**Distribution Agreement**

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____     _____
     Alishah Rahemtulla                  Date

Centralized electronic inventory system to improve access to
essential medicines in rural areas of Tanzania: The Tanzanian Electronic Medication
Inventory System (TEMIS)


By


Alishah Rahemtulla, PharmD
Degree to be awarded: Master of Public Health


Applied Public Health Informatics

_____

Laurie Gaydos, PhD
Committee Chair




_____

Melissa Alperin, EdD, MPH, MCHES
Field Advisor

Centralized electronic inventory system to improve access to
essential medicines in rural areas of Tanzania: The Tanzanian Electronic Medication
Inventory System (TEMIS)

By

Alishah Rahemtulla
Doctor of Pharmacy, Philadelphia College of Pharmacy, 2012

Thesis Committee Chair: Laurie Gaydos, PhD

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Applied Public Health Informatics
2018

# Abstract

Centralized electronic inventory system to improve access to
essential medicines in rural areas of Tanzania: The Tanzanian Electronic Medication
Inventory System (TEMIS)
By Alishah Rahemtulla, PharmD

In developing countries, access to essential medicines is tremendously inadequate, and there is a major need to improve the availability of affordable medicines. Additionally, there is no formal procedure to track inventory, assess medication stock outs, document medication procurement sources, and abide to recalls by drug manufacturers. Therefore, there is a need for a standardized pharmacy inventory management system that can provide inventory tracking for rural clinics and health facilities, and that can provide data regarding the inventory, availability, accessibility, and affordability of core medicines. To expand access to medicines, the World Health Organization (WHO) has an expert committee that develops an Essential Medicines List (EML) which serves as a formulary guide for clinics and hospitals in developing countries. These medicines are deemed as essential for addressing the most important public health needs globally, for both communicable and noncommunicable diseases. However, the minimum criteria of basic inclusion on the EML marked as available on a country formulary, does not mean it is procured by the country, is of the right quality, or that adequate stock is maintained. The Tanzania Electronic Medication Inventory System (TEMIS) serves to provide data about medication procurement, inventory, storage, and stock outs of medicines on formulary in each health facility. This data will help determine stock outs trends, regulate medication procurement sources, and analyze medication usage so that the WHO and similar organizations can offer assistance and recommendations to improve access to medicines in even the most rural areas of Tanzania.

Centralized electronic inventory system to improve access to
essential medicines in rural areas of Tanzania: The Tanzanian Electronic Medication
Inventory System (TEMIS)

By

Alishah Rahemtulla

Doctor of Pharmacy, Philadelphia College of Pharmacy, 2012

Thesis Committee Chair: Laurie Gaydos, PhD

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Applied Public Health Informatics
2018

**TABLE OF CONTENTS**

## 1    EXECUTIVE SUMMARY

### Problem

In developing countries, access to essential medicines is tremendously inadequate, and there is a major need to improve the availability of affordable medicines. A study conducted in 2012 found that public health facilities in Tanzania had very high levels of medication stock-outs, with only 37% of facilities being in stock for any given drug (Wales). Medicine stock outs are a result of resource constraints, technical limitations, political logics, and poor drug distribution (United Nations).

Currently, there is no formal procedure to track inventory, assess medication stock outs, document medication procurement sources, and abide to recalls by drug manufacturers. In addition, there is not enough data to assess the level of access to medicines, especially in rural areas of Tanzania, and therefore, there is a need for a standardized pharmacy inventory management system that can provide inventory tracking for rural clinics and health facilities, and that can provide data regarding the inventory, availability, accessibility, and affordability of core medicines.

### Solution

The Tanzanian Electronic Medication Inventory System (TEMIS) is intended to serve as a pharmacy inventory management system that works to streamline and harmonize medication stock management in Tanzania's hospitals, clinics, and pharmacies. The purpose of the system is to gather data regarding the inventory, availability, accessibility, and affordability of medicines in order to increase access to medicines, improve medication distribution management, standardize procurement practices, improve medication recall procedures, and reduce stock outs. Each clinic, hospital, health facility, and pharmacy that procures medicines will use TEMIS to

capture medication information and inventory. This data will be uploaded into the centralized system at the national health center in Dar es Salaam, Tanzania. This project will be a focused pilot study, where TEMIS will only be implemented in 20 selected dispensaries.

**Objectives**

The objectives of TEMIS are as follows:

- Increase access to medicines in Tanzanian health facilities.

- Regulate and validate medication procurement by providing health facilities a method to document procurement sources.

- Identify regions where the most frequent stock outs occur in order to provide preventative measures to significantly reduce medication stock outs of essential medicines.

- Provide guidelines of storing medicines in limited resource areas in order to standardize and improve medication storage procedures.

- Identify medication usage trends of essential medicines to determine adherence to evidence-based protocols.

**Duration and Funding**

Estimated project duration is five years with a tentative roll-out date of December 2022, and estimated budget is $1 million for the first year including start-up, personnel, server software, and training costs for the 20 selected dispensaries. Funding for TEMIS will be provided by the Tanzanian Ministry of Health with assistance from the World Health Organization.

## 2    DECISION BRIEF OUTLINE

### Problem Statement and Recommendation

In developing countries, access to essential medicines is tremendously inadequate, and there is a major need to improve the availability of affordable medicines. A study conducted in 2012 found that public health facilities in Tanzania had very high levels of medication stock-outs, with only 37% of facilities being in stock for any given drug (Wales). With high-level stock outs at public dispensaries, patients turn to private facilities to receive essential medicines, which results in high premiums for medicines that should be available for free or at a discount from public facilities.

Additionally, there is no formal procedure to track inventory, assess medication stock outs, document medication procurement sources, and abide to recalls by drug manufacturers. Currently, there is not enough data to assess the level of access to medicines, especially in rural areas of Tanzania, and therefore, there is a need for a standardized pharmacy inventory management system that can provide inventory tracking for rural clinics and health facilities, and that can provide data regarding the inventory, availability, accessibility, and affordability of core medicines. TEMIS will work to gather data regarding the inventory, availability, accessibility, and affordability of medicines in public clinics, hospitals and dispensaries (i.e. retail pharmacies) in Tanzania in order to increase access to medicines, improve medication distribution management, standardize procurement practices, improve medication recall procedures, and reduce stock outs. Each public clinic, hospital, health facility, and pharmacy that dispenses medicines will use TEMIS to capture data regarding medication information and inventory. Subsequently, this data will be sent to the centralized system, which will be maintained by the national health center in Dar es Salaam, Tanzania. This project will be a focused pilot study, where

TEMIS will only be implemented in 20 selected dispensaries, henceforth referred to as pharmacies.

