Lilongwe Central Hospital
Paediatric Information System

An Information Technology Approach to Improving Healthcare Delivery in Malawi

Pilot Project Final Report

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Introduction

This report describes the development and deployment of a pilot computer-based health information system. The objectives of the system are twofold: 1) to augment clinicians' ability to deliver healthcare, and 2) to collect complete and accurate information and make it available in a timely fashion to support decision-making at all levels. The ultimate goal of this system is to contribute to the reduction in morbidity and mortality in the target population.

The system integrates clinical workstations into the healthcare delivery process leveraging two technologies that are novel in this setting. A touchscreen interface is used to accommodate low computer literacy among the target users. Wireless networking is used to connect clinical workstations used in the outpatient clinic and on the wards to a central repository of health data. The site chosen to deploy the pilot system was the paediatric department of the central hospital in Malawi's capital city of Lilongwe.

Figure 1 – Clinical Workstation being used for patient registration

Background

Malawi is one of the world's poorest countries with much of its population suffering tremendous health problems. The 1998 human development report of the UN Development Programme (UNDP) states that 48 percent of the population have inadequate income to acquire basic needs. The World Health Report 2000 published by the World Health Organization (WHO) ranks Malawi 189 out of 191 countries studied in disability-adjusted life expectancy (DALE) and 185 out of 191 in overall health system performance. Infant mortality is among the highest in the world. The WHO data for 1999 shows that one out of every 8 infants die before their first birthday and one in 4 die before reaching five years of age.

Lilongwe Central Hospital (LCH) was opened in the 1970's to server as a referral hospital for Malawi's central and northern regions. Regrettably, due to a lack of adequate health centers in the immediate area, LCH was forced to take on the additional responsibility of providing primary care. In 2000 the paediatric department handled in excess of 10,000 admissions on its 180 bed wards and saw more than 75,000 children in its outpatient clinic.

Malawi, like most developing countries, is hampered in its ability to provide healthcare by a severe lack of medical staff, medications and diagnostic resources. Unfortunately the situation is slow to improve due in part to the absence of reliable data on which to base a plan for improvement. While there are a variety of possible interventions aimed at improving the situation, the application of information technology holds promise in two ways.

- The traditional method for collecting medical data in Malawi replies on the completion of pre-printed forms by clinicians, nurses and clerks. In a perfect world data would be recorded completely and accurately on forms at the time the finding was observed. Shortly thereafter this information would be transcribed into a computer with complete fidelity. Finally the data would be processed and reports generated and fed back to the stakeholders sufficiently quickly to be of use. In reality, the Ministry of Health and Population in Malawi has struggled to refine its implementation of this system but has fallen short for a variety of reasons. Inadequate funds to print forms has resulted in gaps in data collection lasting for weeks and sometimes months each year. Health facilities frequently allow their inventories of forms to be exhausted before re-ordering more. Re-ordering of forms, distribution of new forms and collection of completed forms is severely hampered by the country's poor communication infrastructure.

  Sadly, even when forms are available they frequently do not get completed. Clinicians argue that the high patient to physician ratio results in them being over worked and consequently they have less time for paperwork that is not directly related to the management of the patient. Some clinicians have reported that after a long day in the clinic they have completed morbidity tally sheet forms from memory after seeing 80+ patients that day. When a genuine attempt is made to complete forms some fields are frequently left blank. Completed forms often accumulate for weeks or months before getting transcribed into the computer.

  Some forms get lost before ever getting transcribed. Auditing has demonstrated that transcription errors occur frequently. The transcription of forms into the computer is usually done by clerks having little on no medical background. During transcription clerks are required to code free text diagnoses into ICD9 codes. The combination of a lack of controlled vocabulary, poor handwriting and little or no medical training on the part of the clerks has resulted in a high percentage of coding errors.

  Inconsistencies in the data on the form identified at transcription time (e.g. John Phiri with a diagnosis of vaginal bleeding) are rarely resolved, or worse, are resolved "arbitrarily". On occasion data has been fabricated when essential fields on a form have been left blank. The resulting data set, albeit somewhat incomplete and inaccurate, is used to generate reports which attempt to describe the state of the morbidity and mortality of the population. Regrettably, these reports are only processed and distributed once a year. Furthermore, the reports are so summary in nature that they are of little or no value to individual health facilities. It should be noted that the Dutch Government has an initiative in progress that has come a long way in putting systems in place to address many of these problems.

- Malawi's astronomical patient to clinician ratio (approximately 25,000:1) demands that clinicians see large numbers of patients. One solution to the shortage of clinicians is to train more. This is currently in progress. However, it may take another decade before the situation improves. An alternative approach would be to leverage the existing pool of clinicians by providing them with tools that would allow them to see more patients in less time without compromising quality of care and, wherever possible, improving it.

This report describes the introduction of a computer-based health information system into the Paediatric Department at Lilongwe Central Hospital. The system attempts to address the problems described above.

The Intervention

The pilot system introduces computer-based clinical workstations into the *existing* workflow. Workstations are used in real-time to support a number of healthcare delivery processes. Each workstation consists of a computer, printer and power supply, all built into a rolling desk (Figure 1). The computer uses a touchscreen interface in place of the traditional mouse and keyboard to accommodate low computer literacy among the target users. The computer and printer are powered from a car battery allowing the workstation to run for up to 3 days before recharging is necessary. Workstations communicate with a centralized computer where all data is stored. This communication is achieved using wireless networking technology. The combination of self-contained power and wireless networking allows the workstations to be untethered making it simple to move workstations to different locations as necessity demands. A total of eight workstations were deployed in the following areas:

- One in the patient registration area
- Three in the paediatric outpatient clinic
- One in the paediatric medical records office
- Three on the paediatric wards, one at each of the nursing stations

The integration of the workstations into healthcare delivery is intended to have two benefits:

- Augment clinicians' ability to deliver healthcare
- Collect complete and accurate data and make it available in a timely fashion as a byproduct of their use

Augmenting Clinicians' Ability to Deliver Healthcare

There is extensive literature supporting the success of computer augmentation in medicine. Examples of augmentation include reducing documentation time through the use of templates, checking for potentially dangerous medication interactions, critiquing clinicians' diagnoses and monitoring trends in data. It should be noted that augmentation is not automation. The role of the computer is not to replace clinical judgement and experience, rather to reduce both the mental (cognitive) and physical workload of the clinician, and to enhance their ability to solve problems and make decisions.

