Mobile Technology as an Optimal Method for Assisting in the Management of Diabetic Patients in Kenya

by
Adam Lee Turner

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Abstract

The burden of diabetes is no longer restricted only to high income countries. The global incidence of diabetes is rising as many low-income countries are transitioning into altered diets and increasing urbanization. Kenya has a diabetic prevalence ranging from 3.3% to 12%, depending on the population measured. This article explores the current Kenyan health sector regarding diabetes management with the objective of delivering methods to improving health outcomes, while saving money in healthcare expenditures. In 2010, only 23-30% of the non-diabetic population had a "good" understanding of diabetes. As one of the first national efforts, the Kenya's National Diabetes Program 2010-2015 was launched to strengthen diabetic care within the country through targeted categorical interventions. The interventions are working but their efficacy may be limited by low healthcare workforce capacities, short-term educational engagements, geographic distribution of care, and healthcare expenditures. Alternatively, Kenya's mobile technology marketplace is robust and growing with one of the most advanced mobile banking systems globally. Moreover, studies have confirmed telemedicine interventions work in chronic care management in Kenya. Consequently, a mobile assisted management system is proposed to aid Kenya's patients, healthcare workers, insurance providers, and the ministry of health (MOH) in diabetic management. The proposed system's core components are as follow: 1) cellular glucometers for patient blood glucose measurement, tracking, and education, 2) patient application for health information, 3) healthcare worker application for patient management and communication, 4) insurance and MOH applications for broader drug and patient management. These components, used together, can improve patient outcomes and save money in health related expenditures. It is recommended that the NHIF and MOH conduct a pilot of this system with the diabetic population to further evaluate healthcare and cost efficacy.

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List of Abbreviations

CKD	Chronic Kidney Disease
CVD	Cardiovascular Disease
CHW	Community Health Worker
HbA_{1C}	Glycated Hemoglobin
EHR	Electronic Health Record
EMR	Electronic Medical Record
GNI	Gross National Income
IDF	International Diabetes Foundation
IGT	Impaired Glucose Tolerance
KNDS	Kenya National Diabetes Strategy 2010-2015
Ksh	Kenyan Shilling
MOH	Ministry of Health
MPHS	Ministry of Public Health and Sanitation
MAM	Mobile Assisted Management
NACC	National AIDS Control Council
MMT	Mobile Money Transfers
NHIF	National Hospital Insurance Fund
NGO	Non-governmental Organization
SMS	Short Message Service
OOP	Out of Pocket
SSA	Sub-Saharan Africa
THE	Total Health Expenditure
UI	User Interface
USD	United States Dollars
WDF	World Diabetes Foundation

Background

Diabetes Across the World

The burden of diabetes is no longer restricted to high-income countries. The global incidence of diabetes is increasing as many low-income and middle-income countries are transitioning into different diets, increasing urbanization, and living more sedentary lifestyles.[1] While the prevalence of diabetes still may not outweigh the prevalence of other communicable diseases in many low-income nations, it may quickly become a financial liability, especially if patients are poorly managed.[2,3] For technical reference, the World Bank classifies countries into different economic categories by their gross national income (GNI) per capita. The full classification as provided by the World Bank is listed in Table 1.

Table 1. Country Economy Classifications[4]

Country Classification	Gross National Income per Capita
Low-income	$ 1,035 or less
Lower-middle-income	$ 1,036 - $ 4,085
Upper-middle-income	$ 4,086 - $ 12,615
High-income	$ 12,616 or above

In high-income countries diabetes is one of the leading causes of illness and leads to numerous other life changing complications.[5] Currently, high-income countries expend more resources on diabetes, than middle- and low-income countries, despite the higher burden of disease in these countries. The higher burden of disease is due in large part to the greater populations in the middle-income countries. Table 2 more fully explains the substantial differences between income, prevalence percentages, and current expenditure as documented by Bloom and colleagues.[5(p25)]

Table 2. Cost of Diabetes: Breakdown by Economic Classification for 2010[5(p25)]

Income Group	Direct Costs (Billions)	Population with Diabetes (Millions)	Direct Cost as % of World Total	Indirect Costs as % of World Total	People with Diabetes as % of World total
High	$341.5	74.7	90.8	49.8	26.2
Upper Middle	$28.1	96.1	7.5	36.8	33.8
Lower Middle	$6.0	97.5	1.6	12.6	34.3
Low	$0.4	16.2	0.1	0.8	5.7
Total	$376.0	284.5	100	100	100

Most projections show the global prevalence of diabetes continuing to grow from 6.4% in 2010 to 7.7% in 2030.[1(p7),6] This forecast is primarily accounted for by increased diabetic prevalence in middle- and low-income countries.[1(p7)] It is expected that these countries will experience greater changes due to increasing urbanization, lifestyle, and diet than high-income countries. Correspondingly, total expenditures on diabetic care made by the middle- and low-income countries are estimated to overtake the total expenditures of high-income countries by 2030. Bloom et al. project that high-income countries will be spending less and that middle- and low-income countries will be spending more in direct cost for diabetes management and more for indirect cost associated with diabetic complications.[5(p24-25),6(p299-300)]

Diabetes in Sub-Saharan Africa

Focusing on a smaller geographic subset, Sub-Saharan Africa (SSA) has not been immune to the changes in the incidence and prevalence of diabetes over the past few decades. A listing of SSA countries, as defined by the United Nations, are listed in Appendix A for reference.[7] Hall et al. explains the reported diabetes increase in SSA has been solely accounted for by type 2 diabetes due to incomplete

survey data on both type 1 diabetes and gestational diabetes. Historically, research and reporting data for Type 1 and gestational diabetes has not existed or has been founded on previously diagnosed cases, instead of representative population surveys or screenings.[3(p8),8] In fact, SSA is projected to experience the greatest percentage increase in prevalence over the next 20 years, going from 12.1 million in 2010 to 23.9 million in 2030, a 98 % increase.[1(p7)] While the overall number of people affected by diabetes will likely remain higher in Asia, North America and other regions, the incidence rate in Africa appears to be escalating at a faster rate.[1(p8)] The rise in SSA is generally thought to be due to common risk factors such as urbanization, diet changes, obesity and inactivity.[2(p102)] The rising incidence may reflect an increase in risk factors rather than any medical anomaly. Genetic predisposition or vulnerability has also been mentioned by multiple researchers but Cruickshank et al. discovered that caloric imbalances and "intergenerational socioeconomic influences" are more influential in the development of diabetes than genetics.[9] Even so, the SSA prevalence increase necessitates an intervention, especially as researchers Azevedo and Alla have discussed, this region has struggled with diagnosis, education, and medical resources.[2(p103-106)] If diabetes and its complications were well managed in this region, the increase in prevalence might not be as alarming. However, the complications of diabetes, including cardiovascular disease, nephropathy, neuropathy, amputations, acute metabolic complications and more, make the disease much more problematic. Indeed, Azevedo and Alla found that the most common causes of death among Africans with diabetes are infection and acute metabolic complications. Conversely, In high-income countries, the common causes of death in diabetic patients are renal and cardiovascular complications.[2(p103),10] This significant variation begins to describe the struggles individuals face in SSA in managing their diabetic illness. Additionally, SSA is thought to suffer from the highest rates of undiagnosed diabetes in the world,[11] placing extra burden on the individual and the economies of SSA.[8(p2254)] The International Diabetes Foundation (IDF) estimated that 62% of the total diabetic population in SSA was undiagnosed as of 2013 (ages 20-79 years). Overall, SSA prevalence is at 4.8% for those 20-79 years of age (2013).[11(p57)] The purpose of this paper further narrows the area of focus to Kenya.

