects propose as well as solving the issues found during her work in the projects.

Another beneficial course that aided the author during her internship was the course of HINF 6101 – Health Information Flow and Use where the knowledge needed to understand the information flow between the hospital information system and the clinical subsystems during her work at the MSS department.

In addition, the course of HINF 6102 – Health Information Flow and Standards provided the author with knowledge needed to understand the standards of developing and modifying a health information system, specifically, in using HL7 messaging as the standards of the interface engine between the Clinical Nutrition Information System and the hospital information system (QCPR) and in modifying the workflow of the QCPR during the medication reconciliation project.

During the course of HIN 6300 - IT Project Management, the author drew a deep understanding of the importance of change management in any health informatics project in order to successfully implement the project. This knowledge helped the author in providing change management solutions related to the projects that she participated in during her internship.

5. Problem Analysis

5.1 *Clinical Nutrition Information System Project*

During the development and testing of the VersaSuite-Clinical Nutrition Information System, there were some problems that the project team, including the author, faced. One of these problems was seen during the integration testing phase. The following is the description of the problem and related solution in detail:

- **Integration testing:**

There are various types of information sent from QCPR and received by VersaSuite via the Orion Health Rhapsody Integration Engine. These types should follow the HL7 messaging standards from both ends in order to properly read this information. Health Level 7 (HL7) messaging standards are used for the interface engine for integration between QCPR and VersaSuite (HL7, 2013).

HL7 message has four parts: components, sub-components, fields, and segments. Each message has a type depending on the activity that it supports. One of HL7 message types is ORU (Observation Result Unsolicited) messaging. ORU is used for transmitting observations and results from the producing system to the requesting system. ORU message type has several segments. One of these segments is the OBX, Observation/Result segment which is used to transmit clinical observation or result to the requesting program in order to produce a clinical assessment (Care Point Health, 2014).

VersaSuite is following the HL7 messaging standards and cannot customize these standards according to the interface needed. However, NGHHA is using the HL7 standards with its own customized version of interface codes which QCPR is using. While testing the integration between QCPR and VersaSuite, a problem emerged, an error occurred after transmitting the ORU message that includes OBX 4. The error resulted in the inability of VersaSuite in interpreting the observation sent from QCPR during the nutritional assessment step on QCPR carried by the nurse upon admission. This assessment carries the anthropological measurements of the patient (i.e. Height, Weight, Head Circumference, etc.). These measurements are crucial for the dietitians to carry out most of their clinical nutrition assessments of the patient for example the Body Mass Index (BMI) assessment (see Figure 10). Because the anthropological information is important for the nutritional assessment, there is an ORU message sent from VersaSuite to QCPR requesting the Core Admission Assessment HL7 message that includes the anthropological information. In the ORU message from QCPR to VersaSuite there were in error while VersaSuite is trying to interpret the message.

The author carried out an in-depth investigation of the HL7 messages sent during the communication of nutritional assessment observation from QCPR to VersaSuite in order to find the source of the error. The error source discovered was the OBX 4 segment. The project team contacted the integration specialist of VersaSuite to help in solving this problem. The integration specialist of VersaSuite mentioned that VersaSuite is following the HL7 messaging standards without any modifications. One of these standards is the number of characters in each segment.

OBX 4 segment carries up to 20 characters while the OBX 4 in the ORU message sent from QCPR has more than 20 characters which produced the error in interpreting the message by VersaSuite.

After reading the HL7 message customized standards of the NGHHA, the project team discovered that also the NGHHA standard has the maximum length of 20 characters for the OBX 4 segment.

The reason that QCPR did not discover the error earlier before the production of VersaSuite is that the ORU message including OBX 4 segment was not sent to any other subsystem as an observation. Therefore after integrating with VersaSuite, QCPR used the ORU message with the defected OBX 4 segment to send observations to VersaSuite. OBX 4 segment carries the Total Parenteral Nutrition (TPN) information. In NGHHA, TPN is done and administered by pharmacists not dietitians. Appendix B shows the HL7 ORU message that included the defected OBX4 segment and a snapshot of the HL7 standards of QCPR in NGHHA.

The solution proposed by the project team is to delete the OBX4 segment in the ORU message from QCPR during communication with VersaSuite. The reason that this solution was optimal is because clinical dietitians do not perform the TPN procedure therefore the segment with TPN information was not needed.

As a final step in solving the integration problem, the project team contacted the NGHHA integration team to modify the ORU message sent from QCPR to VersaSuite. The modification includes a query to delete OBX 4 from the ORU message sent from QCPR to VersaSuite whenever VersaSuite requests the ORU message.