## Background Information

- Medicine stock outs are a result of resource constraints, technical limitations, political logics, and poor drug distribution. (United Nations)
- Average availability of selected essential medicines was 57% in public sector facilities and 65.1% in private facilities (United Nations).
- In Tanzania, only 37% of public facilities on average are in stock for any essential medicine (Wales)

## Facts, Assumptions, and Requirements

- Facts
  - Tanzania has large number of stock-outs of essential medicines that impact patient health outcomes. (Wales)
  - Public facilities have a higher level of medication stock outs than private facilities. (United Nations)
  - There is no current method to track medicines electronically from wholesaler to dispensary. (Wales)
- Assumptions
  - Pharmacies will willingly participate in the study.
  - The mobile application will be incorporated into day-to-day activities, and monthly inventory will be conducted.
  - Wholesalers and other medicine distributors will ensure barcode information is up to date.

o The pharmacy and national health center will react in a timely manner when alerts are fired.

o Medicines will be safely stored according to recommendations.

- Requirements

  o The system must have the ability to send, receive, and store data from mobile devices.

**Alternatives**

- Leverage an Existing Pharmacy System

- Develop Individual, Decentralized Systems

- Create an RFID-Based System

**Evaluation Criteria**

Each alternative was measured based on the following evaluation criteria:

- Reduce stock-outs/Improve availability of medicines

- Replace paper-intensive processes

- Operate as connected system

- Reduce costs

- Improve distribution of medicines

- Increase sharing of information across agencies

- Increase timely reporting of medicine inventory

- Business Architecture Strategic Alignment

- Information Architecture Strategic Alignment

- Technical Architecture Strategic Alignment

**Analysis of Alternatives**

The strategies and goals that will be addressed through TEMIS were translated into criteria that would be used to evaluate the alternative solutions that were considered. Each technology was rated on scale from 1-5, with 1 being the least aligned with the criteria and 5 being the most aligned. Scores were totaled to determine which alternative technology was best aligned with the strategic initiatives defined.

***Table 1:*** *Evaluation Matrix*

| Criteria | Existing Pharmacy System | Individual System (not centralized) | RFID-based System | Mobile Application (with centralized) |
|---|---|---|---|---|
| Reduce stock-outs/Improve availability of medicines | 4 | 4 | 5 | 5 |
| Replace paper-intensive processes | 2 | 5 | 5 | 5 |
| Operate as connected system | 1 | 1 | 1 | 5 |
| Reduce costs | 5 | 4 | 1 | 3 |
| Improve distribution of medicines | 1 | 1 | 5 | 5 |

| | | | |
|---|---|---|---|
| Increase sharing of information across agencies | 2 | 1 | 1 | 5 |
| Increase timely reporting of medicine inventory | 5 | 5 | 5 | 5 |
| Business Architecture Strategic Alignment | 5 | 5 | 5 | 5 |
| Information Architecture Strategic Alignment | 4 | 4 | 5 | 4 |
| Technical Architecture Strategic Alignment | 3 | 3 | 5 | 4 |
| **TOTAL** | **32** | **33** | **38** | **46** |

**Recommendations**

The recommendation is to use a centralized system that collects data through mobile applications. TEMIS serves a cost-effective electronic, connected inventory system where data can be gathered from all areas of Tanzania, including the most rural areas. Implementing a mobile application that stores data in a centralized system will allow for strategic alignment with initiatives, and will allow for a good foundation to expand the scope of the solution to meet future needs.

## 3 PROJECT AND PRODUCT OVERVIEW

The TEMIS project is intended to serve as a pharmacy inventory management system that works to streamline and harmonize medication stock management in Tanzania's hospitals, clinics, and pharmacies. The purpose of the system is to gather data regarding the inventory, availability, accessibility, and affordability of medicines in order to increase access to medicines, improve medication distribution management, standardize procurement practices, improve medication recall procedures, and reduce stock outs.

Each clinic, hospital, health facility, and pharmacy that procures medicines will use TEMIS to capture medication information and inventory. This data will be uploaded into the centralized system at the national health center in Dar es Salaam, Tanzania. Estimated project duration is five years with a tentative roll-out date of December 2022, and estimated budget is $1 million for the first year including start-up, personnel, server software, and training costs.

## 4 JUSTIFICATION

### 4.1 BUSINESS NEED

In developing countries, access to essential medicines is tremendously inadequate, and there is a major need to improve the availability of affordable medicines. A study conducted in 2012 found that public health facilities in Tanzania had very high levels of medication stock-outs, with only 37% of facilities being in stock for any given drug (Wales). Additionally, there is no formal procedure to track inventory, assess medication stock outs, document medication procurement sources, and abide to recalls by drug manufacturers. Currently, there is not enough data to assess the level of access to medicines, especially in rural areas of Tanzania, and therefore, there is a need for a standardized pharmacy inventory management system that can provide inventory tracking for rural clinics and health facilities, and that can provide data

regarding the inventory, availability, accessibility, and affordability of core medicines.

## 4.2 PUBLIC HEALTH AND BUSINESS IMPACT

To expand access to medicines, the World Health Organization (WHO) has an expert committee that develops an Essential Medicines List (EML) which serves as a formulary guide for clinics and hospitals in developing countries (United Nations). These medicines are deemed as essential for addressing the most important public health needs globally, for both communicable and noncommunicable diseases. However, the minimum criteria of basic inclusion on the EML marked as available on a country formulary, does not mean it is procured by the country, is of the right quality, or that stock is maintained. The Tanzania Electronic Medication Inventory System (TEMIS) serves to provide data about medication procurement, inventory, storage, and stock outs of medicines on formulary in each health facility. This data will help determine stock outs trends, regulate medication procurement sources, and analyze medication usage so that the WHO and similar organizations can offer assistance and recommendations to improve access to medicines in Tanzania.