Diabetes in Kenya

Kenya is located on the East African coast at the equator with a population of 43.18 million[12] (2012), of which, 24% (2011) live in an urban setting.[13] Over the past few decades Kenya has seen increasing economic growth, yet according to the World Bank, it still remains a low-income country with a GNI of $860 per capita as of 2012.[14] Nevertheless, Kenya has been outperforming the average economic growth of low-income countries since 1995.[12]

Along with this economic growth, the prevalence of diabetes in Kenya has been increasing with estimates and survey data ranging from prevalence at 3.3% (as of 2010)[15] in rural environments, to 6.6% (2008 survey)[16,3(p3)] and up to 12% (2009 survey).[3(p3),17] The discrepancies in prevalence rates are primarily due to different survey techniques, definitions, and survey locations. For example, the 2009 Christensen et al. study, responsible for the 12% prevalence finding, was measured from a completely urban environment comprised of type 2 diabetics and patients with impaired glucose tolerance (IGT).[17(p306)] Nevertheless, the Kenyan National Diabetes Strategy states the 3.3% is an underestimation of prevalence because of the undiagnosed population.[15(p3)] In 2013, the IDF reports the Kenyan national prevalence at 3.58% and at 4.56% when adjusting for Kenya's population age profile.[11(p120)]

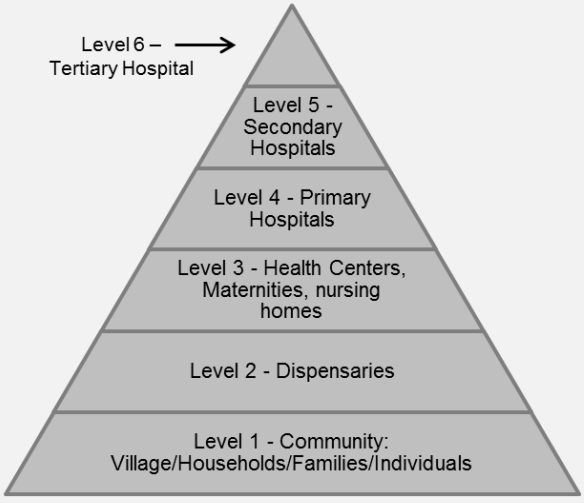
While Kenya does not experience the highest diabetic prevalence rates in the world, it historically was not focusing significant resources on diabetes management or prevention until around 2010. This is evident by reading the Kenyan report: Kenya National Diabetes Strategy 2010-2015.[15(pv)] To date, diabetes is the only non-communicable disease that Kenya has a national initiative to fight. All the same, Kenya is now dealing with a historical unobstructed rise in incidence of diabetes and its related complications. As the prevalence and incidence of diabetes grow, the Kenyan government has realized the importance of managing diabetes to curb the its major complications such as: nephropathy leading to chronic kidney disease (CKD), hypertension, cardiovascular disease (CVD), blindness, neuropathy, and more.[15(p6)] According to Mwendwa et al., in a 2005 cross-sectional study of persons with type 2 diabetes in Kenya, with an average duration of diabetes at 10.3 months, individuals had: a 7% incidence of retinopathy; 50% with hypertension; 25% with micro-albuminuria; 1% with macro-albuminuria; 40%

with a high LDL cholesterol measurement; and 66% of these were obese.[3(p7),18] Additionally, only 29% had glucose control in ideal ranges.[18] Other studies, not necessarily from Kenya, show an increase in acquiring other co-morbidities not typically thought of with diabetes. Across numerous geographic regions and income classifications, meta-analysis by Jeon and Murray found diabetes was associated with a threefold increase in risk for developing tuberculosis.[19] Other studies show a 25-75% increased risk for pneumonia,[20,21] pneumococcal bacteremia,[21(p8),22] and a 2.5 chance of developing sepsis.[21(p9),23] These severe complications, partially attributable to diabetes, often require hospitalization increasing the financial burden of the disease.

Kenya's Health Infrastructure

Kenya's overall health infrastructure consists of the following types of organizations: ministry of health (MOH) and public health services, private enterprises, non-profits, and non-governmental organizations (NGOs). Health services are classified into tiers ranking from 1 to 6 with level 6 representing a referral hospital, with the highest ability to provide care. Figure 1 defines each level, showing a progression of service ability, however the number of these organizations decrease as one moves from 1 to 6.[24] Based on Kenya National Bureau of Statistics data from 2011, there were 7,549 physicians or 0.181 per 1,000 population. Similarly, in 2011, there were 0.792 – 1.26 nurses and midwifes per 1,000 population, depending on the type of nursing qualifications used in the calculation.[25] Despite Kenya's economic growth, the physician ratios are relatively low in comparison to other regional African nations.[26,27] Additionally, nurses have been unemployed or underemployed due to hiring and/or wage ceilings, even up to 50% during some

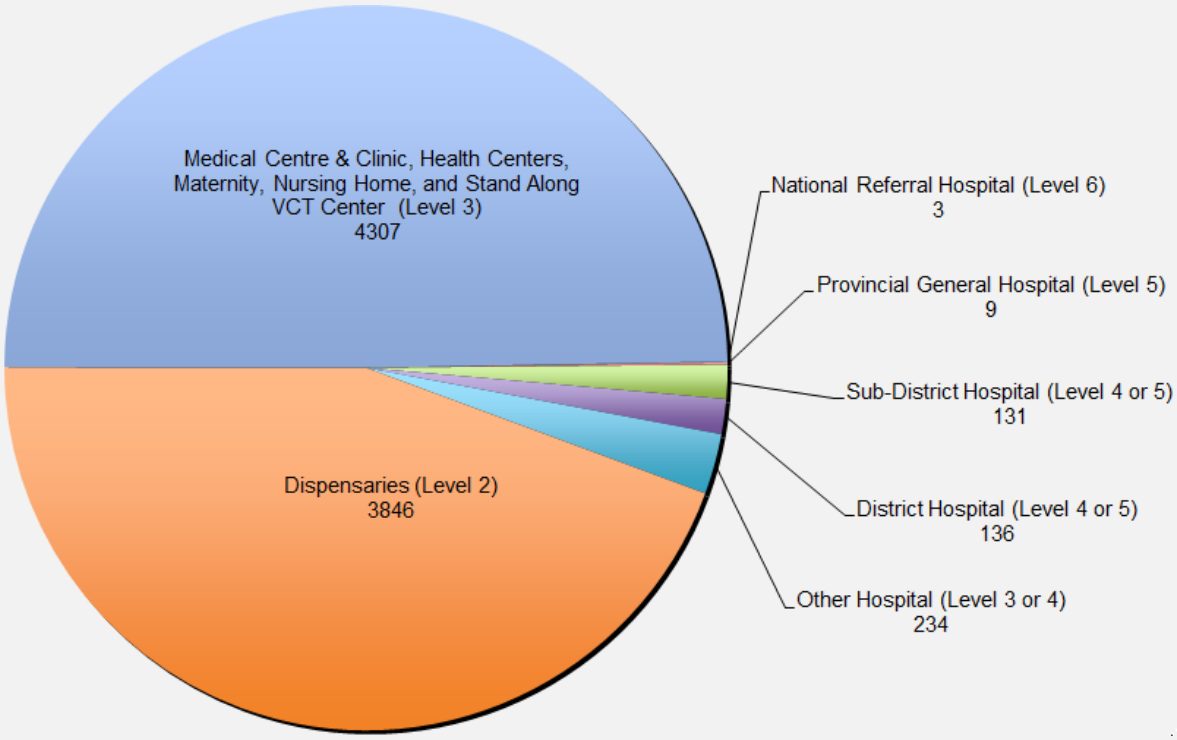
Figure 1. Kenya's Health Services Rankings[24(p8)]



years bringing the nurse to population ratio much lower. Furthermore, due to these issues the healthcare workforce has experienced heavy migrations out of the country to work elsewhere.[27(p73)]

As another measurement of healthcare availability, based on current MOH data as of 2014, there are 115 hospitals in Kenya with 100 beds or more and only 46 with 200 beds or more. In 2010, the World Bank reported the inpatient hospital availability equated to approximately 1.4 beds per 1000 population.[28] Beyond hospitals, there are numerous health centers, medical clinics, and dispensaries distributed throughout the country, which focus on care in the outpatient setting. According to work done in 2008 by Noor et al. there has been significant improvement since 2003 in the number and distribution of healthcare facilities throughout the country, with 89% of the Kenyan population within 5 kilometers of public health facility. Of the remaining population, 80% were found to have lived in sparsely populated areas.[29] USAID[30] listed the dispensary count in 2004 at 1,540 and the Ministry of Health database[31] listed the 2014 count at 3,846 in operation. It is difficult to know if both listings are accurate, but the numbers are presenting significant (approximated to be two-fold) growth in infrastructure over the past 10 years. Figure 2 shows actual number of facilities broken down by number for a better mathematical understanding.