The screenshot shows the 'Objective' section of the VersaSuite interface. At the top, it displays patient information: 'Vs, Patient One Age: 34 Sex: M', 'Allergies: Beans', and 'Current Meds: Ciprofloxacin HCl 250 mg Tablet; Warfarin 3 mg Tablet'. Below this is a navigation bar with tabs for 'Dashboard (S)', 'Observations', 'History', 'Objective (O)', 'Assessment (A)', 'Education', and 'Goals and Plans'. The 'Objective' tab is selected, showing a form for anthropological measurements. The form includes the following fields and values:

- Height: 160 Cm
- Current Weight: 50 Kg
- Admission Weight: 50 Kg
- BMI: 20.0
- IBW: Min: 51.2 Kg, Max: 64.0 Kg
- Previous Weight: (dropdown menu)
- Prev. Dry Weight: (dropdown menu)
- Weight Change in: (input) Kg in: (input) %
- Amputation: (checkbox)
- Temp: (input) C

At the bottom of the form, there are checkboxes for 'Edema', 'Ascitis', 'Appetite', and 'Intake'.

Figure 10: Anthropological Measurements on VersaSuite

5.2 Medication Reconciliation Application Project

There were several problems faced during the analysis of the medication reconciliation application. The main two problems were as follow:

- **Out-patient pharmacy legacy system:**

Although KAMC is using QCPR as the main hospital information system some departments are still using legacy systems. The out-patient pharmacy is still receiving orders and dispensing medications on the pharmacy legacy system. The main problem in using legacy systems is that there are no integration options whatsoever with other programs or systems. Due to this problem the medication reconciliation project team faced the issue of keeping track of out-patient medications that are being prescribed at the out-patient clinics where the physician writes a prescription and give it to the patient then the patient goes to the out-patient pharmacy to hand in the prescription and receive the medications. Also, the team faced the problem of sending the discharge medication orders because prior to the project, the discharge medication orders were written manually by the ordering physician on the visit medication list printed from QCPR, then the orders sent by fax to the out-patient pharmacy to be re-entered on their legacy system where the discharge medications are being dispensed. The written discharge orders produced transcription errors especially that the orders are faxed which leads to difficulty in reading the orders then re-enter them on the legacy system.

There are two solutions needed for this problem, first a solution for keeping track of medication history of out-patient. The second solution is for sending the discharge medication list to the out-patient pharmacy from QCPR without integrating with out-patient pharmacy legacy system, and without the need of printing the orders then fax them manually.

The first solution proposed is to resolve the issue of keeping track of out-patient medications was to print, from the legacy system, the list of medications that the patient took from the out-patient pharmacy either as discharge or out-patient clinic orders. This list is printed, by the nurse, upon admission or upon patient visit to out-patient clinic so it will be available for the physician to perform medication reconciliation. Upon admission the physician will take the list printed from the legacy system and enter the medications on it manually to QCPR as home medications, while the out-patient physician will take the list and perform any changes manually on paper, and then this list will be stored in the patient paper chart. Although the hospital is in transitional phase of eliminating paper charts and depending on computerized patient record however, the hospital is still

using paper record and still in need to keep patient records complete with all patient history needed for proper medical evaluation. Upon patient visit to the out-patient clinic or admission to in-patient ward, the patient record is requested from the medical record department and sent to the proper location for making sure that the physician has all the tools needed to evaluate the patient history.

The discharge medication orders come from the in-patient ward where QCPR is used in to enter orders and print lists. The second solution was proposed to solve the integration problem between the out-patient pharmacy legacy system and the QCPR in regards to discharge medications. To send the orders from the QCPR to legacy system, the solution was to send an automatic fax for the discharge medication list from QCPR to the out-patient pharmacy to be re-entered in the legacy system for label printing and medication dispensing. This solution will reduce the possible errors of written discharge orders and of sending the fax manually where the nurse will have to print the orders which can create confusion when this paper (the printed discharge orders) is put in the patient chart while there is an electronic copy on QCPR. The dispensed medication list will be stored on the legacy system and can be printed upon request from out-patient or in patient physicians.

- **Change Resistance:**

While planning the project the team faced change resistance from the physicians as the end-users of the medication reconciliation solution. This resistance is due to the physician claims of not having the time or enough manpower to do the medication reconciliation process on the QCPR rather than doing it manually on paper.

In order to make the physicians buy-in the proposed application, the author, under the project manager's supervision, utilized the following change management ideas:

1. Employment of a change champion who is an advocate for the solution and is from the medical team that can influence the other physicians to support the solution. The physician who was chosen to be the change champion is a member at the Saudi Medication Safety Committee. Being a member at the safety committee is a strong merit in order to convince the physicians of the importance of optimizing the medication reconciliation process. A positivity of choosing this champion is that he knows the importance of medication reconciliation for ensuring patient safety.
2. Demonstrating the benefits of automating the medication reconciliation process during the project meetings with the end-users. During the meeting the team ensured the presence of

the change champion in order to advocate and approve the benefits demonstrated by the team.

3. Setting some meetings with the end-users to educate them about the importance of this solution for the decision-making process. With the presence of the champion, the team listened to the physicians' requirements and customized the solution accordingly.
4. Proposing full support for the physicians during training and after implementing the application.

6. Conclusions

This internship was a great opportunity for the author to practically apply what she learned during her studying period in MHI. The tasks given to the author allowed her to critically think about solutions for the problems that most of health informaticians face during system analysis.