## 5 SCOPE

## 5.1 OBJECTIVES

The objectives of TEMIS are as follows:

- Increase access to medicines in Tanzanian health facilities.

- Regulate and validate medication procurement by providing health facilities a method to document procurement sources.

- Identify regions where the most frequent stock outs occur in order to provide preventative measures to significantly reduce medication stock outs of essential medicines.

- Provide guidelines of storing medicines in limited resource areas in order to standardize and improve medication storage procedures.

- Identify medication usage trends of essential medicines to determine adherence to evidence-based protocols.

## 5.2 HIGH-LEVEL REQUIREMENTS

The following table presents the requirements that the project's product, service or result must meet in order for the project objectives to be satisfied.

*Table 2: Requirements of Project*

| Req # | Requirement Description |
|---|---|
| 1 | The system should have the ability use barcode scanning to correctly identify a medicine, including drug identification code, lot, expiration date, and manufacturer. |
| 2 | The system should have the ability to track inventory through extracting dispensing information from an electronic health record or manual dispensing by the end user where an electronic health record is not used. |
| 3 | The system must have the ability to send and receive data through secured means. |
| 4 | The system should have the ability to store data offline in case of an upload failure and then re-try when connection resumes until data is successfully transferred. |
| 5 | The system must send a confirmation to the user that data was successfully transmitted from system to the centralized database. |
| 6 | The system should have the ability to send an alert to the national health center if the supply of an essential medicine is running low in any health facility within 7 days. |

| 7 | The system should allow the administrator the ability to enter queries on the database to run reports on network performance. |
|---|---|

## 5.3 RISKS

*Table 3: Risks and Mitigation Strategies*

| Risks | Mitigation Strategy |
|---|---|
| Interests of organizations may not be aligned | Seek support from all stakeholders involved and develop a concise business agreement that outline clear expectations |
| Funding may be diverted or retracted | Develop a financial support plan with WHO and other organizations that are providing funding |
| Compliance of clinics, hospitals, and pharmacies may not be monitored long-term | Assist the Tanzanian Ministry of Health with support within the first year of implementation and encourage incentivized programs to ensure compliance |
| Network performance needs may be different in each area where TEMIS is located | Perform an information system needs assessment prior to implementation and develop flexible approaches to combat network performance issues, particularly in rural areas |
| Lack of technical support | Train staff on common technical issues that may be encountered and provide other means of technical assistance, such as remote support |

## 5.4 MAJOR DELIVERABLES

The following table presents the major deliverables that the project's product, service or result must meet in order for the project objectives to be satisfied.

*Table 4:* *Deliverables with Descriptions*

| Major Deliverable | Deliverable Description |
|---|---|
| Project Management Plan | Define how the project will be initiated, planned, excecuted, monitored/controlled and closed. The project management plan will outline scope, schedule, cost, quality, staffing, requirements, and communication management. |
| Business Agreement | Business agreements with the Tanzanian governement and organizations that will share data. |
| Risk Management Plan | Outlines the process by which the project manager will identify, evaluate and eliminate/minimize risks in conducting the TEMIS Project. |
| Quality Assurance Results | Test the system for defects and assess if it can support day-to-day business. |
| User Manual | The manual will provide the end-user instructions on how to use the TEMIS system to meet project ojectives. |
| Training Program Plan | Develop training sessions for administrators and end-users. |

## 5.5   BOUNDARIES

The TEMIS system will be used to facilitate medication distribution within Tanzania by tracking inventory of medicines and ensuring medicines are procured by valid sources. The system will not provide real-time data and will not be available 24-7 due to constraints of resources. The system will only be implemented in the Tanzanian health facilities that store and dispense medicines

at this time.

# 6 ENTERPRISE ARCHITECTURE IMPACT

## 6.1 BUSINESS NEED AND SOLUTION

Access to affordable essential medicines, vaccines, diagnostics, and health technologies of assured quality are limited in low- and middle-income countries (LMIC) settings. According to the United Nation's Millennium Development Goal (MDG) Gap Task Force Report of 2012, from 2007-2012, the average availability of selected essential medicines was 57% in public sector facilities and 65.1% in private facilities (United Nations). In Tanzania, the public health issue of medicine stock outs are a result of resource constraints, technical limitations, political logics, and poor drug distribution. A study conducted by the Ifakara Health Institute in Tanzania covering 923 public health facilities (hospitals, health clinics and dispensaries) found high levels of medicine stock-outs, with only 37% of public facilities on average being in stock for any given drug (Wales). Additionally, the study found that there was a significant amount of variation between districts, concluding that that were better levels of availability in private facilities and urban areas than public facilities. There is a strong need of a technical solution to this problem not only to streamline and harmonize medication stock management of essential medicines in Tanzania's public facilities, but also to assist in working towards achieving the Sustainable Development Goals (SDG) as identified by the United Nations (UN). TEMIS will work in achieving SDG 3 which is to ensure healthy lives and promote wellbeing for all at all ages, by targeting SDG 3.8: *To achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all (United Nations).*

Therefore, TEMIS will work to gather data regarding the inventory, availability, accessibility, and affordability of medicines in public clinics, hospitals and dispensaries (i.e. retail pharmacies) in Tanzania in order to increase access to medicines, improve medication distribution management, standardize procurement practices, improve medication recall procedures, and reduce stock outs. Each public clinic, hospital, health facility, and pharmacy that dispenses medicines will use TEMIS to capture data regarding medication information and inventory. Subsequently, this data will be sent to the centralized system, which will be maintained by the national health center in Dar es Salaam, Tanzania. This project will be a focused pilot study, where TEMIS will only be implemented in 20 selected pharmacies. The pharmacy staff will use TEMIS, which will be accessible through a mobile application, to inventory essential medicines. At each drug delivery by the wholesale distributor, the pharmacy staff will use the mobile application to barcode scan medicines using GS1 barcoding standards. Data captured will include manufacturer, drug identification code, lot, and expiration date. The mobile app will be used to conduct weekly inventories of essential medicines, and will provide drug monographs of storage, beyond-use dating, dosing, administration, and compounding recommendations. The pharmacy will receive alerts if any stocked essential medicines are:

- Critically low,

- Purchased through unverified sources,

- Beyond manufacturer expiration date, or

- Recalled.