Figure 2. [a]Kenyan Health Facility Numbers by Type [31]



Type of facility, followed by the level of facility, followed by number of facilities in country

[a]Adapted from eHealth-Kenya Facilities online database

Beyond the density and distribution of health workers and facilities, equitable access to care is an ongoing process. Munge and Briggs claim the distribution of private-for-profit enterprises are concentrated in the higher tiers (hospitals) while public or governmental institutions are more frequent in the lower tiers.[32] This pattern has historically had negative effects on equal access to healthcare. Research performed in 2003 and 2007 by Chuma et al. has indicated that private-for-profit healthcare service delivery favors wealthy individuals over the poor population. This was especially true for inpatient services.[33] Diabetic patients are not immune to these issues, more often than not, requiring specialized patient care.

Kenya's Need Moving Forward

Kenya's growth in diabetic patient population is unlikely to be met by an equivalent growth in their healthcare workforce, facilities and financial support. Additionally, the current patient load is not being fully cared for, primarily because of a lack of resources. Therefore, it is the aim of this paper to outline a promising strategy for the use of mobile technologies to assist in diabetic patient management. Mobile technologies have been proven to be effective at assisting both the healthcare provider and patient with management of care.[34–37] Care providers can have a better insight into their patients' actions, are able to manage a higher number of patients, and are alerted when patient circumstances need immediate attention. Most importantly, mobile technologies could aid patients in education and self-management, which increases buy-in, leading to better outcomes. Portions of Kenya's infrastructure, evidenced by their mobile banking infrastructure, make it an exceptional candidate towards implementing a leading mobile health strategy.

Methods

A search for relevant published papers in the past ten years was conducted (2003-2013). The primary search scope started broadly by searching for global trends about the prevalence of diabetes, narrowing into the SSA region, and then narrowing to Kenya. Therefore, this strategy combined the words "global or world," "Sub-Saharan Africa," and "Kenya," with the following search terms: "diabetes prevalence," "diabetic complications," "diabetes management," "diabetes self-management incentives," "chronic-care management", "low-income chronic-care," "mobile technology," "mobile glucometer," and "glucometer technology." All searches were performed through the University of North Carolina at Chapel Hill's institutional connection to Google Scholar; therefore, excluded sources were those inaccessible to Google Scholar or those requiring a paid subscription outside those presently available to the University. Often content and references from these articles prompted directed searches for the primary research source. Google Scholar was again used for this purpose. Lastly, the following grey literature sources were used for their valuable content: The Communications Commission of Kenya, eHealth-Kenya Facilities, GSMA

Intelligence, IDF, Kenya Health Information System, The World Bank, The United Nations, and The World Health Organization.

Results

Current Kenyan Programs to Manage Diabetes

In 2009, The World Diabetes Foundation (WDF), in coordination with the Ministry of Public Health and Sanitation (MPHS), developed a project for Kenya entitled, "The National Diabetes Programme." This project called for "strengthening the healthcare system to address diabetes by building capacity for the health facilities and increasing community participation in health care delivery."[38] The primary action was to develop a strategic guideline and action plan, which the Kenyan MOH initiated the following year with the help of a few organizations and funding by the WDF. The guide, known as the Kenya National Diabetes Strategy 2010 – 2015 (KNDS), is a multi-faceted strategy to "consolidate and improve the quality and coverage of diabetes care services in Kenya."[15(pv)] The document has the following eight "key strategic interventions":[15(px-xi,10-14)]

1. Advocacy
2. Empowerment
3. Resource Mobilization and Prioritization
4. Capacity Building
5. Partnership and Coordination
6. Diabetes Policies, Legislation and Regulations
7. Research
8. Monitoring and Evaluation

Each of these strategies have corresponding action items, monitoring indicators, time periods, lead agency responsibilities, and partnership recommendations.[15(p15-24)] The WDF-initiated program has set high standards and Kenya has met a few of them as of 2013, even as the project continues. Importantly, Kenya has delivered on the expectation of a national strategy, outlining further action plans. As reported on the WDF website, awareness meetings and screenings have largely been successful, with meetings reaching an estimated 8 million people. Screenings have revealed over a thousand new diabetic patients, out of the 27,964 people screened. This represents almost 18,000 more participants screened beyond the

expectation. A total of 83 care clinics have been established since the 2009 WDF program launch date. [38] Before this particular program, the WDF completed two previous programs in Kenya targeted at diabetes, specifically for enhancing diabetic foot care and diabetic awareness through preventative care and enhancing care.[39,40] Both were mostly successful according to the WDF results. The National Diabetes Programme initiated in 2009 is ongoing, but the results for the Diabetes Management & Information project ending in 2010 are listed in Table 3 below.

Table 3. WDF Diabetes Management & Information Project Expectations versus Results[39,40]

Expectations	2010 Results
42 diabetes clinics established	32 diabetes clinics established in district hospitals
200 mini-clinics established	91 diabetes mini-clinics at dispensaries and health centers
500 doctors trained	736 doctors trained
1,000 para-medicals trained	839 paramedics trained
3040 nurses trained	2,234 nurses trained
250 dieticians trained	393 dieticians trained
2,500 lay educators trained	4,169 lay educators trained
250,000 people diabetics receive education annually	no data available
5 million people educated on risk factors & healthy lifestyles	4.4 million reached by 4-6 hour awareness activities
no data available	663,203 people reached by one-day education sessions
no data available	121,763 screened with 13,029 with diabetes of which 1890 were not aware of their condition

Kenya's Education Level on Diabetes

In 2010, Maina et al. were able to show that only 23-30% of the non-diabetic population had a good understanding of diabetes' signs and symptoms, its causes, and complications. Conversely, 70-77% had little to no knowledge on these three scales.[41] Slight variances depended on education level attained and country district.[41] Recent data was not found for diabetes related education of the diabetic population. While the general public's education appears to be lacking, education for healthcare workers is improving, through the WDF program mentioned above. Training has not fully met the WDF goals, but

time still remains and significant headway has been made. Results to date for the WDF's National Diabetes Programme are as follows: "95 doctors, 439 nurses, and 553 paramedics have been trained."[38]

Kenya's Economics of Health

In 2001, African Union countries, including Kenya, pledged to spend at least 15% of their annual budget on improving the health sector.[42] As of 2009/10, health sector expenditures were at 4.6% of the total governmental expenditure, a drop from 2001/02 at 8.6% and well below the targeted 15%.[43] According to an interview with S. Masinde (Mar 2014), the MOH covers a significant share of cost at the lower levels of care within public facilities. The major items discussed regarding MOH coverage were as follow:

- Most primary care is free at health centers and dispensaries (both level 2 facilities) but drugs are usually not free.
- Secondary level of care (level 3 and 4 Facilities) often requires a fee of 10 or 20 Kenyan Shillings (Ksh) but after that fee is paid, care is free and the MOH pays for it. The patient is responsible for overnight ward charges that cost around 100 Ksh per night/day.
- Maternity care is usually always free.
- Basic surgeries at level 3 and 4 cost around 10,000 Ksh to the patient and the MOH covers the rest of the cost.
- At level 5 and 6 facilities, the typical cost to the patient for surgery rises significantly. Also, at levels 5 and 6, public ward cost are typically 200 Ksh per day/night and at level 6 hospitals, private room cost can be up to 1,500 Ksh per day/night for the patient.