The system implemented at LCH employs augmentation with two broad objectives; 1) to improve diagnostic accuracy, and 2) to reduce encounter time without compromising patient outcomes.

Improving Diagnostic Accuracy

The formulation of a diagnosis is based on information derived in a variety of ways and from a variety of different sources (Figure 2). Mapping this information into a diagnosis is subject to interference or "noise" that confounds the diagnostic process. The role of augmentation in improving diagnostic accuracy is to increase the availability of information from which the diagnosis is derived and reduce the effect of noise on the diagnostic process.

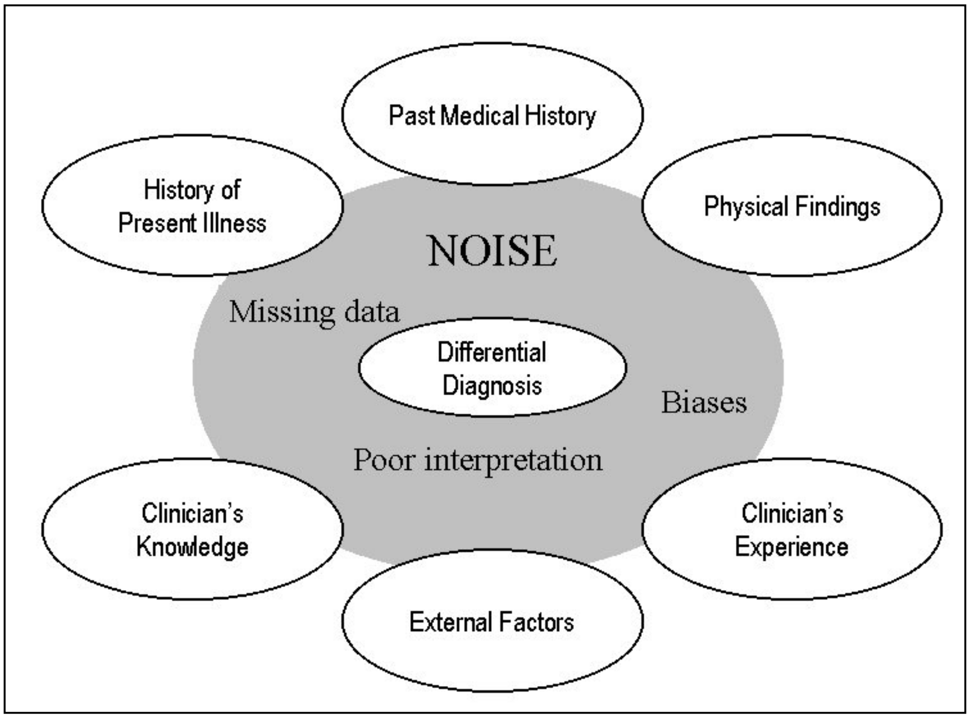

Figure 2 – The diagnostic process

In the LCH paediatric outpatient clinic past medical history is derived both through discussion with the patient and from records retained from previous visits. Unfortunately patients rarely remember their medical history with any degree of completeness or accuracy. Furthermore, any paperwork they were given during previous visits is frequently lost or so tattered that it is illegible. To date LCH has not maintained permanent records for outpatients. With the introduction of the clinical workstations information recorded during the encounter is stored and can be made available during subsequent encounters to inform the diagnostic process. This will be particularly valuable when managing patients with chronic illness.

Variations in style and level of knowledge and clinical experience among clinicians create variability in thoroughness and completeness when eliciting a history of present illness and conducting a physical examination. To promote consistency in the way patients are managed clinicians are asked to record the values of 8 diagnostically significant pieces of information about the patient (Figure 8 & 9). The checklist effect experienced by clinicians as they record this data should increase the likelihood that the information will be considered when formulating a diagnosis.

The format in which data is presented to the clinician can affect the degree to which the information is conveyed. Where appropriate, the system attempts to display quantitative information in graphical rather than tabular form to maximize its diagnostic value (Figure 7).

In formulating a diagnosis a number of biases come into play. The effect of a single piece of evidence unduly influencing clinical judgement is well documented. Displaying signs and symptoms recorded during the encounter on a single screen (Figure 9) should reduce this bias allowing the clinician to better integrate the evidence.

Clinicians are encouraged to enter not only the diagnosis they believe most likely, but in addition to provide up to two alternative hypotheses where appropriate (Figure 9). This is referred to as the differential diagnosis. Clinicians are expected to entertain all relevant diagnoses in the differential until further investigation has been done to rule them in or out. By encouraging the clinician to consider other plausible diagnoses, the patient is more likely to be receiving the correct treatment early on in their management and consequently more likely to have a better outcome.

In a subsequent phase of the project a knowledge base will be incorporated into the system that will provide a basis for diagnostic critiquing.

Reducing Encounter Time

The limited number of clinicians and the high volume of patients attending the outpatient clinic put a strain on the system. Each encounter typically lasts from two and a half to three minutes during which time the clinician elicits information form the patient and/or guardian, determines a diagnosis and course of treatment, prescribes medications and documents the encounter. Approximately 30 to 45 seconds is consumed by writing a brief summary of the encounter for the patient to take with them. Since the relevant details of the encounter have been captured in the system a summary of the encounter can be easily printed. The printing of encounter summaries saves the clinician the time of having to write them and ensures legibility. A subsequent phase of this project will integrate the printing of prescriptions, referral notes and orders for diagnostic investigations to further save the clinician time.

Collecting Complete and Accurate Data

The real-time nature of the data entry system is expected to improve both the completeness and the accuracy of the data being captured. This is based on the fact that the optimal time to resolve potentially incomplete and inaccurate data is while the information is being elicited from the patient or guardian. Additionally, the interface has been constructed in such a way that data completeness and accuracy are promoted. Improved completeness is promoted by the system prompting the user for each piece of information and providing the user with a list of possible responses. An example of this can be seen in Figure 5 where the clerk is being asked to record the area where the patient is currently living. Users are given the option to enter “Unknown” wherever reasonable to discourage them from fabricating data when the information is truly not known. Improved accuracy is promoted through data validation checks built into the system. For example, the system will check to see if the discharge data for a patient comes before the admission date, or if it is sometime in the future.