This data will be sent and stored in the centralized TEMIS database. The centralized system will be used by the national health center to monitor and control inventory of essential medicines in all the pharmacies and will assist in the re-distribution of medicines as necessary using data gathered from the mobile apps. In the event of a

trigger of any alerts at the pharmacy, the system will also notify the national health center so that preventative measures can be taken to maintain medicines of assured quality and reduce stock outs. The following diagram shows a high-level information flow model (IFM) of TEMIS:

*Figure 1: Informational Flow Model (IFM) of TEMIS*
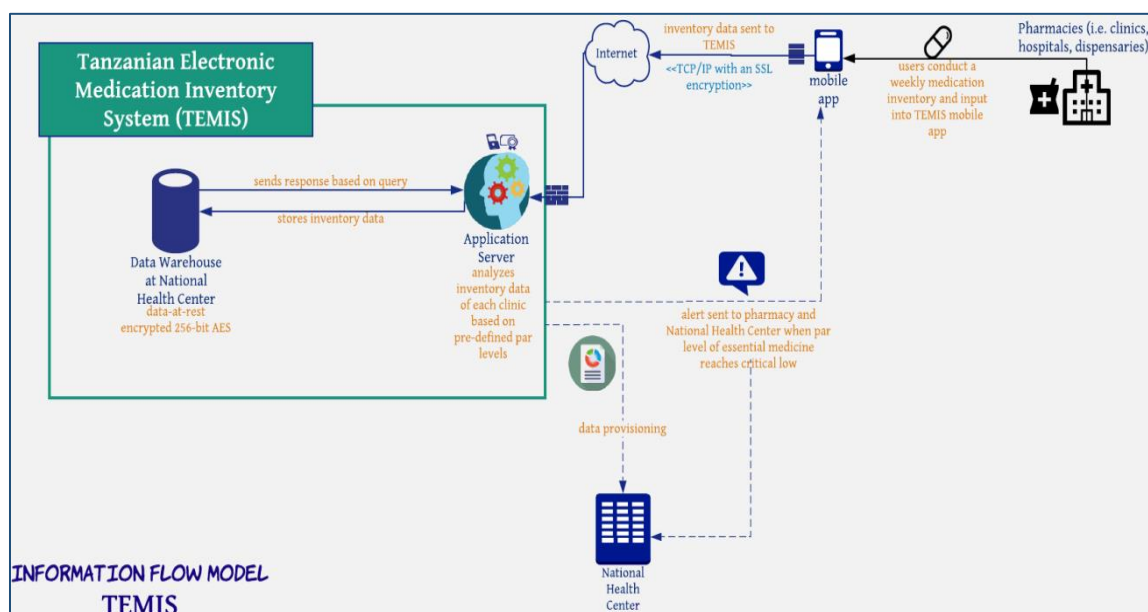


## 6.2 BUSINESS ARCHITECTURE

### 6.2.1 Business Processes

*Table 5: Business Processes for TEMIS*

| Business Process | Description |
|---|---|
| Procurement | Materials will need to be gathered to implement this project. |
| Create Business Agreement | Business agreements will be formed and signed with the wholesale distributor, since barcode data are owned and maintained by them, and with cell phone service providers. |
| Supply Mobile Phones | For this pilot study, mobile phones will be supplied to each pharmacy. |

| Build Mobile Application | The mobile application has to be programmed and tested. |
|---|---|
| Request Data | Upon receival of purchased medicines, the mobile application will use the distributor's rest API in order to retrieve barcode information so that barcodes are recognizable in the system. |
| Alert to Pharmacy | Data inputted by the pharmacy staff of inventory updates will trigger certain alerts when par levels are not met. Additionally, upon receiving inventory from the distributor, the application will trigger an alert if a medicine is recalled, expired, or not recognized in the system. |
| Secure Transmission | The inventory data gathered by the mobile app should be encrypted prior to sending it through the cell phone service provider to the database. |
| Send Data | Data from mobile applications of inventory will be sent and stored in the centralized system. |
| Receive Data | TEMIS will receive data of inventory from the mobile applications. |
| Query the Database | The application should automatically query the database anytime new information is stored and displayed on the user interface. |
| Create User Interface for Centralized System | An interface should be created for users to easily visualize data gathered from mobile applications. |

| | |
|---|---|
| **Alert to National Health Center** | The centralized system will alert the national health center if any pharmacies are running critically low of essential medicines. |

### 6.2.2 Business Processes

#### A. *Alert to Pharmacy Critical Low*

**Objective**: To trigger a real-time alert message on the mobile application if any essential medicines are critically low so that proactive measures can be immediately taken by the pharmacy or by the national health center to provide a quick and efficient restock of medicine.

**Business Rules**: Tanzania cellular service standards, Pharmacy Par-Level Policies, Wholesale Distributor Database Management, Manufacturer Metadata Sharing

**Triggers**: Inventory count is saved on the mobile app AND amount on hand is below the pre-defined par level

**Task Set**: Inventory received from the wholesale distributor, Data inputted using mobile app by pharmacy staff, Weekly inventory counts conducted by pharmacy staff, Medicine count on hand falls below "critical" par-level (defined by each pharmacy), Alert is fired to the pharmacy staff

**Inputs**: Data of medicine (e.g. medicine name, dosage form, strength, package size), Weekly inventory count, Par level parameters

**Outputs**: Alert message fire on mobile application that must be acknowledged, Detailed information of alert fire sent to central database

**Measurable Outcomes**: Complete inventory information inputted to the mobile app weekly, Fired alerts have been acknowledged in a timely manner

#### B. *Mobile App Sends Data*

**Objective**: To successfully send data of medication inventory from the mobile app to update the TEMIS centralized database in real-time through Wi-Fi or cellular service.