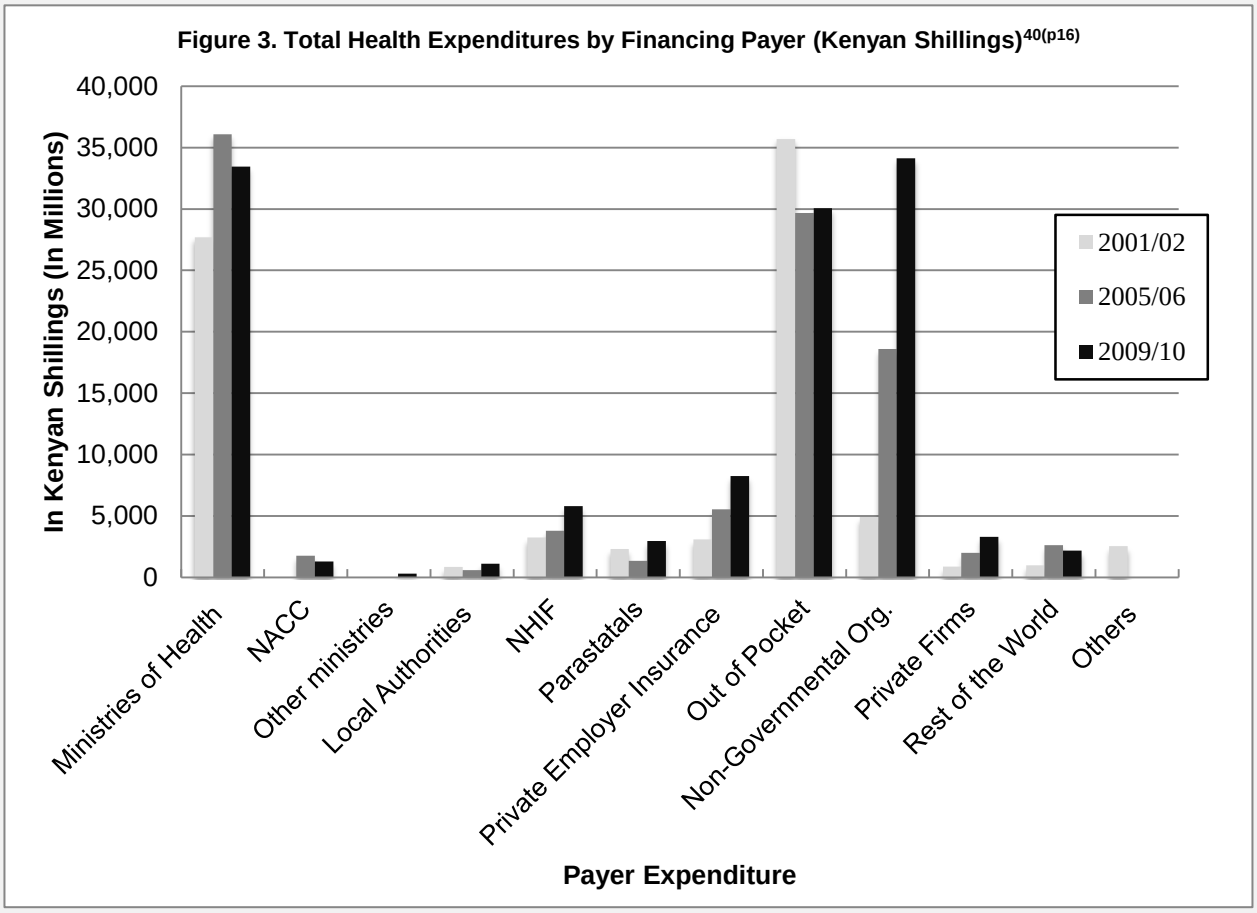
In 2005-06, approximately 10% of the population was covered under some form of insurance and the National Hospital Insurance Fund (NHIF) accounted for 40% of that insurance market share. The remaining 60% was covered by private insurers.[32(p3)] By 2012, the NHIF projected its insurance base at 20% of the country's total population, but the benefits provided were almost solely for inpatient services.[44] Of the 20% covered, civil servants and disciplined service members are given extra benefits beyond the standard coverage, in accordance with a government contract.[45] Membership to the NHIF is mandated for those working in the formal sector and for their dependents. Formal sector employment is typically made of professions and jobs that are taxable by the government. As of 2014, formal sector premiums range from 30 Ksh for a person making 1,000-1,499 shillings per month, up to a premium of

320 Ksh per month for those making 15,000 Ksh per month or more. The level of benefits paid out by the NHIF depends on the type of institution where the patient receives care. Category A facilities are always public institutions that are NHIF accredited and benefits are typically 100% paid by NHIF for inpatient services. Category B institutions are typically private, mission based institutions and NHIF pays for most services in these facilities outright, but will charge a copay for required surgeries. Finally, category C institutions are private facilities and the NHIF will pay an unspecified amount for services at these locations.[45] Table 4 gives a summary of the NHIF accredited facilities based on self-reported NHIF data. Healthcare received in foreign countries may actually be reimbursed if the patient qualifies. Most patients under NHIF would only qualify for a 1,700 Ksh payment per day for foreign care. However, civil servants and those in the disciplines services are able to receive extra benefits. While completely dependent on job category, some civil servants and disciplined services workers have no cap on their benefits. Most of the widely published benefits are related to extra outpatient services and diagnostics.[45]

Table 4. NHIF Accredited Hospitals by Category[45]

Type	Accredited Hospitals	Total Beds in Category Group
Category A	152	20,137
Category B	172	11,441
Category C	128	5,516
Grand Total	**452**	**37,094**

Other payers, including individuals, account for a significant portion of the total health expenditures (THE). The majority of citizens that are unemployed or who work in the informal sector are not covered under any health insurance plan and pay by out of pocket (OOP) expenses, by MOH subsidies, or through NGO benefits.[32(p2)] In Kenya, OOP expenses are customarily paid up-front, before healthcare service is rendered, which can be significantly burdensome for those in need of care in a short period of time.[32(p7)] Payments for all healthcare expenditure can be broken into the following categories as defined in Figure 3.



Adapted from Kenya National Health Accounts 2009/10 with source data in Appendix B.