The System Development Process

System requirements were put together through interviews with staff and by observing existing manual processes. Two ward clerks from the paediatric medical records office, a senior clinical officer and two senior physicians assisted by providing clarification and domain specific knowledge where necessary. A software-engineering framework was used to guide the development process paying close attention to usability, accessibility, availability, reliability, sustainability and security/privacy.

Usability

The primary threat to the successful implementation of the system was considered to be the lack of adoption by the target user group. In light of the many challenges healthcare workers face in their day-to-day duties a system that was unintuitive and cumbersome to use would almost certainly fail to be adopted. Recognizing this, it was decided that the system should mimic existing processes and workflows so as to be as minimally invasive as possible and should attempt to replicate the metaphor of the familiar paper register and other forms traditionally used to collect data. Additionally, the time taken to perform tasks using the system should be no longer than the time taken to perform the task manually and significantly shorter wherever possible. Given the unfamiliarity of the target user group with computer technology and particularly their lack of skill in typing, it was decided that a touchscreen interface would provide the optimal solution in usability. In designing the user interface screens, button size and inter-button spacing were chosen to optimize usability.

Accessibility

Due to the real-time nature of system use, high system accessibility was considered to be essential. The nature of healthcare delivery is such that multiple users need access to the system from a variety of locations. During the outpatient clinic at LCH, up to three clinicians see patients concurrently while others are being registered. At the same time admissions, transfers and discharges are taking place on the paediatric wards at the opposite end of the hospital. To meet the need for high system accessibility multiple workstations were deployed.

Availability & Reliability

Given that healthcare delivery is a non-stop process the system should be available for use 24 hours a day year-round. Like many developing countries the power in Malawi is unreliable. To protect against power failures preventing the workstations from functioning, batteries were built into each workstation. The capacity of the battery is sufficiently large that workstations can run continuously for approximately 3 days from a single charge. Both the main server and the network electronics were backed up with an uninterruptible power supply (UPS). This was not intended to run the system for long periods of time, just sufficiently long for the hospital generator to come online.

A failure of the server would cause the entire system to fail. Consequently measures were taken to keep it running. The hardware chosen for this project incorporates two fault-tolerant features. The first feature is the presence of three hard drives in a Redundant Array of Inexpensive Drives (RAID) configuration. This allows for the system to continue to run without any downtime or loss of data in the event of a catastrophic failure of any single drive. The second feature is the presence of two power supplies connected in a failsafe configuration such that if the first power supply fails, the second will take over before power to the system is interrupted. To protect against theft the server was located in a highly secure room protected by heavy duty steel door with two very large high quality pad locks. In the highly unlikely event that the main server failed or was stolen a backup server is in place at an alternate location and ready to take over. This backup server is an older computer absent of the fault-tolerant features of the main server. Data from the main server is replicated to the backup server once a day.

To ensure that day-to-day activities are not interrupted by the failure of a workstation, a spare has been provided. This is feasible given that all the workstations are identical. Spare network hubs and wireless access points have also been provided.

Sustainability

The presence of a local support person was considered to be essential to the sustainability of the system. The role of the support person would be to provide training to new users and perform system repairs when necessary. A Malawian was hired to fill this post. Additional factors contributing to the sustainability of the system are the availability of printer paper and ribbons for the 3" wide receipt printers used to print discharge slips, etc. Unfortunately the paper was unavailable locally and had to be imported from South Africa. The hospital was provided with a 4-month supply of paper to get them started. The hospital was also provided with 50 new printer ribbons and a re-inking machine complete with ink that allows used ribbons to be re-inked up to 100 times.

Security & Privacy

While the system has greatly increased the accessibility to information for the target user group, it has also increased the potential for unauthorized access to information in the process. To protect against unauthorized access to the system, users are provided with a unique 6 digit "secret code" (Figure 3). The terminology is used in place of password to reinforce to the user the fact that this code should not be made public knowledge. During user training the staff are sensitized to the issue of security and privacy and encouraged to "Secure the workstation" by pressing a highly visible button on the main menu screen when they have finished using the workstation (Figure 4). Timers are also in place to do this automatically after 3 minutes if a user forgets to do so.

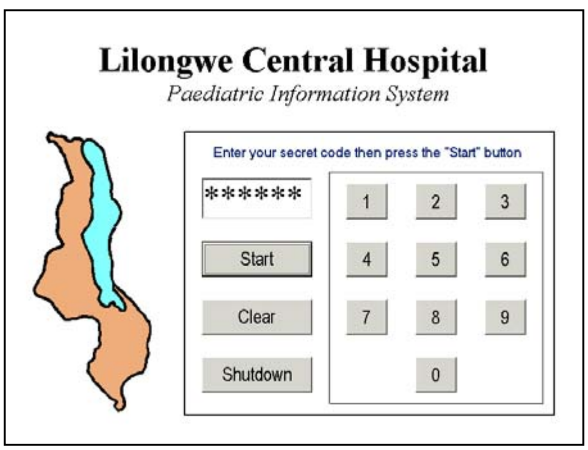

Figure 3 – Login screen

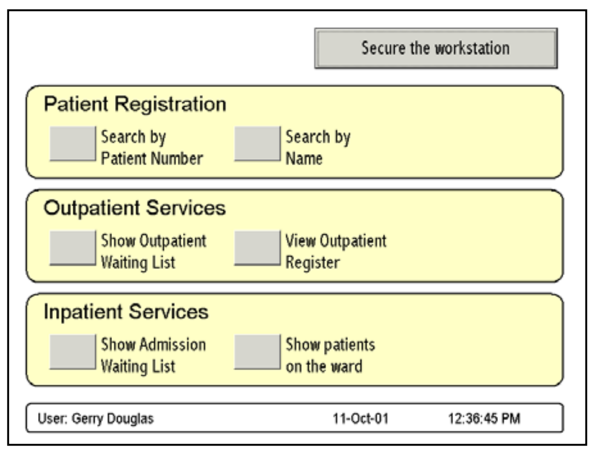

Figure 4 – Main task menu

System Hardware

The Server is a Dell PowerEdge 2400 series computer with dual redundant power supplies and 3 x 9 GB SCSI hard disks arranged in a level 5 RAID configuration. Six Linksys WAP11 wireless access points are connected to the server through an Ethernet network of 10BaseT wiring and hubs.