**Business Rules**: - Tanzania cellular service standards, Internet service providers, Tanzania Patient Information Privacy Laws

**Triggers**: Medication inventory data is saved and submitted on the mobile app by the pharmacy end-user

**Task Set**: Medication inventory data is saved and submitted on the mobile app, Data is transmitted through Wi-Fi or cellular service once connection is established, Data flows through the internet, to the server, then stored on a secure, encrypted database

**Inputs**: Data of weekly medication inventory, Data from a new medication delivery, Modifications to inventory and/or logistics

**Outputs**: Successful submission message, Error message if connection cannot be made and/or data was not successfully submitted, Acknowledgement of receipt

**Measurable Outcomes**: Participation of pharmacy staff, Medications inventoried and data inputted in a timely manner, Complete data submitted, Data successfully sent in real-time ≥ 80% of submissions

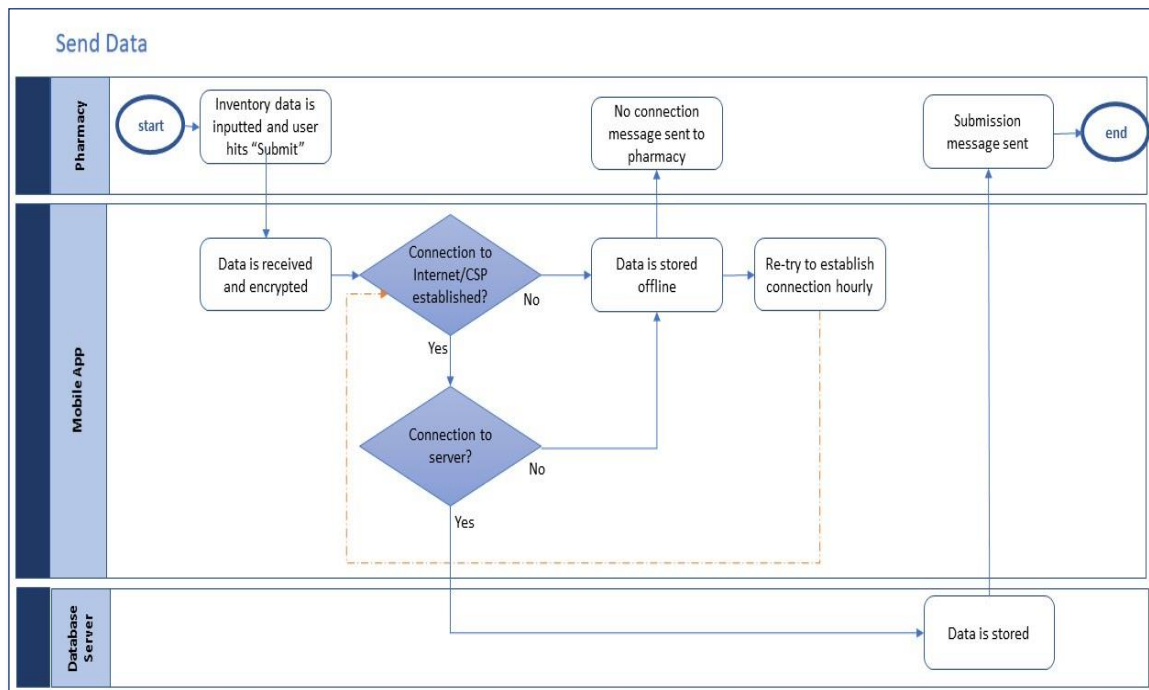### 6.2.3 Task Flow Diagram

*Figure 2: Task Flow Diagram of when a Medicine is Critically Low*
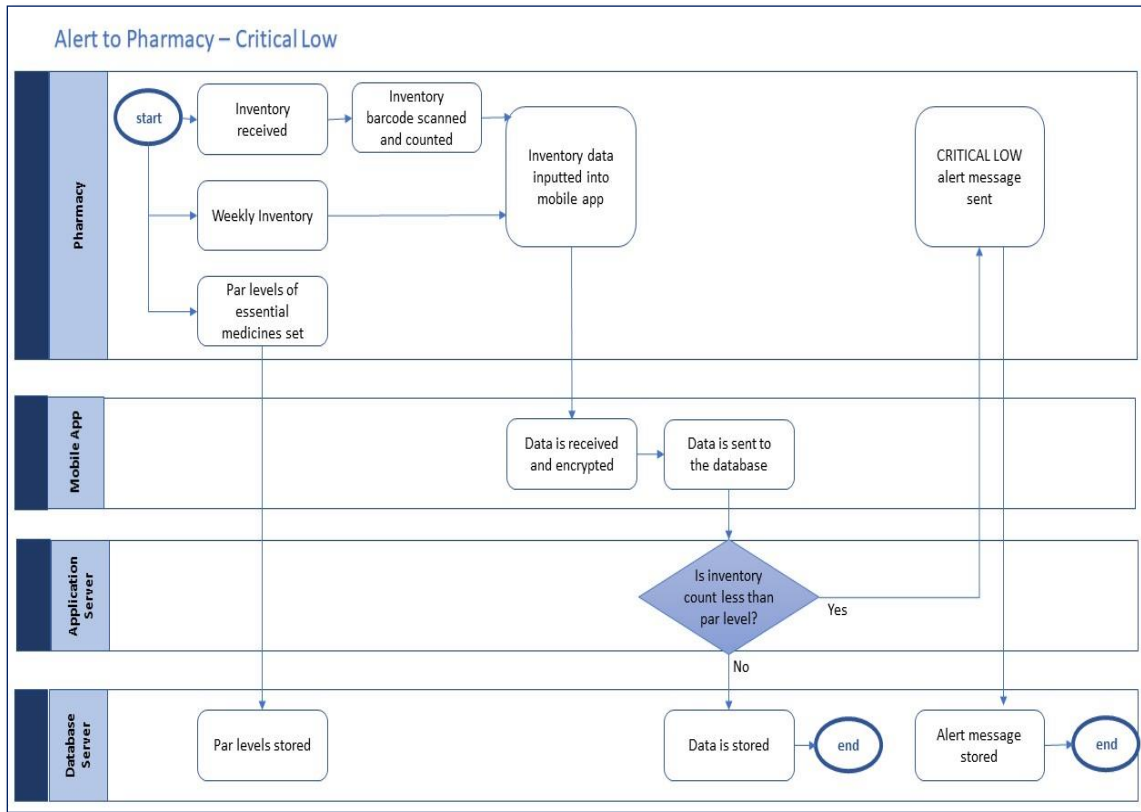