Overall the cost of diabetes is the summation of medical visits, medications, diabetes supplies, travel costs, loss of productivity, and possibly hospitalization.[46(p15)] The annual cost to care for diabetes and diabetic complications in Kenya as a whole is estimated at $ 22,073,370 (USD) in 2010, which equaled approximately 5% of Kenya's total health expenditures (THE).[6] Kenya's expenditure by type of service is known for the THE (Figure 3), but it is not broken into care categories for disease-specific considerations such as diabetic care. Total direct cost for medications and care were not available at the time of this writing. However, it is known that the NHIF does cover medication and supplies for most inpatient visits, and if the beneficiary is a civil servant or disciplined services member, they qualify for further coverage of medication and supplies on an outpatient basis. For those not covered under the NHIF, most medications and supplies must be covered by OOP. Of the commonly known complications,

from diabetes, there is some economic data available for caring individuals with nephropathy. Hemodialysis, which is required in patients with severe diabetic nephropathy, reportedly costs between $50 (USD) per session[47] up to $173.00 (USD) per session,[48] of which NHIF may pay up to 2,300 Ksh[49] ($26.47 USD on March 26th, 2014) that represents less than 25% of the estimated average cost. As of 2012, there were only about 100 dialysis machines working in the country, leaving many in need without access to this treatment.[50] Another example relates to diabetics suffering from renal failure. Kidney transplants are the last remaining option for those in renal failure and with an identifiable suitable donor. These procedures cost on average $17,500 (USD) in India[51] and around 500,000 Ksh ($5,755.00 USD on March 26th, 2014) at Kenyatta Hospital in country.[52] Many patients may go to India for this procedure for the high standard of care, reported good outcomes, shorter waiting times, and increasing popularity (S Masinde, oral communication, Mar. 2014). Another serious complication which carries significant burden for the payer and patient both is lower-limb amputation. Ogeng'o et al. found significant results when studying amputation caused by diabetes versus non-diabetic amputation. Unfortunately, in Kenya, like other geographical regions, diabetics often suffer greater levels of infection post-amputation than do non-diabetics. The average post-amputation hospital stay in Kenya was observed to be 11 days for non-diabetic patients and up to 19 days for diabetic patients, resulting in significant added cost.[53]

Another readily available cost approximation at the individual patient level, is the cost of insulin; under the new Novo-Nordisk distribution plan, it is about $0.20 per day or $73 (USD) per year.[54] In early-2012, Novo Nordisk partnered with Kenya to provide subsidized access to insulin throughout the country.[55,56] As of early 2013, this partnership has brought insulin access to about 2,600 patients and lowered the unit cost of an insulin vial from approximately $21.60 to $6 USD.[56] Previous studies revealed a history of poor distribution of subsidized insulin and medication, even a markup of subsidized pricing to generate profit.[57] Medication access at the rural local levels is notably the worst.[57(p128)] To battle price markups, in 2010, Novo Nordisk pre-stamped the cost of the insulin vials with the price and signed memorandums of understanding with every portion of the distribution chain.[58] Before the recent 2012 partnership, Novo Nordisk remarked that the Kenyan government bought insulin "based on budget,

not on need" which often led to shortages.[57(p128)] Current data out of Denmark regarding the renewed partnership shows gains in increased insulin availability and compliance by distributors,[58] but long-term evidence has yet to be gathered.

Kenya's Technological Infrastructure

Kenya's growth in mobile infrastructure over the past 10-15 years has exceeded expectations. Safaricom, the largest network provider in country with 65% market share (2012),[59] is one of Kenya's largest companies by market value.[60] Three other companies compete heavily with Safaricom: Orange, Airtel, and Yu.[61,62] As of 2014, cellular subscriptions have risen to about 32.3 million, which equates to approximately 72% of all Kenyans owning a personal phone;[62] and a 2010 survey has shown that 90% have access to a phone even when they may not personally own the device.[63] Ownership of a personal computer is much lower, but growing. Wireless technologies in use range from 2G, 3G, limited 4G, and WiMAX technologies. 4G technology exist in Nairobi and Mombasa, but is currently heavily restricted by the government due to governmental plans to roll-out a joint venture with the four large telecom companies.[64] The Kenyan cellular network covers about 96% of the population based on where Kenyans actually live.[62] About 98% of these connections are on a Pre-Paid basis,[62] the standard in low-income countries. Another large use of cellular devices in Kenya comes by way of mobile banking or mobile money transfers (MMT). There are currently 25.1 million subscriptions to this service.[65] Safaricom maintains the highest market share, as they were the company to start the service through their M-PESA program.[59] In 2010, data showed that 4.26 billion USD had flowed through MMT, which was 13.3% of the country's GDP.[66] Lastly, feature phones currently dominate the market with 83.9% of the market, but smartphone adoption has been increasing. While estimates vary on adoption rate and market penetration, according to InMobi analytics, smartphones accounted for 14.4% of the phone market in Kenya in late 2013.[67]

Current Technology Available for Diabetic Chronic Care

In 2002, LG was one of the first mobile phone companies to release a glucophone, a phone with the ability to read glucose tests.[68] The purpose was to give users an easy alternative to the basic glucometer and be able to send the important data to their clinician. As the first of its kind, the data sending abilities operated through Short Message Service (SMS). Ten years later, Telcare, a US based company, is now producing a dynamic glucometer with cellular sending and receiving abilities, which meets both FDA and HIPAA requirements in the Unites States. The Telcare BGM lacks traditional voice capabilities, but has enhanced the user interface, patient, and clinician experience.[69] Bluetooth enabled glucometers and direct connect glucometers are also widely used as an added appendage to a smartphone with a smartphone application. A sample listing of previous and current mobile glucometers, sorted by abilities, is available in Appendix C. These devices use various techniques to send measurement data to the central database and the most efficient devices (though with a higher purchase price) use built-in cellular systems, incurring no extra cost to the patient.[70] As patient side technologies have matured greatly, so have clinical side tools. Electronic health records (EHR) have increased in adoption at an incredible pace, through voluntary and forced adoption. Some of these are represented with disjointed systems and some as coordinated, country-wide systems. In Kenya, there is one main system for aggregated data[37] and various EHR systems in the marketplace. However, Kenya is striving to standardize the EHR deployments and was seeking to deploy electronic medical records (EMR) at 600 sites in 2013.[71] Musya et al indicated in 2012 that in HIV care this EMR implementation is a progression toward one, "all encompassing" EHR.[71]

Several reports have demonstrated the efficacy of joining mobile technology with chronic care. Of note, meta-analysis by Cole-Lewis and Kershaw recognized text message reminders alone were observed to have an impact on tighter diabetic management and the lowering of glycated hemoglobin (HbA_{1c}) levels.[35] Additionally, the same meta-analysis displayed significant positive effect when observing management of weight loss and smoking cessation.[35] In a three month study by Kollmann and

Riedl, there was significant improvement of HbA_{1c} levels after three months of entering glucose measurements into a phone and accessing records through a patient portal.[34] In another meta-analysis by Liang et al., they explored the use of mobile phones specifically for diabetic control and found "statistically significant improvement in glycemic control and self-management."[36] In studies where feedback is given based on data entry, results have shown positive, statistically significant correlation with reducing HbA_{1c} levels and in patient satisfaction.[34] Furthermore, combining mobile management with physical visits to healthcare providers appeared to have a stronger impact.[36] While not specifically related to diabetic chronic care, research in Kenya by Lester et al. has shown that cell phone communication via SMS can significantly improve HIV antiretroviral treatment adherence when compared to controls without communication.[72]

Discussion

Kenya's current project to manage diabetes, headed by the WDF, has made progress, most notably with education of health workers. Numerous screenings have contributed to the recognition of a greater incidence of diabetes, but recent data indicates a large population may yet be undiagnosed. Currently proposed methods to increase awareness in the Kenya National Diabetes Strategy 2010-2015 appear reasonably effective but results indicate that only short-term awareness campaigns are being used.[38] Evidence of using only short-term campaigning may be due to lack of published results, but it may be an indication of a deeper focus on short-term strategies. Research suggests diabetes awareness remains low, despite education efforts. Since the WDF project started in 2009, the capacity building process has been almost completely focused on building human resources through training. As mentioned earlier, numerous healthcare workers have been trained on diabetes; however, the new number trained is not likely to meet the demand of diabetic patients especially as the prevalence and incidence grows.[73(p21,23)] To effectively manage the growing diabetes case load, the following items are needed 1) more health workers, 2) available workers need to be able to effectively manage more patients and/or 3) patients need to improve self-management.