The author was able to fulfill tasks assigned to her during the internship. These tasks were done as part of system analysis and they included workflow design, end-user meeting, integration testing, and change resistance solutions.

The first project that the author participated in was the clinical nutrition information system where the author summarized the objective, scope and expectations of the project. The author met end-users to document the workflows then modify the workflow according to the project's needs. During this project there were several problems faced during the testing phase of the project. The main problem was in the integration between VersaSuite and QCPR. The author joined the team to successfully overcome this problem by applying the knowledge she gained about HL7 standards during MHI courses.

The second project was the medication reconciliation application, a tool to be built in the main hospital information system (QCPR) to automate the medication reconciliation process. During the analysis of this project the author contributed in workflow design and problem solving. There were two problems that the project team faced during the planning stage; the legacy system integration, and the change resistance. With the help of the project manager, the author was able to apply modifications to the workflow in order to capture the medication history and makes it available for evaluation upon physician's request. The author helped in proposing change management solutions to solve the problem of change resistance from the physicians regarding the computerization of the medication reconciliation reporting.

7. Recommendations

The author recommends the following for the clinical nutrition information system:

- To add clinical nutrition guidelines info button to be used by the dietitians on VersaSuite as a decision support function.
- Regarding the comments that are sent from VersaSuite to QCPR to be viewed and approved by the physician then entered manually upon approval, the author recommends to modify QCPR by adding an approval button to the diet recommendation on QCPR which enables the physician, instead of entering the recommendation manually, to click this button as an approval of the new dietitian's recommendation then this approval is sent to VersaSuite to automatically update the patient's diet.

In regards to the medication reconciliation project, the author recommends the following:

- Making the medication reconciliation mandatory upon admission and discharge. This can be done by modifying the QCPR workflow in a way that when the physician initiates admission or discharge he/she needs to submit the medication reconciliation report in order to send medication orders upon admission or discharge.
- Replacing the out-patient pharmacy legacy system by a sub-system that can fully integrate with QCPR. This sub-system should have the ability of receiving orders from and sending observations to QCPR. Additionally, because it is an out-patient pharmacy, this sub-system should be able to generate medication instruction labels to be given with the medication to the patient.

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9. Appendix A:

Workflows of the Clinical Nutrition Information System Project

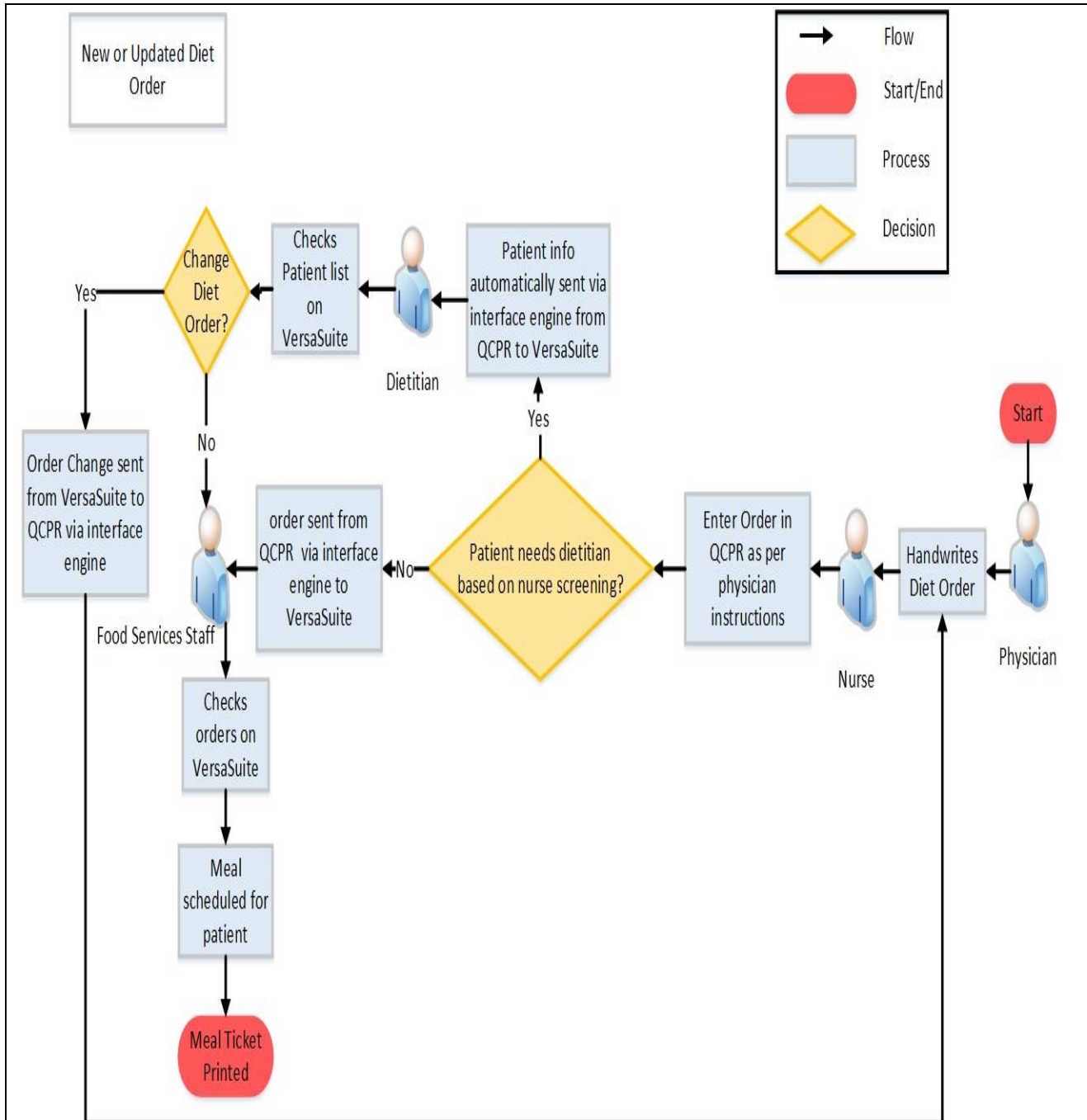


Figure A 1: Workflow of New Diet Order(by author)

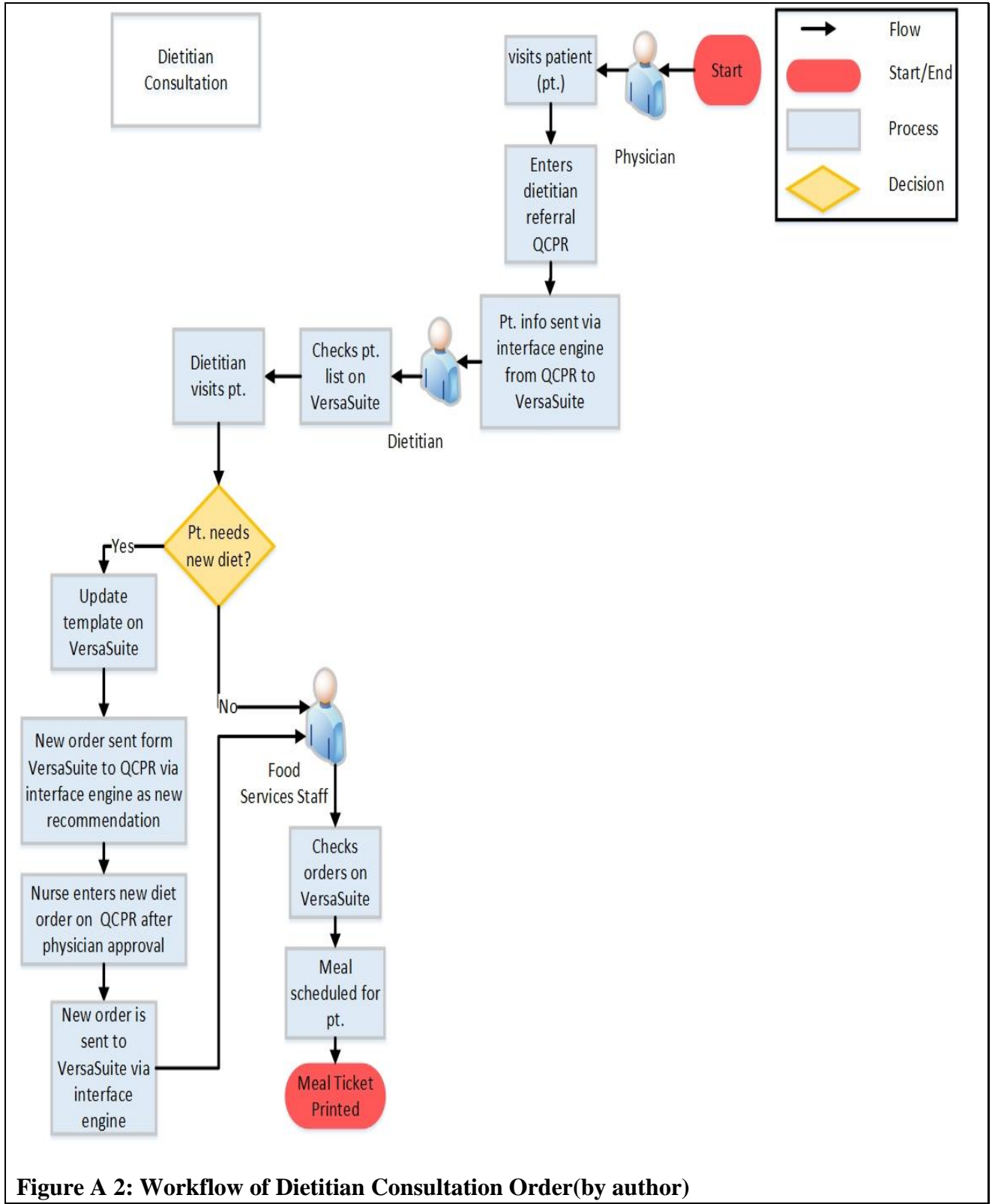


Figure A 2: Workflow of Dietitian Consultation Order(by author)