*Figure 3: Task Flow Diagram of when Mobile App Sends Data*

### 6.2.4 Requirements

*Table 6:* *Requirements for TEMIS*

| ID | Business Process | Requirement (The system must or should…) |
|---|---|---|
| 1 | Alert to Pharmacy Critical Low | Have the ability to store and edit/modify par levels of essential medicines defined by the pharmacy and or/national health center. |
| 2 | Alert to Pharmacy Critical Low | Allow the end-user to edit/modify, add, and update inventory counts, even outside the scheduled weekly inventory. |
| 3 | Alert to Pharmacy Critical Low | Have the ability to send the alert to the end-users in real-time. |
| 4 | Alert to Pharmacy Critical Low | Prompt the end-user to acknowledge with reason when an alert is triggered. |
| 5 | Alert to Pharmacy Critical Low | Store all alerts with time of alert trigger and time of acknowledgement. |
| 6 | Send Data | Send encrypted data through establishing a connection through the Internet or cellular service provider. |
| 7 | Send Data | Display an alert if connection cannot be established. |
| 8 | Send Data | Re-try to establish a connection to the Internet and/or server every hour until successful. |
| 9 | Send Data | Notify the user when submission of data into the database is successful. |

| 10 | Send Data | Store time of submission, time of database update, time of error in connection, and/or time successful submission message. |
|----|-----------|---------------------------------------------------------------|

## 6.3 ROLES AND SKILLS NEEDED FOR PROJECT IMPLEMENTATION

- **Roles**
  - Architects for:
    - Business Architecture
    - Data Architecture
    - Application Architecture
    - Technology Architecture
    - Program Manager
    - Mobile App Designer

- **Skills**
  - Generic Skills: leadership, teamworking, inter-personal skills, etc.
  - Business Skills: business cases, business process, strategic planning, etc.
  - Program Management Skills: managing business change, project management methods and tools, etc.
  - Mobile App Designer Skills: brokering applications, asset management, migration planning, software engineering, security, data interchange, data management, etc.
  - Legal Environment: data protection laws, contract law, procurement law, fraud, etc.

## 6.4 RISK MANAGEMENT

- **Risk Impact:** impact each risk event could have on the project

o   Levels: High, Medium, Low

- **Probability of Occurrence:** chance each risk event will occur

    o   Levels: Certain, Expected, Likely, Possible, Unlikely

- **Contingency Strategy:** actions that can be taken in order to reduce the probability of the risk, or to reduce its impact on the project

- **Mitigation Strategy:** actions that will be taken when the risk materializes and threatens the scope, budget, or the schedule of the project

*Table 7: Risk Management Strategies*

| ID | Risk Impact | Probability of Occurrence | Risk Description | Contingency Strategy | Mitigation Strategy |
|---|---|---|---|---|---|
| 1 | Medium | Unlikely | No connection for long periods of time can cause the database to fall out of sync | Network sources should be mapped out in detail for each pharmacy participating in the project. | Pharmacy to contact national health center and use a validated third-party source after connection cannot be established after a certain number of times. |
| 2 | High | Possible | Mobile phone is lost or stolen. | Encrypt all data stored locally and enable remote | Pharmacy to contact national health center for another mobile phone. |

| | | | | wipe when application is installed. | Inventory may have to be re-done and new delivery should be re-scanned into a new phone. |
|---|---|---|---|---|---|
| 3 | Medium | Unlikely | Wholesale distributor changes API without notification. | Business agreement should outline in detail what needs to be completed by both parties when this occurs and the time they should report any changes. | Companies should be contacted for a new API. |
| 4 | High | Possible | Server goes down | Ensure that the server and the database are backed up in certain time intervals. | Setup redundancy servers. |
| 5 | High | Expected | Lack of participation | Ensure that the mobile app is | National Health Center to run |

| | | | | user-friendly, provide proper training and resources, and develop participation incentives. | analysis on participation and contact pharmacy supervisors if participation goals are not met. |
|---|---|---|---|---|---|
| **6** | High | Likely | Funding issues | Obtain support from all stakeholders before project initiation. | Seek financial support from organizations with similar interests. |
| **7** | Low | Likely | Par levels are not updated according to needs of the pharmacy | Develop formalized policies and protocols that pharmacies can follow to update par levels in a timely manner. | Reports can be run at the to monitor number of par level updates at the pharmacy level. National Health Center can also adjust par levels for pharmacies based on disease trends. |

## 7    ANALYSIS OF ALTERNATIVES

The aim of the Tanzanian Electronic Medicine Inventory System (TEMIS) is to leverage emerging technologies in order to monitor inventory of medicines, distribute medicines

in an efficient manner, and gather pertinent inventory data that can be useful for joint initiatives through the United Nations (UN). TEMIS touches on three strategic goals defined by the Tanzanian Ministry of Health:

1. Improve accessibility, accountability, affordability, and availability of essential medicines.
2. Improve health outcomes for communicable and non-communicable diseases.
3. Leverage technology to improve the healthcare of all citizens.

This project not only allows Tanzania to meet these health initiatives, but it also provides a strategy to meet the UN's Sustainable Development Goals, such as supporting the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, and provide access to medicines for all.

In addition to exploring the technology that is used for this project (i.e. a centralized system that stores data from mobile applications), many other emerging technologies were considered to support an electronic inventory system in Tanzania, such as adding a functionality to existing medicine dispensing systems, developing a stand-alone personal computer (PC) based application, and constructing a radio-frequency identification (RFID) based system.

