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Supporting the Health Impact Fund with
Mobile Technology

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Abstract: The Health Impact Fund (HIF) is a proposal designed to incentivize pharmaceutical innovation by rewarding the development of new medicines in proportion to their health impact. The health care sector is plagued by wastage and poor governance, especially in developing countries. The MHIF system is a mobile payment and data collection system designed to enhance transparency and accountability, whilst improving the quality of data available for impact assessment. It also provides a platform for reporting misuse and abuse. The system is designed to mitigate some of the deployment challenges of the HIF and to act as a springboard for further expansion into broader mobile health (MHealth) solutions.

1. INTRODUCTION

This paper explains a concrete version of a mobile payment and data collection system, called MHIF, that is designed for implementation in conjunction with the Health Impact Fund (HIF). The HIF is a supplement to the global pharmaceutical patent system that rewards pharmaceutical innovations in proportion to their overall health impact. In exchange for voluntarily registering a new drug, an innovator commits to providing the medicine at a price no higher than the variable cost of production. The HIF would certainly—but not only—benefit people in tropical countries, where so-called "neglected diseases" such as malaria and schistosomiasis cause enormous harm, and yet residents' low purchasing power provides meagre incentives to conduct pharmaceutical research related to those diseases. Patients in all countries would benefit from research induced by the HIF, since they would gain access to new, low-cost drugs that would not otherwise be available.

Readers who are unfamiliar with the details of the HIF proposal are encouraged to read the detailed explanation set out in Hollis and Pogge (2008) and at www.healthimpactfund.org.

Because the HIF is designed to reward pharmaceutical firms based solely on the impact of their products, the benefits of the HIF depend on the accuracy with which health impact is measured. Random deviations from true impact lead to greater uncertainty for firms, which in general will result in their demanding higher rewards. Predictable deviations from true impact could l could bias impact assessment toward or away from particular drugs, potentially leading to an lower health impact from the Fund overall. In addition, where controls on health impact measurement are weak, firms have incentives to manipulate sales data to falsely inflate impact. Data on drugs dispensed primarily in countries with weak governance would be especially susceptible to manipulation. Both random and biased deviations could thus lead to a reduced actual health impact.

MHIF aims chiefly to address the problems associated with data accuracy by collecting widely dispersed data on sales and patients' health, especially in areas where public health governance is weak. Improved accuracy in impact measurement will increase incentives for companies to encourage adherence and good prescribing, for example, by providing relevant information to patients, prescribers and vendors. In

addition, MHIF would enable aid agencies or governments to bypass local corruption and directly subsidize individuals' drug purchases.

The core idea of MHIF is to use software installed on mobile phones to communicate between patients, doctors, pharmaceutical vendors, and public health officials. MHIF works as follows: Patients, prescribers and drug vendors open HIF accounts with their personal ID using a SIM card. Patients can purchase HIF-registered drugs by transferring money from their HIF account using a mobile-phone banking system. All transactions, with their GPS location, will be recorded in a central database. In addition, once patients have received medication, they will be asked to enter follow-up information on their health status via SMS.

The system generally builds on the extraordinarily successful M-PESA mobile telephone financial transfer system used in Kenya. M-PESA is a partnership between Safaricom and Vodaphone that allows customers without access to conventional banking services to electronically transfer money in a convenient, cost-effective manner. Each customer maintains an M-PESA account connected with a personal SIM-card. Customers can use a password-protected menu system on their phone to transfer funds to other customers.

While mobile phone usage is remarkably widespread, it is not universal. Thus the MHIF may not be a mandatory component of the HIF. It could, however, be used as an optional, preferred mechanism for payment and reporting. Usage in individual countries and regions will improve the overall accuracy of the HIF's health impact measurement. We recommend the MHIF system to be prototyped and tested in controlled set-ups to obtain field-level feedback for further improvements. Kenya would be a good testing ground considering their successful deployment of M-PESA and open telecommunication protocols for ease of deployment.

The next section reviews relevant components of the HIF, as well as some data issues that it must address: drug management and leakage, fund leakage, informal payments, and number manipulations. We analyze these problems and show how the MHIF helps to mitigate them. Section 3 explains a concrete version of the MHIF in detail. In Section 4, mobile phone penetration rates are discussed to indicate where the MHIF could be deployed. Section 5 explores how the MHIF could enhance the effectiveness of other existing mobile-health services.

2. IMPROVING DATA COLLECTION

> All organizations involved in development finance… face the constant risk of possible misappropriation of funds and of corruption. That's a fact of life in development finance. The key is to minimize the risk—to have in place oversight systems and to identify problems before they occur.
>
> *—Sir Richard Feachem, Executive Director, Global Fund to Fight AIDS, Tuberculosis and Malaria (Eaton, 2005)*

The Health Impact Fund would rely substantially on collection of data about the number of units sold, and the expected effectiveness of those units, for each registered drug. There is a variety of ways such data could be manipulated, including through exaggerating the number of units sold and the effectiveness of the product. In some cases, the registrant (i.e. the company that had registered the drug with the HIF) may have an interest in manipulating data; but data may also be manipulated without the registrant's knowledge. We consider below how the MHIF could help to reduce the potential for data manipulation.