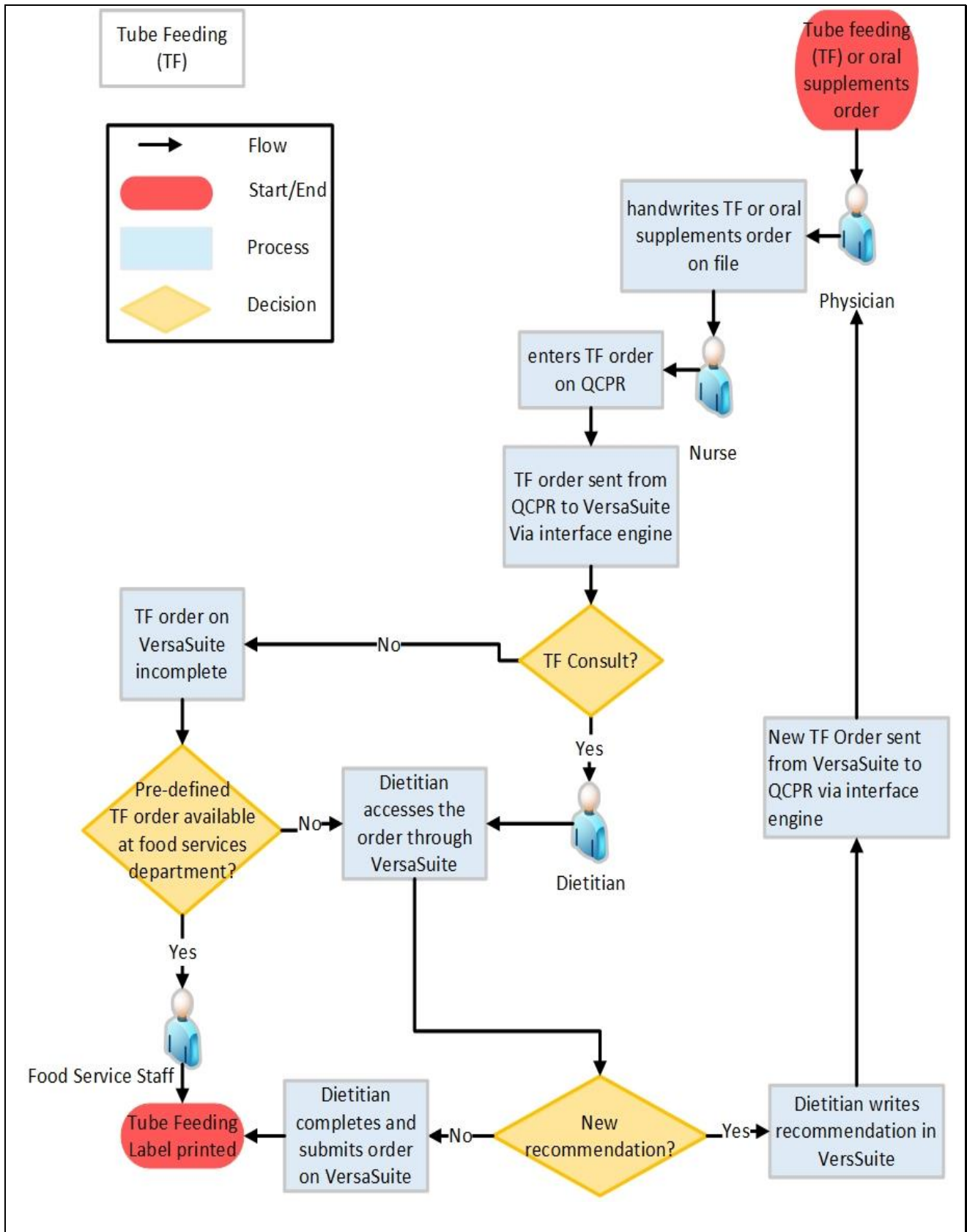


Figure A 3: Tube Feeding Workflow (by author)