The most cost-effective option would be to add a functionality to existing medicine dispensing systems, such outpatient pharmacy systems and inpatient electronic health systems, by enabling a feature to automatically deduct the count of inventory when a medicine is dispensed based on an electronic prescription order that comes through the pharmacy system. It would provide the ability to track, in real-time, inventory counts of all medicines, not just essential medicines, without having to conduct a manual weekly

inventory. It can also reduce medication errors upon dispensing since the pharmacy system will be able to ensure the correct barcode is scanned based on the electronic prescription order. However, the drawback to this technology is that many rural clinics do not have an existing pharmacy system in place, and we would be unable to track inventory in those areas that have the most need for such a system, thereby not meeting Strategic Initiative 3 (SI3) and SI5. Additionally, we would have problems with standardization and interoperability since each pharmacy would potentially be using different systems. Another technology that was considered to support an inventory system was developing a stand-alone PC-based application that each pharmacy can use to track their own inventory. This would provide the ability to expand into the private sector since there would be no centralized system maintained by the government. Each pharmacy can manage their medicines and develop individual policies and procedures to handle stock-outs. The major disadvantage to an individualized system is that it does not support the distribution/re-distribution of medicines to areas that are more likely to experience stock-outs. This technology would not promote the big-picture understanding of medicine inventory trends around the nation, and would not facilitate the connection between pharmacies, which is not in line with SI3, SI5, and SI6. The third technology that was considered was an RFID-based system, where instead of barcodes, we would use RFID technology to track medicines from the warehouse to the pharmacy quickly and efficiently. Additionally, RFID tags can hold larger amounts of data that can be read in remote locations without having a connection to a back-end database. Though this would be particularly helpful in rural clinics, the major drawback to this technology is cost. The warehouses would have to invest in converting the standard linear barcodes to RFID-tags, and the pharmacies would have to invest in the system that is able to read and interpret RFID coding. Additionally, we will have incompatible standards since Tanzanian pharmacies obtain medicines from many different sources, not just large local

warehouses, such as the World Health Organization's African Regional Office and various pharmaceutical companies. These drawbacks do not align with SI3, SI4, and SI6. By using a centralized system using data from mobile applications, the technology that is used for this project, it will fill the gaps that the other technologies have, and is most aligned with the strategic goals outlined below.

*Table 8: Strategic Initiatives*

| | |
|---|---|
| **SI1** | Enable an electronic logistics and supplies system to ensure adequate quality and quantities of health commodities (i.e. medicines) are **always available at the point of service** to meet patient demand. |
| **SI2** | Enable more efficient use of healthcare resources through **replacing paper-intensive** processes and providing better information management. |
| **SI3** | Enable the health sectors to operate more effectively as a **connected system**, overcoming fragmentation and duplication of service delivery. |
| **SI4** | **Lower the cost** to the government, other healthcare providers, and the public without reducing the supply of medicines. |
| **SI5** | Enable **access to appropriate healthcare services** for patients in remote, rural, and disadvantaged communities. |
| **SI6** | Support improved multi-way communication and **sharing of information** across agencies. |
| **SI7** | Support access to timely, accurate, and comprehensive **reporting of health commodity information**. |

The strategies and goals that will be addressed through TEMIS were translated into criteria that would be used to evaluate the alternative solutions that were considered (see 8.1 Evaluation Matrix). Each technology was rated on scale from 1-5, with 1 being the least

aligned with the criteria and 5 being the most aligned. Scores were totaled to determine which alternative technology was best aligned with the strategic initiatives defined.

## 7.1    EVALUATION MATRIX

*Table 9: Evaluation Matrix*

| Criteria | Existing Pharmacy System | Individual System (not centralized) | RFID-based System | Mobile Application (with centralized) |
|---|---|---|---|---|
| Reduce stock-outs/Improve availability of medicines | 4 | 4 | 5 | 5 |
| Replace paper-intensive processes | 2 | 5 | 5 | 5 |
| Operate as connected system | 1 | 1 | 1 | 5 |
| Reduce costs | 5 | 4 | 1 | 3 |
| Improve distribution of medicines | 1 | 1 | 5 | 5 |
| Increase sharing of information across agencies | 2 | 1 | 1 | 5 |

| | | | | |
|---|---|---|---|---|
| Increase timely reporting of medicine inventory | 5 | 5 | 5 | 5 |
| Business Architecture Strategic Alignment | 5 | 5 | 5 | 5 |
| Information Architecture Strategic Alignment | 4 | 4 | 5 | 4 |
| Technical Architecture Strategic Alignment | 3 | 3 | 5 | 4 |
| **TOTAL** | **32** | **33** | **38** | **46** |

## 8    STRATEGIC PLANNING

### 8.1    PROJECT PLAN FOR CREATION OF STRATEGIC PLAN

*Table 10:*  *Project Plan*

| **Action or Step to be Completed Method for Completion** | **Timeline** | **Milestones** | **Person(s) Responsible** | **Status / Completion Date** |
|---|---|---|---|---|
| **Engage stakeholders** | Weeks 1-2 | 1. Identify stakeholders 2. Complete stakeholder analysis | Strategic Planning | Completed 9/1/2017 |

| | | 3. Set first stakeholder meeting | Committee Chair | |
|---|---|---|---|---|
| **Identify organizational mandates** | Weeks 3-5 | 1. Obtain documentation of current mandates 2. Compile source of applicable mandates | Compliance Officer | Completed 9/15/17 |
| **Clarify organizational mission and values** | Weeks 6-9 | 1. Define organization mission and values 2. Gather input from stakeholders 3. Compile results | Executive Vice President | Completed 10/6/17 |
| **Assess the external and internal environments to identify strengths, weaknesses, opportunities and threats** | Weeks 10-13 | 1. Identify and review data 2. Identify and obtain missing data | Data Analyst | In Progress 10/27/17 |
| **Identify the strategic issues facing the organization** | Weeks 13-15 | 1. Analyze and input data into quadrants 2. Identify emerging issues | Strategic Planning Committee Chair | In Progress 11/10/17 |

| | | | | |
|---|---|---|---|---|
| **Formulate strategies to manage the issues** | Weeks 16-18 | 1. Choose goals<br>2. Define measures using formulas<br>3. Conduct action-oriented strategic mapping | Strategic Planning Committee Chair | 11/24/17 |
| **Review and adopt the strategic plan or plans** | Weeks 19-20 | 1. Create logic model<br>2. Gather input from stakeholders | Strategic Planning Committee Chair | 12/1/17 |
| **Establish an effective organizational vision** | Weeks 21-22 | 1. Determine vision of success | Executive Vice President | 12/15/17 |
| **Develop an effective implementation process** | Weeks 23-24 | 1. Assess readiness<br>2. Clarify direction with stakeholders<br>3. Structure implementation by resourcing, aligning, and ongoing learning | Strategic Planning Committee Chair | 12/22/17 |
| **Reassess strategies and a strategic** | Weeks 25-27 | 1. Maintain process for strategic change<br>2. Manage strategic design | Strategic Planning Committee Chair | 1/5/18 |

| | | | | |
|---|---|---|---|---|
| **planning process** | | | | |

## 8.2  MISSION STATEMENT

The Tanzanian Electronic Medication Inventory System's (TEMIS) mission is to improve access and regulate distribution of essential medicines by reducing the number of medication stock outs and standardizing inventory management in clinics, hospitals, pharmacies, and other dispensaries in all areas of Tanzania.