Kenyan capacity building also refers to building a better distribution network of medications and supplies. Current efforts are working but appear to be moving slowly, as is indicated by the Novo-Nordisk project that only affected 2,600 patients with insulin injections in the first year of deployment. Known issues with subsidized medicines may be hampering this project as it has with previous projects. Nevertheless, medication disbursement projects could benefit from a heightened measure of oversight, both in the distribution channels and in patient procurement. Insulin is the drug of choice in advanced diabetes management, but oral medications used earlier in the disease state, such as metformin and glibenclamide, need better distribution and subsidization as well.[57]

Mobile Assisted Management Proposal

For being classified as a low-income country, Kenya has many advancements that rival high-income countries regarding telecommunications. Nearly every indicator from Kenya shows that the mobile market is growing with more adoptions of service usage, diversity of technology, greater access to the internet, and more.[74] This is advantageous in Kenya where the population is largely rural and access to specialized care is often focused in urban environments. As mobile technology continues to develop and Kenya's usage increases, access to specialized care through telemedicine can become more distributed. Because of current and expanding mobile use and historic welcomed adoption of new mobile technologies, it is recommended that Kenya utilize existing mobile technologies to aid in chronic diabetic management and resource allocation. Mobile assisted management (MAM) has the capability of assisting in the management of glucose levels, educating patients, assisting healthcare workers in daily and emergent activities, and in influencing healthcare payer and MOH decisions through real-time information.

Before going further, the phrase "mobile technologies" encompasses a vast array of technologies, but for the sake of this argument, it encompasses the following components, at a minimum:

1. Cellular network connected to main Internet grid
2. Glucometer (cellular enabled)
3. User interface (UI) for displaying glucose readings and relevant information on glucometer
4. UI for input of ongoing, relevant patient information, such as medication or complications

5. Relational database to store patient readings and extra data
6. Application for displaying historical patient data to patient's glucometer or over the Internet
7. Application for healthcare workforce management of patients
8. Application for management of staff, medication distribution, and project

Other equipment or technology may be necessary to function as an adjunct to the systems above, but this list covers the majority of items needed. Importantly, the technology and intelligence for these items already exist. Indispensable and desirable functions of the system are listed in Appendix D.

In an established environment, the hypothesized MAM system begins with the patient taking every blood glucose measurement on their cellular glucometer. The current measurement is simultaneously presented to the patient and sent to a secure database, using a secure SMS or other cellular connection. Using older SMS technology allows for a greater coverage area, with use on nearly any mobile network, globally. Based on the patient's current and previous information, the device uses internal algorithms to present relevant data and educational material to the UI. Cues to take medication, eat, or contact a medical provider can be given as needed. In a recent study detailing the effects of a system nearly identical to the MAM system, Javitt et al. highlighted the importance of this automated "coaching and guidance" in its ability to prioritize healthcare worker interaction and provide automatic feedback to the patient.[75] Once the information arrives in the database, it can then be stored and later accessed by the patient or appropriate medical staff. Medical workers are able to view numerous patient records at once, using intuitive displays ranking patients by type of care needed. From the same application, medical workers can send messages to the patient or contact other workers for assistance. Each level of healthcare provider, from the community health worker (CHW) up to the national referral hospital physician, can have varying levels of access to the patient's history. On the spot access can be granted to medical staff by using their information in combination with the patient's information or the glucometer's device information.

In addition to the traditional healthcare worker, local dispensaries and other medication access points should have a basic level of permissions to the system in order to access the medication portion of the patient's record. Allowing dispensaries access to the patient's medication history allows them to see

historical usage and input current medication allotments, which has multiple positive effects. Firstly, it may help to reduce counterfeit pharmaceuticals in the market. Secondly, it may help to reduce medication errors at the patient level. Thirdly, this function gives the MOH heightened oversight of medication supply chains. This data influences medication and supply purchases as well as can inform the regional diabetic management agenda. Aggregated patient, healthcare worker, and medication data are essential for the MOH to effectively manage the diabetic patient load.

With the stated strategy, the cellular glucometer has the capability to raise the level of self-management on its own. However, the MAM system also allows the MOH and other payers in the system to reward or incentivize achievements in self-management. Patients and physicians generally agree that it can be an effective addition in motivating effort for short-term education goals, as well as long-term care plans.[76] Financial incentives, medication incentives, or other forms of reward can easily be allotted to those patients who do well with medications and their glucose measurements. Certainly, an incentive program must be carefully crafted to ensure the poorer populations or inherently sick populations are not disadvantaged. Nevertheless, the MAM system allows for tracking patient management, thus creating a framework where incentives and rewards can be effective and even cyclically build better self-management. Many advantages have been listed and the main items have been summarized in the following section.

Chief Advantages Summary of Mobile Assisted Management System Proposal

Patients:

1. Support patient education through dynamic, real-time feedback based on patient symptoms
2. Assist patient in understanding of short- and long-term effects of proper management
3. Support patient education through regular messages - automated or sent by medical worker
4. Aid patient adherence to prescribed medication protocol through automated reminders
5. Automatically send emergency indicator on extremely high or low blood glucose readings
6. Access to historical glucose records and diabetic medical checkup information
7. Personal access to limited medical opinion
8. Healthcare action plan accessible via device
9. Patients benefit from increased oversight of medication and supply control by the MOH because they can more reliably receive medications and supplies at set costs
10. Patients can be rewarded for good self-management, through various strategies

11. Friends or family members are able to remotely check patient's status, which may be essential in the care of minors and some elderly

Healthcare Workers:

1. Able to see diabetic patients under personal care, in one system, at one time
2. Automation of patient care for minor tasks
3. Receive alerts for patients out of blood glucose range or in emergent situation
4. Management is easily shared among workers
5. Less personal visits are necessary with daily monitoring of a majority of patient base
6. Able to see historical trends and medical information for patient
7. Provide a simple way to connect with patients

Healthcare Payer (e.g. MOH, NHIF, or insurance company):

1. Aggregate data influences decision making for risk factor management and intervention analysis
2. Assist with planning campaigns and strategy
3. Directly measure diabetic population in real-time
4. Allow for regulation of medicine distribution for greater cost savings and transparency
5. Save money through better management, lowering complication rates
6. Adapt technology to aid in other diseases, non-communicable and communicable
7. Assist in understanding of geographic distribution of care

Necessary Infrastructure for Implementation in Kenya

Besides policy obstacles and development of stakeholder buy-in, to initiate the project suggested several factors must be addressed. Firstly, the proposed MAM system is based on technology in which the core infrastructure currently exists in the global marketplace. However, some minor re-designs or alterations may be necessary for adaption into the Kenyan setting. The Kenyan telecommunications market already has a robust 2G network in place with growing coverage of 3G and 4G networks. The 2G backbone is likely sufficient for basic patient use and the 3G and 4G networks will continue to add more services as they expand. These services will grow and be maintained regardless of the health sector's use. Further infrastructure is categorized into items oriented towards patients, healthcare workers, and payers.

For the patient, the main items necessary are a cellular glucometer, compatible testing strips, and proper medication. The higher end cellular glucometer with a graphical user interface can be purchased at the manufacturer's suggested retail price for approximately $150.00 (USD), with lower end devices costing less. Additionally, some devices include data transmission at no extra cost to the patient. Please

see Appendix C for a listing of published prices for numerous models. Due to the price of the device, part or full purchasing responsibility may fall on the MOH or insurance provider, as the individual may default to a cheaper model when given the choice. Beyond the glucometers, the key component to implement is a database and related web based application or portal. Database applications described above exist in other countries and they are often tied to EHR systems. Existing database applications, specifically designed for diabetic management, can be purchased and adapted for Kenya's usage or developed from the ground up. According to the Jeanine Ayers, a US based software engineer and architect, it would take an experienced engineering team approximately 2400 hours to build a working prototype of the database and applications from the scratch (phone and email correspondence in April 2014). However, this does not include time to build the cellular glucometer, quality assurance of the software, or project management. Mrs. Ayers' estimated analysis for time required for the core components can be found in Appendix E. As an alternative, existing databases and applications can be purchased and linked to existing Kenyan EMR/EHR using an application interface. This affords the ability to use a prebuilt, customized diabetic management application with the usability of existing EMR solutions. A good example of a blending of these options is the Telcare system which uses its own cellular glucometer and applications and databases, with the ability to link to other systems.[77] If a limited pilot project is pursued for proof of concept, existing applications and associated database can likely be procured on a trial basis. Notably, medication supply chain management functions may need to be left out of a pilot to simplify early implementation. Additional cost for the system is further explored below.