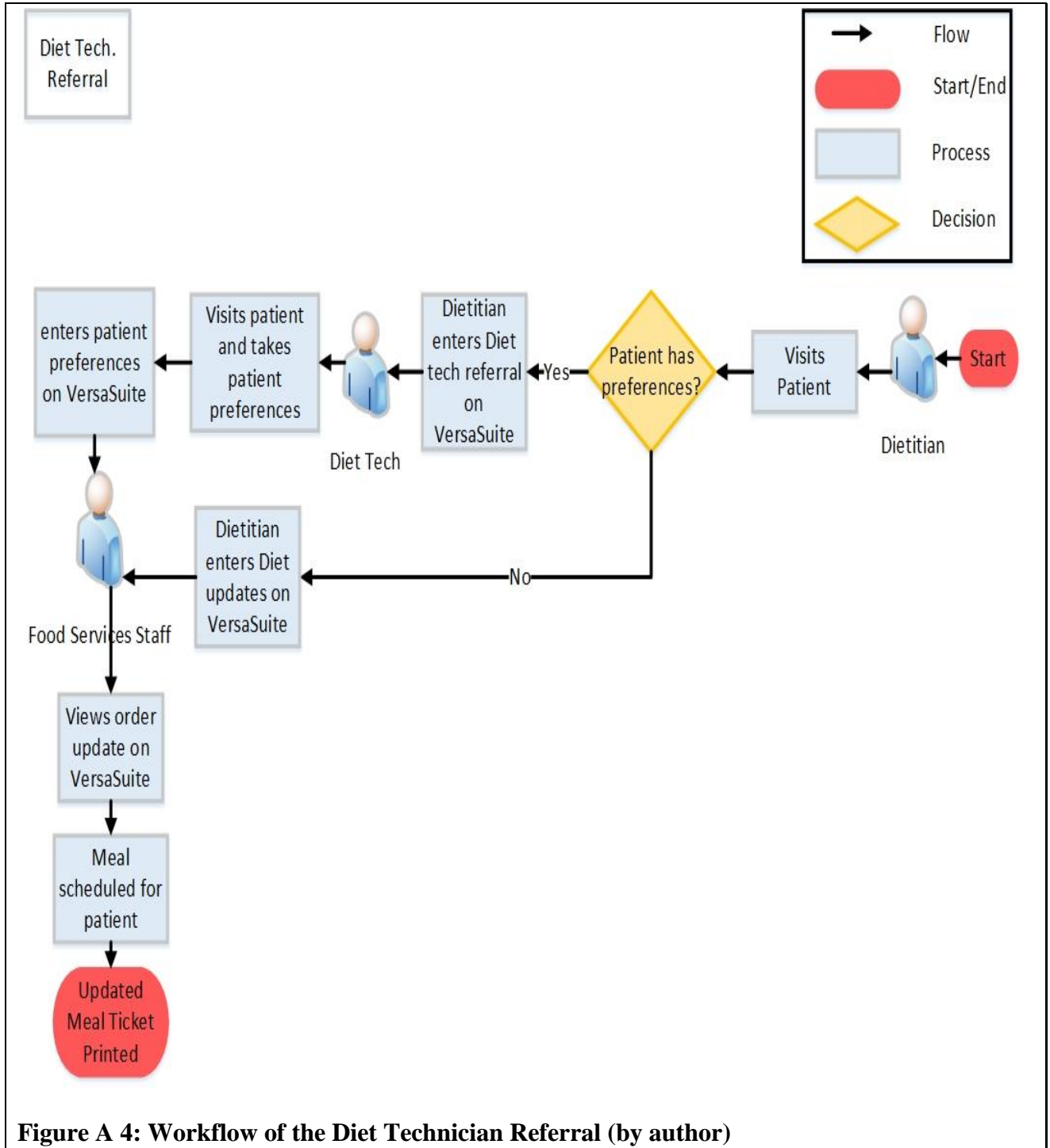
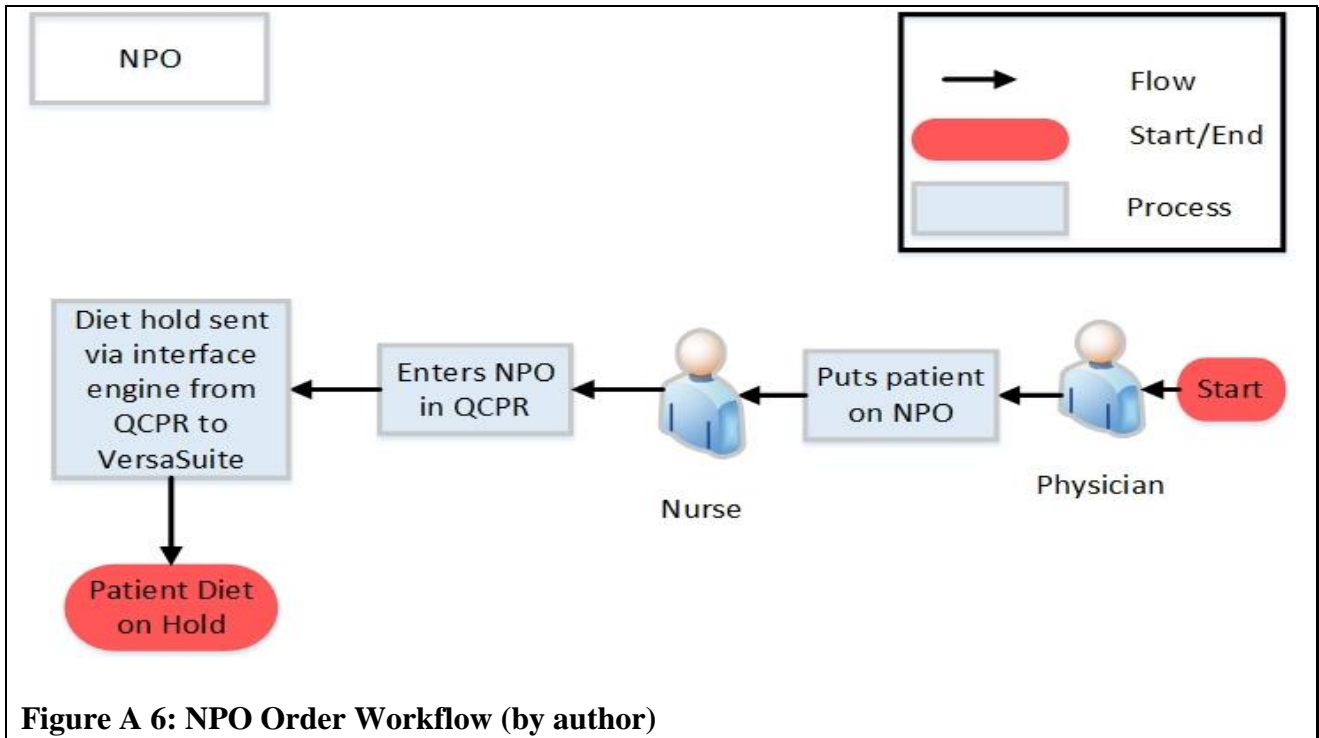