## 8.3  VISION

This project is developed to implement an electronic method to manage medication inventory, and is devoted to improving patient outcomes to the most rural parts of Tanzania by increasing access to medicines in all regions. The vision of TEMIS is to not only ensure access, availability, and affordability of essential medicines, but it also hopes to meet the objectives of international organizations, such as the World Health Organization.

### 8.3.1  Vision Statement

TEMIS will be internationally recognized as a leader in effective medication inventory regulation of a developing country.

## 8.4  GOAL AND OBJECTIVE TIMELINES

*Table 11: Goal and Objective Timelines*

| |
|---|
| **Priority**: Pharmacy Engagement<br><br>**Strategy**: Obtain End-User Input<br><br>**Goal**: Engage the pharmacist to be forefront of inventory management and leverage their role to improve access of essential medicines. |
| **Outcome Objective 1**: By December 2017, conduct analysis of current pharmacist role to include medicine dispensing procedures and purchasing methods. |

| Programs Activities Interventions | Person/Group Responsible | Timeline | Process Indicator | Outcome Indicator |
|---|---|---|---|---|
| Assess pharmacist role in tracking inventory of essential medicines | Program Managers | September 2017 – October 2017 | 1. Conduct evaluation of pharmacy workflow 2. Determine available resources | 1. Visualization of current infrastructure |
| Assess resources needed to provide pharmacists with the tools necessary to manage inventory | Program Managers | October 2017 – November 2017 | 1. Determine available resources in each region 2. Conduct gap analysis | 1. Cost effectiveness analysis guides decision on resource allocation |
| Develop guideline/policies to engage pharmacist in inventory management | Team Leaders | November 2017 – December 2017 | 1. Integrate pharmacist education within training manual 2. Create implementation plan | 1. Increase pharmacist engagement in inventory management by 60% |

**Priority**: Support the Growth of Inventory Management using Information Technology

**Strategy**: Ensure any new development of information technology of medication inventory is interoperable with TEMIS.

**Goal**: Foster integration between new emerging technologies and the existing national inventory system.

**Outcome Objective 1**: By May 2018, ensure that analysis of any new inventory technology includes the analysis of interoperability with TEMIS.

| Programs Activities Interventions | Person/Group Responsible | Timeline | Process Indicator | Outcome Indicator |
|---|---|---|---|---|
| Assess cost effectiveness of integration analysis | National IT Team | January 2018 – March 2018 | 1. Conduct a gap analysis 2. Determine available resources | 1. Cost effectiveness analysis guides decisions on integration |
| Disseminate IT infrastructure of TEMIS | IT Staff and Management | March 2018 - April 2018 | 1. Conduct evaluation of IT infrastructure of TEMIS 2. Determine IT requirements needed for interoperability | 1. Create report of IT infrastructure of TEMIS to guide new technology standards |

| Develop national standards, policies and procedures to include integration analysis | National Regulation Team | April 2018 – May 2018 | 1. Develop standards, guidelines, and thresholds 2. Create implementation plan | 1. New medication inventory technologies should seamlessly integrate with TEMIS |
|---|---|---|---|---|

# 9   DISCUSSION

The next phase of this project plan will include conducting a detailed risk analysis during each project phase along with identifying mitigation strategies in order to recognize any potential risks throughout the project duration and system deployment. An impact analysis will also be conducted to identify consequences and risks of any change to project scope. The project plan will also comprise of more detailed technical design for the TEMIS centralized system and mobile application, including requirement specifications, user interface, deployment and training using agile software development methodology. Each iteration will involve small incremental builds throughout the software development life cycle, and acceptance of each iteration will be documented using a formalized documentation process.

Other next steps for TEMIS include expanding the study into more clinics, dispensaries, and hospitals around Tanzania, and hopefully, serve as a standard

approach to medication inventory in other developing countries. The application of

this system hopes to provide data to public health agencies regarding availability,

accessibility, and affordability of essential medicines, and also hopes to coordinate

medication procurement efforts among Tanzanian local and regional agencies.

As a graduate student in the Master of Public Health program, I have gained the

skills and knowledge to understand and manage public information systems, as

well as implement informatics solutions using a high-level perspective on common

public health problems. I have learned that public health is in no way an individual

effort, and that many organizations about many different disciplines must

coordinate efforts to provide optimal health outcomes for the population.

## 10   REFERENCES

Bryson, John M. (2011). Strategic Planning for Public and Nonprofit Organizations: A
Guide to Strengthening and Sustaining Organizational Achievement. Retrieved from
Emory eLibrary.


FY10 Ref Model Mapping Quick Guide. EGov FEA Reference Model. Aug 2008. v2.3.
Available at < http://www.ibrarian.net/navon/paper/FEA_Reference_
Model_Mapping_ Quick_Guide__FY10_Bud.pdf?paperid=20274223>


Redesigning Public Health Surveillance in an eHealth World, June 2012. Public Health
Informatics Institute. Available at <https://www.phii.org/sites/www.phii.org/
files/resource/pdfs/Requirements%20Lab_Final%20Deliverables_RWJ%20Sureveillan
ce.pdf>

The Open Group Architectural Framework V9.1. Open Group Standard, 2011. Available at < https://www.opengroup.org/architecture/togaf91/downloads.htm>

United Nations. Essential Medicines, 2008. Available at <http://iif.un.org/content/essential-medicines>

Wales, J, et al. Stock-outs of essential medicines in Tanzania. Overseas Development Institute. 2014 Mar. pp 8 – 10.