Economic Value of Using a Mobile Assisted Management System

The burden of cost for this system is likely to be split across the government, insurance providers, and the patient. The medical and financial benefit of the devices, correlating applications, and management must outweigh the cost to train, purchase, deploy, and utilize. In economic analysis, both short-term and long-term cost savings are important to consider. It has been thoroughly proven in high income countries that management of blood glucose can lead to lower diabetic complications and lead to

long-term cost savings; however, savings in the short-term can be realized as well.[75(p199),78-79] For example, in the United States, a case study done with the Telcare BGM device decreased medical claims costs by an average of $3,384 (USD) per person in one year.[75(p121)] This significant savings does not even account for increased work productivity or a decrease in absenteeism, which the study by Javitt et al. further estimated at over $3,000 (USD) per worker with diabetes per year.[75(p122)] These findings are significant because they reveal the financial implications for managing chronic conditions efficiently, even when measuring results under short-term constraints.

For the NHIF and other major payers, this system could lead to savings as it has in the US. Under the current NHIF model, which only pays for inpatient services for the majority of its beneficiaries, the value of the proposed MAM system can be measured by the monies saved for reducing inpatient visits and emergency visits, which often end in serious morbidity and even mortality. Treating poorly managed diabetic cases often carries significant financial cost for the payer, and patient OOP expenses cannot be understated. As the NHIF progresses into paying for outpatient services for a greater percentage of beneficiaries,[45] the benefit of this system would become even more apparent. For the MOH, which accounts for a considerable portion of the THE, similar savings can be assumed at the primary and secondary care levels. Because the MOH does not cover as much of the financial burden of the patient at higher levels of inpatient care, in comparison to the NHIF, the MOH's short-term savings may be less substantial. As with most drastic changes in healthcare, a pilot project would help identify and quantify the various costs of the system, allowing comparisons against the financial and medicinal status quo. In order to determine a reasonable return on investment for both the formal and informal working population, the costs this system adds to health expenditures that are not covered by savings in other expenditures, should be evaluated against the value added to the wellbeing of the patients and the satisfaction of the healthcare staff. Costs and saving for implementing the system are a major factor, but other items need consideration.

Key Considerations

Firstly, the MAM system is not meant to fully replace current efforts targeting the establishment of new clinics and services or education initiatives that Kenya is working to increase. The system is meant to augment these required resources and provide another access point to healthcare service for the patient. This system cannot replace hands on or directed service by a healthcare professional, but it may be able to assist the healthcare professional(s) in delivering that care. Furthermore, the MAM system, in its current design, is not a prime candidate to deliver preventative services; its primary purpose is to aid patients currently diagnosed with diabetes or IGT and the healthcare workers serving these patients.

While the system represents an opportunity to improve health outcomes and financial stewardship in diabetic patient management, deploying the system does require upfront financial and political investment to implement. Yet, the financial burden primarily lies in the cost of providing normal access to standard diabetic healthcare for the population: glucometers, testing strips, and required supplies and medications. These expenses represent the greatest portion of cost in this system, which exist regardless of any management scheme in place. Therefore, making provision for those supplies must become part of any successful diabetic chronic care management regimen. The political investment to deploy this system nationwide should start with factors already in place and in favor of the system. Diabetes and its effects on the Kenyan population is already on the national healthcare agenda, which is evidenced by the KNDS. Similarly, electronic management of health records is a nationally recognized goal[80] and efforts in HIV care have led the way. As a second step in policy formation, further data collection, analysis and dissemination of known information must take place. A localized pilot program could significantly aid this effort by presenting a proof of concept, serving to justify the change. A pilot can supplement missing data on current diabetic care and demonstrate the proposed MAM system's positive effects. A third step is to adjust the proposed system according to any new findings to help it fit Kenya's health sector more appropriately. Finally, implementation of the MAM system would require numerous interactions between stakeholders, such as the MOH, NHIF, NGOs, private insurance companies, healthcare staff,

private and public healthcare facilities, patients, mobile phone companies, and pharmaceutical companies. This system and its resulting policies require broad changes and it is paramount for stakeholders to have buy-in with defined responsibilities. To be effective, each organization must understand the positive, neutral, and/or negative consequences of implementation. A successful coalition of stakeholders will include at the least, the main payers in the healthcare market: the MOH, NHIF, and private insurers. Once a coalition among these parties is built, national policy formation and implementation can begin.

Conclusion

Overall, the tools and abilities to implement a mobile assisted management system in Kenya currently exist, and cost savings could be realized through adaptation and adoption, in support of the growing diabetic population. However, before the MAM could be truly effective for the whole diabetic Kenyan population, work remains to develop regular diabetic screenings, advance education about diabetes to the public, as well as ensure diabetic patients have access to needed supplies and medications. A recognized starting point for this system, and a potential pilot project, could involve NHIF's beneficiaries and especially, civil servant and disciplined services beneficiaries, as their benefit package includes care beyond the normal employee in the formal sector. An organized pilot project, with this group or another cohort, is recommended to evaluate the standardization of systems processes, expand the reach of trained healthcare professionals, provide greater access to the diabetic population in the management of their condition, reveal missing data, as well as determine intended and unintended consequences; all in an effort to promote usability in Kenya's health sector.

Appendices

Appendix A: Sub-Saharan Countries[7]

1. Angola
2. Benin
3. Botswana
4. Burkina Faso
5. Burundi
6. Cameroon
7. Cape Verde
8. Central African Republic
9. Chad
10. Comoros
11. Congo (Brazzaville)
12. Congo (Democratic Republic)
13. Côte d'Ivoire
14. Djibouti
15. Equatorial Guinea
16. Eritrea
17. Ethiopia
18. Gabon
19. The Gambia
20. Ghana
21. Guinea
22. Guinea-Bissau
23. Kenya
24. Lesotho
25. Liberia
26. Madagascar
27. Malawi
28. Mali
29. Mauritania
30. Mauritius
31. Mozambique
32. Namibia
33. Niger
34. Nigeria
35. Réunion
36. Rwanda
37. Sao Tome and Principe
38. Senegal
39. Seychelles
40. Sierra Leone
41. Somalia
42. South Africa
43. South Sudan
44. Swaziland
45. Tanzania
46. Togo
47. Uganda
48. Zambia
49. Zimbabwe

Source: United Nations, 2013

Appendix B: Kenya's Total Health Expenditure by Category

Table 5. Total Health Expenditures by Financing Payer (Kenyan Shillings)[43(p16)]

Payer	Years		
	2001/02	2005/06	2009/10
Ministries of Health	27,706,318,188	36,078,350,970	33,459,601,497
NACC	--	1,752,413,862	1,301,728,082
Other ministries	42,566,019	--	296,253,589
Local Authorities	848,325,319	588,514,805	1,116,889,928
NHIF	3,233,803,375	3,791,427,337	5,803,838,476
Parastatals	2,317,408,402	1,348,725,333	2,957,902,148
Private Employer Insurance	3,098,297,945	5,543,993,319	8,252,228,595
OOP	35,696,470,988	29,684,923,688	30,074,650,354
NGOs	4,916,278,185	18,590,859,396	34,127,880,676
Private Firms	862,337,797	1,984,914,629	3,296,540,893
Rest of the World	975,558,030	2,613,497,373	2,166,045,565
Others	2,534,652,516	--	--
Total	**82,232,016,764**	**101,977,620,712**	**122,853,559,803**