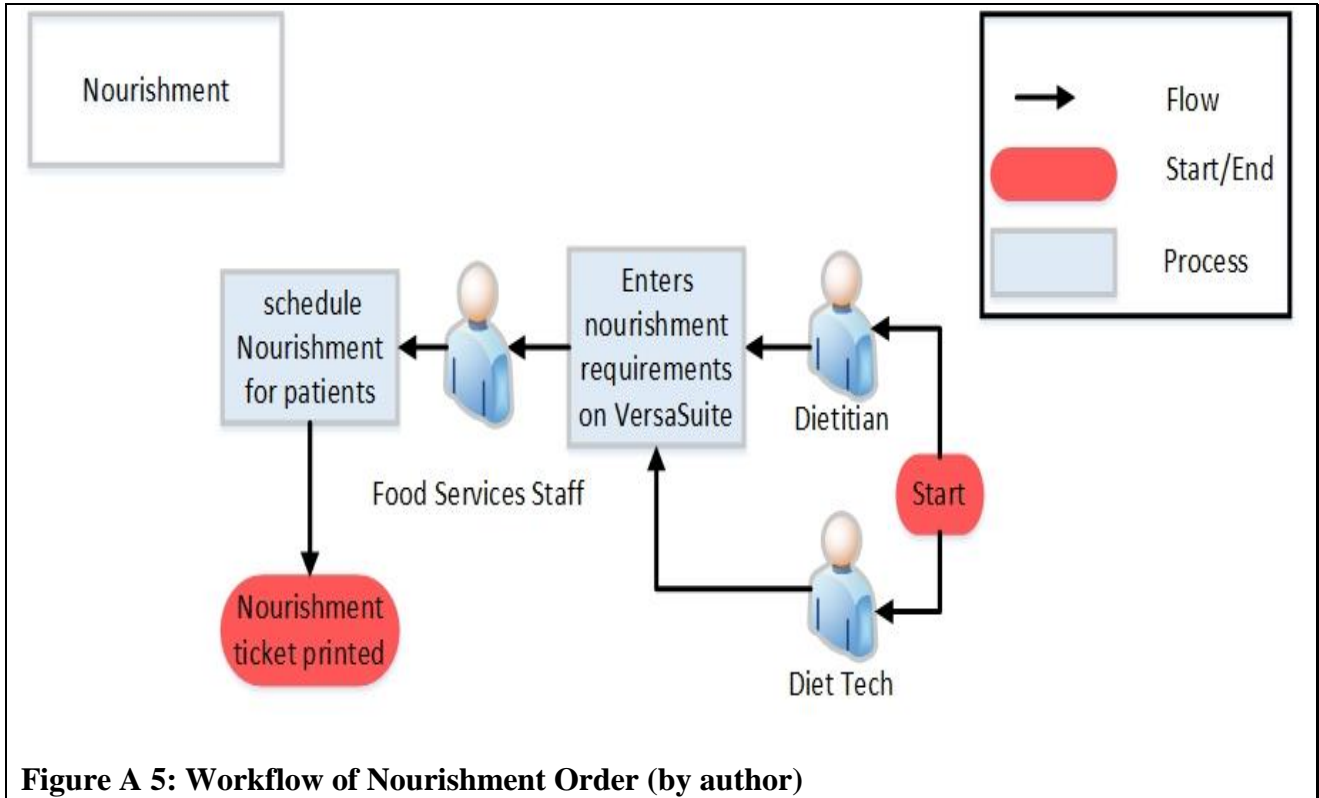