The workstation computer is based on a 200 MHz Intel Pentium platform with 32 MB of RAM. A MicroTouch Systems ClearTek 3000 capacitive touchscreen sensor is added over the 10.4 inch 800 x 600 pixel active matrix display and a SanDisk 64 MB IDE FlashDrive is used in place of a conventional hard disk to reduce current consumption and increase the robustness of the system. An Epson TM-U200D point-of-sale 3 inch receipt printer is connected to the workstation computer via a parallel interface. The workstation computer communicates with the server through a D-Link DWL-120 wireless network adapter connected via a USB interface. Both the 19 volts DC required to power the computer and the 24 volts DC required to power the printer are generated by a custom made DC-DC converter powered from a 12 volt 96 AH deep cycle battery.

System Software

The server is running the Microsoft Windows 2000 Advanced Server operating system. Data is stored using Microsoft SQL Server 2000 database software and reports are generated using Active Server Pages (ASP) served from Microsoft Internet Information Server (IIS).

Workstation computers run a custom-written application developed in Microsoft Visual Basic running on a stripped-down version of the Microsoft Windows 98 operating system. The software is divided into 3 modules: Patient Registration, Outpatient Services and Inpatient Services (Figure 4).

The system tracks patients (children) as they move through the registration process, the paediatric outpatient clinic and the paediatric wards. A flowchart of patient movement through the hospital system is shown in Annex A.

System Functionality

Patient Registration Module

Under normal circumstances all paediatric patients must report to the patient registration desk before they are seen by a clinician. At this time the patient’s hospital visit is logged and they are added to the list of patients waiting to be seen. The Outpatient Waiting List can be viewed from any of the workstations (Figure 4). The patient’s weight is also entered into the computer at this time. A limited set of demographic data is recorded for patients who have not previously been registered in the computer (Figure 1). The demographic variables chosen were first name, last name, sex, day/month/year of birth, traditional authority where born, and area where currently living (Figure 5). Day and month of birth can be left as unknown if necessary. However, if the year of birth is unknown an assessment of the child's age is made and the approximate year of birth recorded. First name, last name and sex are used to differentiate patients when searching the database. Date of birth is recorded for its clinical significance in the diagnostic process, to further differentiate patients of the same name/sex, and to allow aggregate reporting of morbidity and mortality by age group. Traditional authority where born is recorded to further differentiate patients with the same name/sex. The area where the patient is currently living is recorded to allow aggregate reporting by region and to allow for outbreak monitoring. Most of the fields collected can be done by selection from lists as in the example of selecting the area where the patient currently lives shown in Figure 5. However, the first and last name fields must accommodate all possible names and consequently must allow for free text entry. To facilitate this the user is provided with an onscreen keyboard that they can use to type in the patient’s name (Figure 6). As the name is being typed a “shortlist” of common Malawian names appears in the upper right of the screen. If the patient’s name appears in the list the user can simply touch the name to complete the entry. Almost without exception the target user group had no typing experience and consequently had not been exposed to the traditional “qwerty” keyboard layout. Thus it made sense to lay out the onscreen keyboard in alphabetical order to minimize the learning curve.