Appendix C: Table of Past and Current Glucometers with Mobile Abilities, by Abilities

Table 6. [a]Glucometers with Mobile Adaptations, by Abilities

Type/Brand	Distributing Company	Year Released	Estimated Cost in USD (at time of release)	Stand Alone Device	Stand Alone Device with Cellular Abilities	Permanently attached to phone	Calling Abilities	Bluetooth connection to Smartphone	Direct/Wired connection to smartphone	Compatible Smartphone App
LG KP8400[81]	HealthPia	2004	$380			X	X			X
myglucohealth[82]	Entra Health Systems	2009	$90	X				X		X
iBGStar[83]	Sanofi	2010	$72						X	X
Telcare BGM[84]	Telcare	2011	$150		X					X
iHealth BG5[85]	iHealth Lab	2013	$80	X				X		X
Dario[86]	LabStyle Innovations	2013	Unknown						X	X
Test N'GO[87]	ForaCare	2014	$84	X				X		X
OneTouch Verio Sync[88]	LifeScan, Inc	2014	$30	X				X		X

[a]Does not represent an all-inclusive list but represents easily findable glucometers using the search term "mobile glucometer" in March 2014

Appendix D: Mobile Assisted Management Abilities and Benefits.

Patient Oriented Functions:

Essential Attributes and Abilities:

- Cellular glucometer is handheld device, the size of an typical smartphone or smaller
- Battery operated with rechargeable battery
- Must be identifiable or personalized to one patient
- Receive and measure glucose testing strips
- Instantly sends measurement results or during next available connection
- User Interface (UI) displays measurements and whether the reading was on target
- Glucometer can store a large quantity old readings
- Can receive healthcare worker messages
- Can input medication usage and cost
- Alerts healthcare workers in case of an emergency
- Can log in to a dedicated web-based patient portal for access to previous records, upload data, and connect with healthcare staff
- Dynamically show locations of care clinics in surrounding vicinity based on network location
- Alerts patients to educational campaigns in surrounding area

Desirable Attributes and Abilities:

- When available, measure blood glucose through non-invasive near infrared spectroscopy
- UI displays other information such as medication alerts and basic education
- UI displays health tips and reminders for care, depending on the patient and their needs
- Can respond to healthcare worker messages or initiate communication
- Patient may enter vitals and weight measurement if known
- Strong color and intuitive displays to support for patients who struggle with literacy

Healthcare Worker Oriented Functions:

Essential Application Attributes and Abilities:

- Dedicated healthcare worker web-based portal – containing most of the following
- Manual and automated triage of patients
- Triage or separate management of diabetic patients into categories such as location, patient demographics, co-morbidities, type 1 versus type 2 diabetes, insulin dependency, disease state, medication type, self-management ability, and more
- Portal designed very similar to EMR, showing patients health records and historic blood glucose data

- Alerts for patient emergencies
- Message patients through portal (SMS)
- Request assistance from other staff
- Offline access to Patients records, for use in the last mile when network not accessible
- Manage other healthcare workers duties, as it relates to patient management
- Automated reminders for patient management and other job functions
- Supply/Distribution Chain information, relevant to medication distribution easily available
- Automated and manual ordering of medications and supplies

Desirable Attributes and Abilities:

- Integration of the healthcare worker portal with existing electronic medical records to increase ease of use and adoption rates
- Incentivize or reward patients through portal
- Ability to call patients through portal, to phone or cellular glucometer if possible

Ministry of Health or Other Payers, Oriented Functions:

Essential Application Attributes and Abilities:

- Patient data aggregated and filterable by location, patient demographics, co-morbidities, type 1 versus type 2 diabetes, insulin dependency, disease state, medication type, self-management ability, and more
- Management of Supply/Distribution Chain of medicines and supplies
- Ability to organize campaigns through portal (educational, screenings, and more)
- If insurer/payer, ability to verify patients use of equipment, to justify use.
- Ability to easily incentivize or compensate for self-management

Desirable Application Attributes and Abilities:

- Integration of the payer portal with existing electronic health records to increase ease of use and adoption

Appendix E: Table of Development Hours Required for Core Components of MAM System

Table 7. Estimated Development Hours by Software Component and Use

System Component	Software Component	Description	Hours
Client	Mobile App	Simple interface to communicate metrics, analysis and feedback to patient/family members	400
Communication	Service Layer Interfaces	Messaging system to receive and send data between mobile and server	80
Server	Cloud-based Patient Record Storage	Store patient overall and diabetic specific information	160
Server	Patient Compliance Module	Module that understands/manages medical rules about diabetes and medical condition	240
Server	Coaching and Feedback Manager	Manages messages and feedback (custom and default) to patient/family members	160
Server	Trend and Analysis	Provides trend and analysis of data for daily or historical time periods	160
Server	HealthCare Manager Interface	For healthcare providers to monitor individual patient results	400
Server	Healthcare Payer and MOH Management Interface	For managing providers, facilities, and patient and system as a whole	200
Server	Medication Distribution Module	For Managing medication suppliers and distribution of medication	600
Total Hours			**2400**

Appendix F: Mr. Stephen Masinde's Permission to Use Interview as Reference Material

Wednesday, April 9, 2014 11:35:49 AM Eastern Daylight Time

Subject: Re: Information to be used in Master's Paper
Date: Wednesday, April 9, 2014 10:57:00 AM Eastern Daylight Time
From: Stephen Masinde <smasinde@akglobalhealth.com>
To: Adam Turner <adam.turner@akglobalhealth.com>

Dear Adam,

I would like to authorize use of the information I provided for your thesis. I wish you wish all the best in your studies.

Stephen

Sent from my iPad

On Apr 1, 2014, at 8:52 PM, Adam Turner <adam.turner@akglobalhealth.com> wrote:

> Hi Stephen,
>
> I do not think I heard back from you on this. Do you mind if I use information we discussed the other day in the Master Paper I am working on?
>
> A summary of our conversation is in the attached document.
>
> Thanks,
> --
> Adam Turner
>
> ---
>
> **From:** Adam Turner <adam.turner@akglobalhealth.com>
> **Date:** Tuesday, March 25, 2014 10:43 AM
> **To:** Stephen Masinde <smasinde@akglobalhealth.com>
> **Subject:** Information to be used in Master's Paper
>
> Hi Stephen,
>
> Thank you again for the information you shared during our conversation today. Attached is a bulleted listing of all items you mentioned. Please review these for accuracy and let me know if I misunderstood something.
>
> Also, please let me know if you are ok with me using that conversation as reference material for the paper, as we discussed. I will send you a copy once the next draft is complete.
>
> Thanks again,
> --
> Adam Turner

Appendix G: Mrs. Ayers Permission to Use Data and Interview as Reference Material

Thursday, April 3, 2014 11:11:07 AM Eastern Daylight Time

Subject: Re: Paper and content submission
Date: Thursday, April 3, 2014 10:25:43 AM Eastern Daylight Time
From: Jeanine Ayers <jeanine.ayers@akglobalhealth.com>
To: Adam Turner <adam.turner@akglobalhealth.com>

Hi Adam,
Yes, no problem.
Thanks
Jeanine

From: Adam Turner <adam.turner@akglobalhealth.com>
Date: Wednesday, April 2, 2014 8:12 PM
To: Jeanine Ayers <jeanine.ayers@akglobalhealth.com>
Subject: Paper and content submission

Hi Jeanine,

Do you mind if I use the table you sent me and verbal information we discussed over Skype, in the paper? I am required to ask for your permission in writing.

Also, I would like to discuss one more matter with you tomorrow for this. It should take about 10-15 minutes.

Jeanine – thank you so much!
--
Adam Turner

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