Figure A 4: Workflow of the Diet Technician Referral (by author)



10. Appendix B:

HL7 ORU Message Script and a snapshot of HL7 Messaging standards of QCPR in NGHHA

ORU HL7 Message with the Defected OBX 4 Segment

```
MSH|^~\&|CPR|01|RIE||201403161431||ORU^R01|872005|D|2.4^KSA||||SAU||||
PID|1|██████████^KFKH^|██████████EH^~██████████O^~██████████SID^~██████████
^KFKH^|Nutri^Ped^One^L^A^||200806060000|M||^M^~^
^H^||^PRN^PH^|WPN^PH^|200818
0-1||^|
PD1||^|not confidential|
NK1|1|Noks^Three^L^A^|OTH^other^|H^|33333333^PRN^
PH^333^3^3333333^|WPN^PH^|NK||^|
PV1|1|I|07^01^A^01^|C|^01^|30909^AI
██████████^██████████^██████████^Dr^MD^L^A^||PED|07^01^A||AS110||30909^AI
██████████^██████████^██████████^Dr^MD^L^A^|PE|2008180-
1|06|||01|||201403121522||
PV2||SHR^shared room^|N||N||N||^|
OBR|1||69875^Pediatric Admission
Assessment^||20140316143000||No||^
^||20140316143107||ASM^Assessment/Vs/Monitor|A|N/All Nursing^All Chart
Review^N/Baseline Assessment^N/Basic
Nursing|^20140316143000^^|20140316143000|0||
OBX|1|ST|^VHx - Ped Nut Screening^Wt/Age below 5th percentile?|Wt/Age below 5th
percentile?|No|2454|||201403161430
OBX|2|ST|^VHx - Ped Nut Screening^Ht/Age below 5th percentile?|Ht/Age below 5th
percentile?|No|2455|||201403161430
OBX|3|ST|^VHx - Ped Nut Screening^Tube Feeding?|Tube
Feeding?|No|2456|||201403161430
OBX|4|ST|^VHx - Ped Nut Screening^Total Parenteral Nut?|Total Parenteral
Nut?|No|2457|||201403161430
OBX|5|ST|^VHx - Ped Nut Screening^Therapeutic diet?|Therapeutic
diet?|No|2458|||201403161430
OBX|6|ST|^VHx - Ped Nut Screening^Metabolic Diet?|Metabolic
Diet?|No|2459|||201403161430
OBX|7|ST|^VHx - Ped Nut Screening^Poor Oral Intake?|Poor Oral
Intake?|Yes|2460|||201403161430
OBX|8|ST|^VHx - Ped Nut Screening^Vomiting?|Vomiting?|No|2461|||201403161430
```

OBX|9|ST|^VHx - Ped Nut
 Screening^Diarrhea/Constipation?|Diarrhea/Constipation?|No|2462|||||||201403161430
 OBX|10|ST|^NHx - Fall Risk Assessment^Patient Sedated/Intubated/Paralyzed|Patient
 Sedated/Intubated/Paralyzed|??No|||||||201403161430
 OBX|11|ST|^NHx - Fall Risk Assessment^Age|Age|5|||||||201403161430
 OBX|12|ST|^NHx - Fall Risk Assessment^Fall History?|Fall
 History?|??Yes|||||||201403161430
 OBX|13|ST|^NHx - Fall Risk Assessment^Cognitive/Perceptual
 Problems?|Cognitive/Perceptual Problems?|??No|||||||201403161430
 OBX|14|ST|^NHx - Fall Risk Assessment^Hearing/Visual Impairment?|Hearing/Visual
 Impairment?|No|||||||201403161430
 OBX|15|ST|^NHx - Fall Risk Assessment^Mobility Impairment?|Mobility
 Impairment?|??No|||||||201403161430
 OBX|16|ST|^NHx - Fall Risk Assessment^On two or more of the above mentioned
 Medication?|On two or more of the above mentioned
 Medication?|??Yes|||||||201403161430
 OBX|17|ST|^NHx - Fall Risk Assessment^Sensory Limb Impairment?|Sensory Limb
 Impairment?|??No|||||||201403161430
 OBX|18|ST|^NHx - Fall Risk Assessment^Category|Category|High Fall
 Risk|||||||201403161430

HL7 MESSAGES QUADRAMED CPR™ → RIE GATEWAY

OBX's should be sent in same order as screen driver.

SEG. NAME	SEQ. NO.	MAX LEN.	DATA TYPE	R/O	ITEM NO.	HL7 NAME	QUADRAMED CPR™ NAME	DESCRIPTION
OBX							Header	
	1	4	SI	O	00569	Set ID - OBX	Set ID	Field counter/order question
	2	2	ID	C	00570	Value Type	Data Type	See Table 1-A ,1-B, 1-C, 1-D above
	3	250	CE	R	00571	Observation Identifier	Field key	Interface code for the field from the Result Entry Profile Table ^nt("rp") for result fields. Interface Code "Generic Interface Code (12)"
	4	20	ST	C	00572	Observation Sub-ID	Line Counter For Word Processor Fields (Where data type = TX)	Line Counter

Figure B 1: HL7 Message Standard of QCPR in NGH A

11. Appendix C:

Workflows of the Medication Reconciliation Project