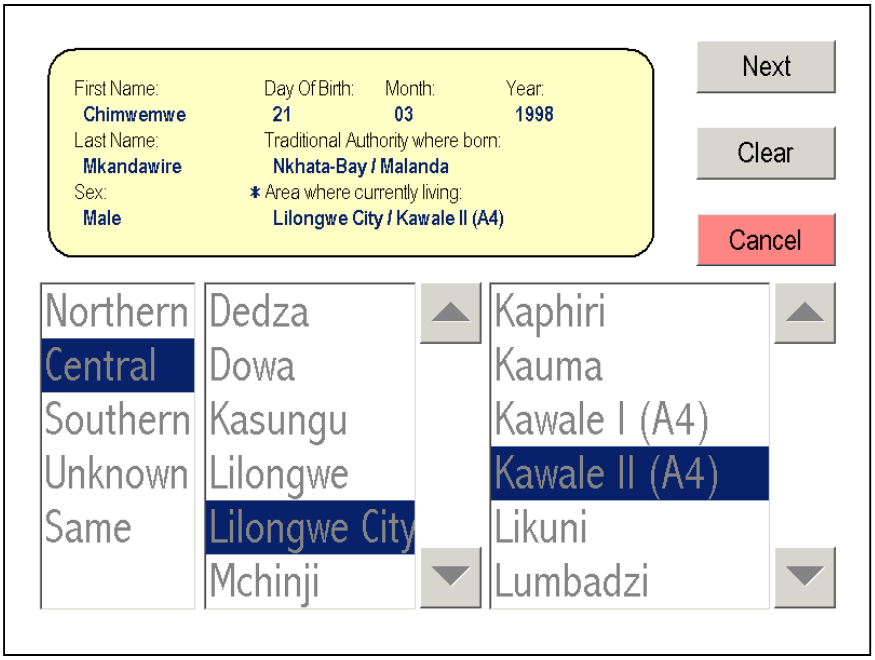

Figure 5 – Entering the location where a patient currently lives

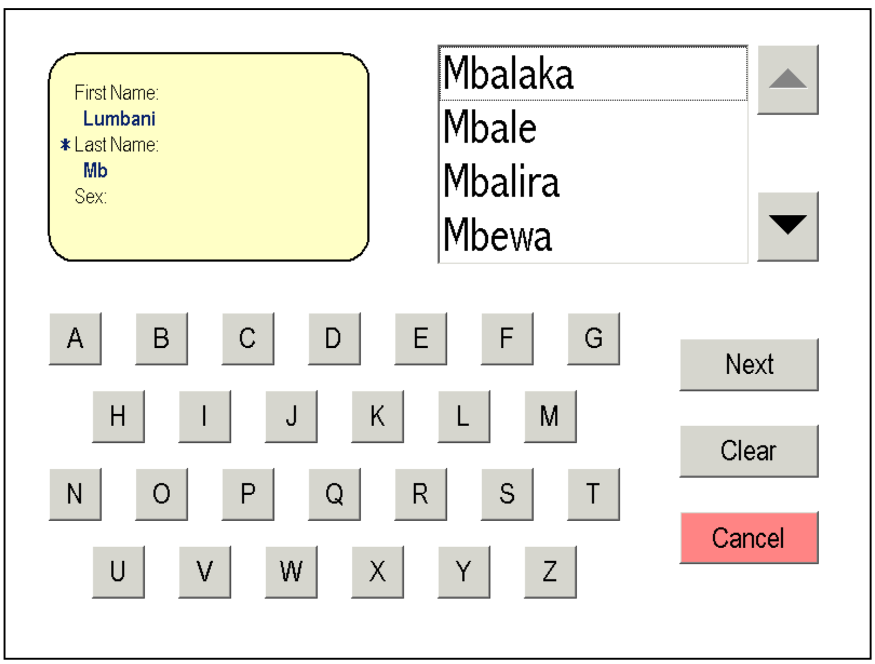

Figure 6 – Entering the last name ‘Mbale’

Once the patient’s demographic information has been entered into the computer the patient is assigned a unique medical record number that can subsequently be used to directly access the patient's information in the system. The same number is used to keep track of the patient’s medical record filed in the paediatric medical records office.

Outpatient Services Module

After finishing at the registration desk the patient waits to be seen by a clinician. Currently between 1 and 3 clinicians practice in the outpatient clinic at any given time. During the encounter the clinician uses his/her workstation to view information collected during the current visit, as well as any information stored in the system from previous visits. The patient's current weight along with weights recorded on previous visits is shown to the clinician in the familiar graphical notation (Figure 7).

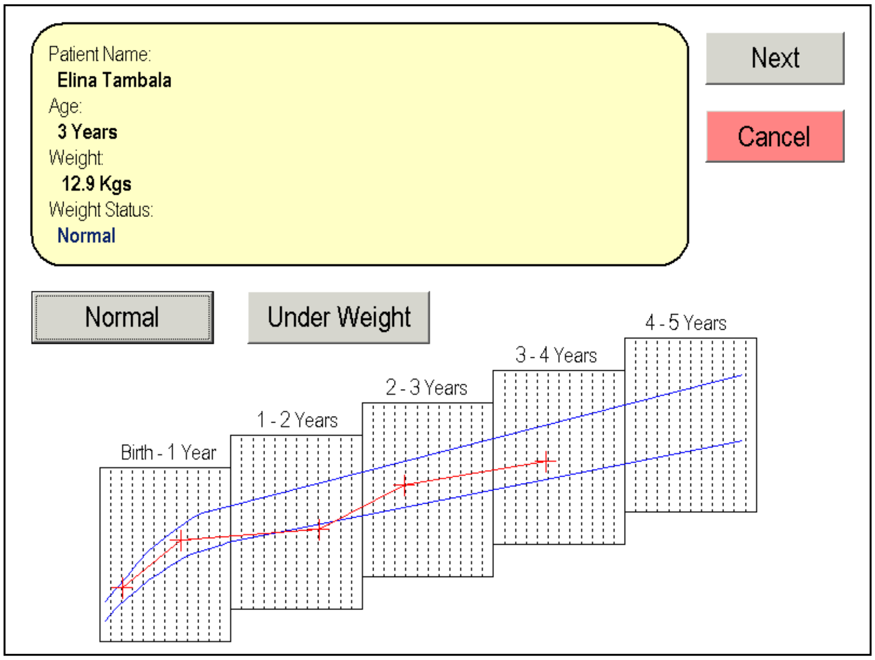

Figure 7 – Growth Chart showing patient's current and previous weights

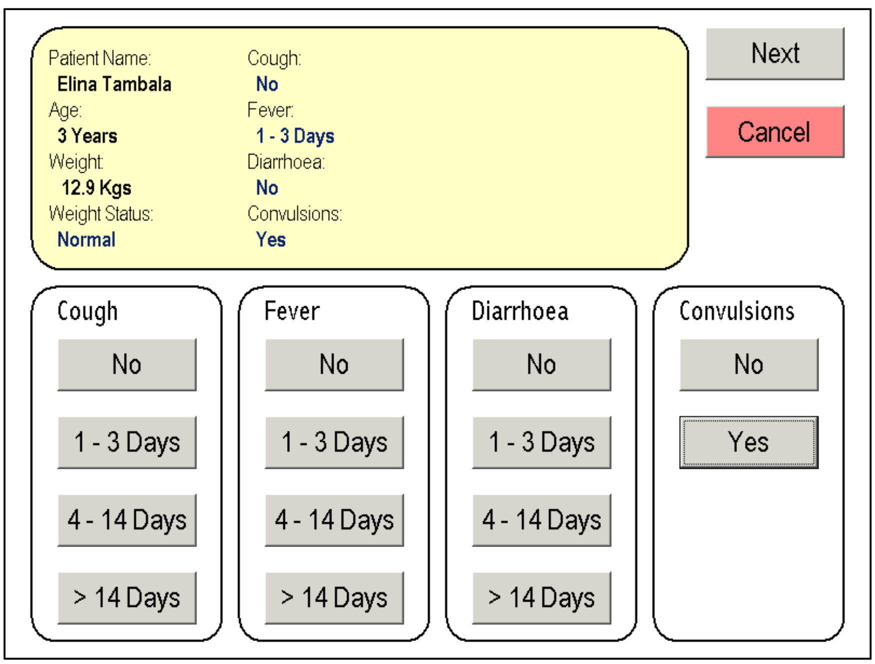

Figure 8 – Four pieces of the patient's history are recorded

After examining the patient the clinician uses the workstation to record 4 pieces of information about the patient's history (Figure 8), 4 pieces of information collected during the physical exam, and his/her diagnoses (Figure 9). The choice of indicators was based on their perceived diagnostic significance in tropical paediatric medicine. It should be noted that these might only be a subset of the evidence considered by the clinician in making a diagnosis. Currently the system does not record treatment. However, this is planned for the next phase of the project. At the end of the encounter the clinician uses the small point-of-sale receipt printer to print an encounter summary for the patient to take with them and the names of patients who meet the criteria for admission are added to the admission waiting list.

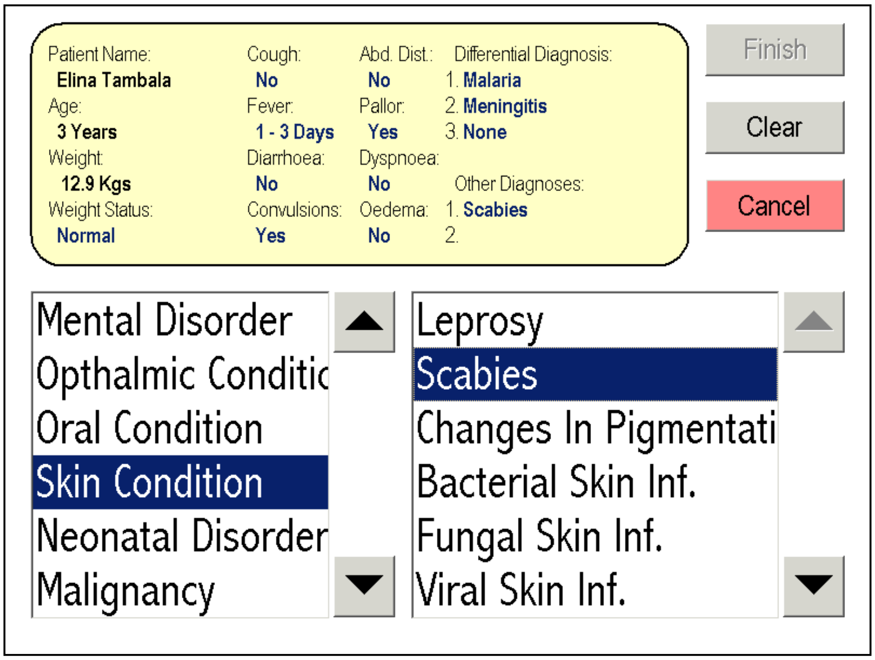

Figure 9 – Several diagnoses may be recorded for each patient

Inpatient Services Module

Patients who require admitting report directly to a nursing station on one of the wards. Using a workstation located at the nursing station the patient’s name is selected from the admission waiting list and the ward onto which the patient is to be admitted is selected from a screen showing the familiar floor plan of the paediatric wards (Figure 10). The floor plan screen shows a census of all wards allowing the user to quickly assess current bed availability. The same screen is used to locate patients on the wards who are to be transferred or discharged. To discharge a patient the user first selects the ward on which the patient is located to bring up a list of patients on that ward. The name of the patient to be discharged is selected from the list bringing up the patient task menu. After selecting the “Discharge Patient” option from this menu the user accepts the current date as the date of discharge, enters the primary and secondary discharge diagnosis from a list of options and prints out a discharge summary for the patient to take with them. Currently the inpatient module is limited to an admission, discharge and transfer (ADT) system. However, additional functionality will be added to this module in the next phase of the project.

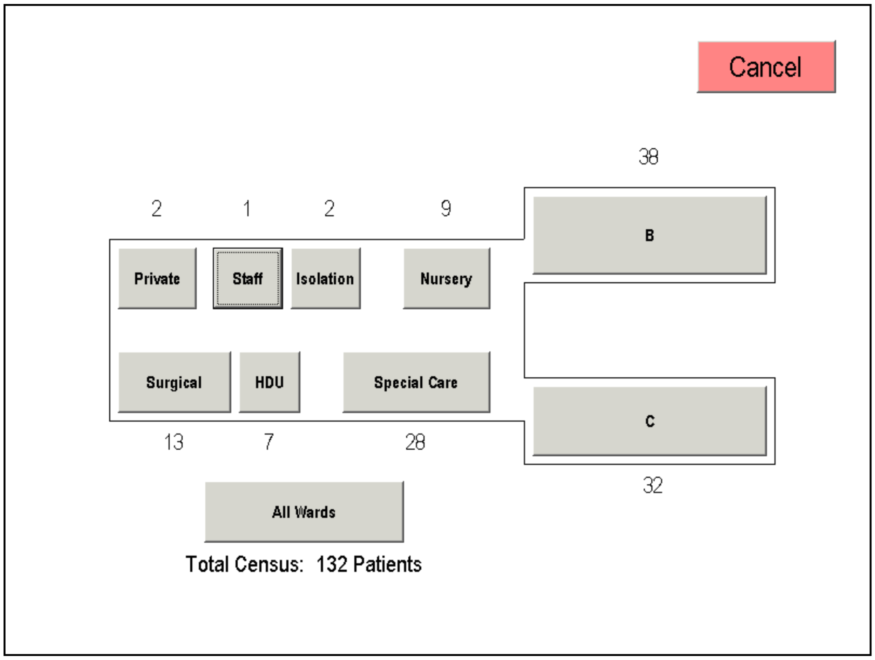

Figure 10 – Floor Plan of the paediatric wards showing current census

Aggregate Reporting of Data

To facilitate aggregate reporting of data collected by the system, two personal computers were connected to the network. The first computer was located in the paediatric medical records office and the second in the office of the hospital information officer. Network cards were installed in each of the computers and network cables run to connect them to the closest network hub. No special software is required to generate reports other than a standard web browser. The server has also been configured for remote dial-up access via a 33.6 KBPS modem and dedicated line.

Deployment of the System

In addition to the system support person three local tradesmen were hired on a short-term basis to help with the deployment of the system. A carpenter, painter and welder/electrician fabricated steel security doors and burglar bars for windows, ran network cables and built the rolling desks that house the clinical workstation hardware.

Once a location had been agreed upon in which the server was to be housed, the room secured and clean power installed, the server was then set up and brought online. Following this, wireless access points were installed on the paediatric wards. Workstations were brought online in four phases starting with the paediatric medical records office. This location was used to field test new software modules and conduct training, both of which were carried out by the two medical record clerks.

The next phase involved bringing the patient registration process online. Two clerks staff the patient registration desk. Training was conducted in short sessions during the late afternoon when the arrival rate of patients is greatly reduced. During the training phase several deficiencies were identified in the system. These were fixed and some fine-tuning done to speed up data entry. After approximately 5 hours of use each the ward clerks were sufficiently comfortable with their speed and accuracy that they were ready to bring the new registration system online.

During the third phase of workstation deployment inpatient services were brought online. This involved locating workstations at each of the three nursing stations. Training was somewhat problematic due to the staff working in shifts. This necessitated conducting some of the training sessions in the evening. Most of the patients on the wards at that time had been admitted prior to the deployment of the registration module and consequently were not registered in the computer. Guardians of non-registered patients were asked to report to the paediatric medical records office where their patients' details were recorded. This registration process was used as a training exercise for nursing staff who would be required to register patients arriving outside normal office hours when the registration desk was closed.

The final phase of workstation deployment was the outpatient clinic. A total of three workstations were deployed. Due to the somewhat higher complexity of this module, workstations were introduced gradually to allow clinicians sufficient time to get comfortable with the system. Clinicians picked up the system quickly with minimal training.

Preliminary Evaluation

User Acceptance and Adoption

Modules have been accepted and adopted by the users with various degrees of success. The most successful module has been patient registration. This may be due to the fact that the registration process is the only responsibility of the registration clerks while nursing staff and clinicians have to focus primarily on their clinical responsibilities.

The nursing staff were less enthusiastic about using the system than initially expected. Some mistrust and skepticism was sparked by an unfortunate rumor that the system was being put into place to monitor them. Recent feedback from the pilot site has indicated that members of the nursing staff have acknowledged some reluctance to use the system. It is unclear at this time whether their reluctance can be attributed to poor usability or other factors. This will be looked into in a follow-up visit to the pilot site in November 2001.

Clinicians were quick to adopt the outpatient module. Several were so anxious to receive their training that they sat with colleagues as they used the system. Suggestions were made by the clinicians on how the usability of the module might be improved and many of these were incorporated into the system.

Usability

Almost without exception all of the nursing and clinical staff had no prior experience with a computer and were unfamiliar with the concept of a touch-sensitive screen. However, staff adapted to the touchscreen interface with minimal training. Most users received between 20 and 40 minutes of one-on-one training.

There is anecdotal evidence indicating that the usability of the system is high. However, a systematic analysis needs to be performed before any reliable conclusions can be made. A usability study will be done during the follow-up visit in November 2001 using observational techniques and analysis of the audit log file.

Accessibility

An adequate number of workstations were used such that accessibility should not have been a problem. However, due to problems with the charging systems on several of the workstations there have been periods of time when users have been required to use an alternate workstation. Due to the real-time nature of the patient registration process and outpatient services, these locations have been kept working by moving workstations from one or more of the nursing stations. It is anticipated that the charging system problem can be resolved during the November 2001 follow-up visit.

Availability & Reliability

In addition to the problem highlighted above regarding the charging system there have been occasional network failures. This is due to the choice of Ethernet hubs used in the cable segment connecting the outpatient clinic to the paediatric wards. These hubs will be replaced during the November follow-up visit.

There have been no reports of system downtime attributable to the unavailability of the server. However there has been one failed attempt to break into the server room during the evening hours.

Security and Privacy

Users appear to be conscientious in maintaining the secrecy of their "secret code". However, no conclusions about the security of the system will be made until an analysis of the system audit log is performed. This activity will be performed on the follow-up trip.

Sustainability

A Malawian has been hired to maintain the system. There have been several problems related to the immaturity of the system that, to his credit, he has tackled and for the most part resolved. Without his resourcefulness and commitment to the success of this project the system might not be functioning today. Nevertheless, while his contribution to date has been essential in keeping the system running, the degree to which the system will require maintenance is expected to decrease significantly as it matures.

Work in Progress

While an infrastructure for generating aggregate reports was put into place during system deployment, little emphasis was placed on providing report formats other than replicating the basic inpatient and outpatient paper registers that the system replaces. A suite of report formats is now being created that provides reports in both tabular and graphical formats.

The rolling desks, while mobile, have proven to be too cumbersome to move from bed to bed during ward rounds and have stayed primarily in fixed locations. Nonetheless, the need for bedside access to information and recording of information is high. Several different designs of a more streamlined version of the workstation that would move easily from bed to bed have been discussed. After further consideration it was decided that wireless handheld computers would better meet the need for bedside use. The handheld platform offers the ultimate in portability and provides a stylus-based interface considered to be equally as user friendly as that of the touchscreen. The Casio E-115 PocketPC computer equipped with a D-Link DCF-650W wireless Ethernet adapter has been chosen as a test platform (Figure 11).

Figure 11 – Casio E-115 PocketPC with D-Link DCF-650W Wireless Ethernet Adapter

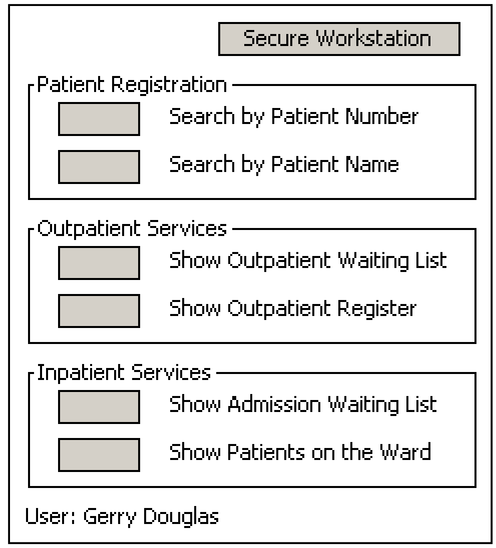

Figure 12 - Handheld interface with 270 x 240 pixel resolution. Physical screen size is 3.4" diagonally.

Five units will be deployed for testing at the original pilot site in early November 2001. Due to the significantly smaller screen size (270 x 240 usable pixels) a separate version of the software is required. Software development is currently in progress using Microsoft eMbedded Visual Basic. Every attempt is being made to model the new screen designs on the existing touchscreen interface to reduce the learning curve for the users (see Figures 4 & 12 for comparison).

Two potential limitations of the handheld platform are the limited capacity of the battery (approximately 3 to 4 hours between charges) and the absence of a printer. It is anticipated that the actual daily usage of the handheld device will not exceed the capacity of the battery. Power settings on the device allow it to power-off during periods of inactivity. The nature of the power save mode allows the user to instantaneously return to the point of departure without having to go through a lengthy startup process. The issue of printing will be addressed by giving handheld users the ability to print on a printer located on any of the existing clinical workstations.

Future Work

Plans are being made to extend the pilot system beyond LCH to cover the paediatric department at Queen Elizabeth Central Hospital (QECH) in Blantyre. One objective of this second phase of the project is to develop an inpatient module for the system based on the clinical pathways that have been developed and are currently in use at QECH. Furthermore it is hoped that this will encourage greater collaboration between the two sites. It is anticipated that this collaboration will improve the generalizability of the information system solution being developed.

As the system matures several facts have become evident. The first observation is that the information needs of healthcare systems in developing countries are more similar than they are different (patient registration, inpatient services, outpatient services, etc.). The second observation is that customization, while traditionally considered to be time consuming can be highly automated and greatly facilitated through the use of pre-built program modules or controls. Lastly, the handheld computer when used as a thin client in conjunction with a server can offer equivalent functionality to that of a desktop or laptop computer at a fraction of the cost and with greater mobility.

Taking these 3 observations into consideration one might envisage a complete turnkey health information system sufficiently compact that it would fit into a suitcase. An entry-level version of such a system might consist of 5 handheld computers, a Laptop computer to be used as a server and a printer, the entire system costing less than $3,000 in total (luggage not included). The system could be preconfigured to meet the most basic information needs of a health facility with the capability of bringing other modules and additional handheld computers online as demand necessitated.

Annex A - Patient Flow Chart

Register Patient (First Visit Only)
(Registration Clerk)

Add Patient to Outpatient Waiting List
(Registration Clerk)

Outpatient Visit
(Clinician)

Home

Add Patient to Admission Waiting List
(Clinician)

Retrieve Old Records
(Ward Clerk)

Admit Patient
(Clinician / Nurse)

Order Studies (e.g. LP, Blood Work, X-ray)
(Clinician / Nurse)

Transfer Patient
(Clinician / Nurse)

Discharge Patient
(Clinician / Nurse)

Home

Annex B - Important Lessons Learned

Try Not to Get Distracted, Focus on Your Objective

As an expatriate working in a developing country one is frequently approached with requests for help from a local person. These requests can come from friends, acquaintances and frequently from complete strangers. They are usually legitimate and more often than not involve requests for money and/or transportation to assist with an emergent medical problem of a family member. One must deal with these requests as one's conscience permits. However it should be noted that a significant portion of one's time could be spent driving between the project site, the bureau-de-change and the hospital. An argument in favor of being "highly selective" in who one provides help to is that time taken away from the project can potentially compromise the outcome having far reaching effects on all the intended beneficiaries. This argument however holds little consolation for the mother of a 6-month-old baby with dehydration and bloody diarrhoea.

Respect Cultural Differences

There were several occasions where members of the staff did not report for duty, the most common reasons being a funeral or a workshop. The phrases "gone for further training" and "temporarily unavailable" were heard frequently during this project. Unfortunately these occurrences, however disruptive, to the project are part of Malawian culture and must be worked around. Doing otherwise could lead to alienation, which would not further the project.

Budget for Security of the Equipment.

At the inception of this project little consideration was given to the issue of equipment security. However, as the project progressed it became evident that the hospital was by no means invulnerable to thieves. This was first made apparent by an attempt to break into the server room. To protect the investment of the system, steel burglar doors were added to the server room, patient registration office, medical records office and the treatment room located in the outpatient area where three of the workstations are stored. Additionally, burglar bars were added to twelve windows. The total cost of security upgrades was approximately $950.

Move Away from Custom Hardware

The workstation platform used in this project was chosen for its cost effectiveness. Unfortunately the integration of the touchscreen interface, addition of the FlashDrive and repackaging of the workstation was very time consuming. In retrospect the cost savings realized using this approach may not have justified the time spent doing the customization. An off-the-shelf solution will be sought for future projects.

Budget Time Realistically

The challenges encountered when working in a developing country can quickly put a project behind schedule. Mandatory holidays, strikes, power failures and the unexpected transfer of key personnel are just a few of the problems that contributed to this project falling behind schedule. In retrospect the amount of time budget to do this project was insufficient.

Do Observational Studies, Don’t Rely on Reports

It became evident at the beginning of the project that many people, when asked to describe an aspect of their daily activity, subconsciously portrayed it the way they believed it should happen and not necessarily in the way it actually happened. Observational studies provided a means of verification ultimately leading to a better understanding of how workflows and processes actually worked.

“Wireless Networking” Still Requires Wires

Due to the large area that required wireless coverage a total of 6 wireless access points were required. Connecting each access point via hubs back to the server required the installation of over 2,000 feet of Category 5 network cable and conduit. This process was very time consuming due to the concrete wall construction of the building. The routing of cables to different locations within the hospital frequently required drilling through 10-inch thick concrete walls. For future projects more time will be budgeted for running network cables.

Centralize Power for Wireless Access Points

On a technical note, centralizing the power supplies for the wireless access points proved to be a good technique. This was achieved by feeding the power to each wireless access point down the unused wires in the network. Removing the necessity of having to locate access points close to available sources of power provided the flexibility to place them in a location that afforded the best wireless coverage. Furthermore, bringing all the power supplies to one location allowed for easy battery backup. Since all network cabling originates from the server room, the network electronics were backed up using the same backup system as the server.

Annex C - A Framework for Planning Similar Installations

Other sites interested in installing a similar system should contact the Baobab Health Partnership to get the most current information about the status of this project and the availability of system software. Before undertaking a similar project sites should consider the following checklist:

- Does the project have the support of management?
- Is the target user group receptive to the introduction of the system?
- Can a post be created for a person to maintain the system and conduct user training once the system is deployed?
- Can a post be created for a person to conduct monthly quality assurance audits to verify the completeness and accuracy of the data being collected?
- Can a post be created for a person to run monthly reports and distribute them to the appropriate recipients (both internal and external)?
- Is there a secure location where the database server can be housed?
- Can funds be allocated to pay for consumables?