Drug Tracking

Virtually all qualitative studies that have probed the issue of supply tracking have emerged with the view that drug availability is critical to the successful operations of a healthcare system, and that a lack of drugs has been repeatedly shown to discourage utilization of public facilities (World Bank, 2005; Lewis, 2006).

Informal interviews by Ravalia of public officials, health care professionals and local pharmacies in a town in western Kenya in 2009 revealed that a large proportion of medicines were being diverted. Medicines that were supplied by that national government or charitable sources in order to be dispensed for free from local clinics were either sold privately or exported out of the area for private gains. This resulted in frequent shortages for local citizens. Other studies confirm that the findings in these interviews are not unusual.[1]

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[1] See, for example, CLARION (n.d.); Medicines Transparency Alliance (2009, p. 2), which quotes the Ugandan Minister of Health as stating in 2008 that 50% of the medicines purchased by the government

If every drug package is stamped with a HIF logo and an associated quick response (QR) code (see section 3 below), drugs can be tracked from manufacturers all the way through distributors to the end patients. Matching up a hospital's drug inflow against its drug outflow helps control inventory and point out potential losses through thefts. Data analysis can be conducted to point out hospitals to be targeted for audits.

Moreover, the technical system also provides the consumer with the option to report drug shortages, which is a scenario very common amongst government pharmacies in developing countries. Drugs are often tunnelled out for private gains, issued only to friends and family, or are "temporarily out-of-stock" until a small bribe is given. The data on drug shortages collected from mobile phones will aid the HIF in auditing centres, probing inventory levels and inventory control mechanisms.

The results of audits could be reported to the central government and the local authorities. As the Public Expenditure Tracking Surveys have shown, there exist effective mechanisms by which information revealing corruption can be used to create bottom-up accountability (Reinikka and Svensson, n.d.) For example, the information could be published in local newspapers or on the walls of hospitals.

Impact Tracking

In addition to reporting sales data, the MHIF system could also be used to survey patients about their health changes following usage of the medicine, as described in Section 4. Such health reports could be incorporated into the HIF's assessment analysis. The data could be matched up with data collected in other ways to increase the accuracy of health impact evaluations. In some cases, the HIF could report data to the registrant to aid the company in adjusting its information provision to patients and prescribers in an attempt to increase the health impact of the drug.

Fund Leakage

The theft of public funds for private gain or for political patronage can occur during the transfer of funds from public treasuries to ministries of health, from the ministries to their provider units, and within the provider units themselves. In fact, when

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for use in the public health system were being siphoned off by health workers and redistributed to private clinics or pharmacies.

international health agencies give cash donations to local authorities to enhance the healthcare infrastructure, to offer free immunizations, or to supply preventive measures, such as mosquito nets, a good proportion of these funds is sometimes siphoned off. Some of these funds may be consumed as overhead in managing the projects, but some may simply be stolen for private benefit. For example, In Uganda and Tanzania, local councils have diverted funds, with leakages resulting in a loss of up to 41% of the funds (Anti-Corruption Resource Centre, 2010) of the allocated funds.

Strong checks and balances in drug procurement are needed to prevent under-the-table contracts between drug manufacturers and purchasing officers. Many scandals in developing countries involve companies delivering invoices for non-existent or over-priced services, with a kick-back paid to the purchasing officer. The MHIF establishes a unit-level checking system to ensure that recorded purchases are actually dispensed to individual citizens.[2]

Mark-ups and "Informal" Payments

There are two kinds of mark-ups that could be added to the wholesale prices of HIF-registered products. Pharmacies and other sellers may simply add legal mark-ups where not prohibited by law or contract, and hospitals and clinics that are supposed to distribute drugs for free or at cost might require a supplementary informal payment. Informal payments are made to individual and institutional providers, in kind or in cash, outside of official payment channels (Gaal et al., 2006). Our concern lies especially with under-the-table payments to medical staff for obtaining drugs. These payments are usually illegal and unreported and create inefficiencies in the overall health infrastructure. For the HIF, any increase in price, whether through legal mark-ups or informal payments, is undesirable since it undermines the goal of wide access.

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[2] As explained by Collier (2009), in countries with elections but without checks and balances on the use of power, governments can pursue the strategy of extracting money for private patronage, using it to control the media, to scapegoat a minority, to buy votes, to intimidate political opponents and thereby to win the next election. The more money the government has at its disposal for private patronage, the less public goods it needs to supply to secure electoral victory. Any increase in the feasibility of extracting money for private patronage skews the odds in favour of the 'private patronage strategy' over the 'being a good government strategy'. Therefore, reducing the opportunities for government officials to privately capture money in the health sector not only decreases wastage of funds consumed by corrupt officials but also increases the expected overall value of provided public goods by making their provision a more attractive strategy for the government. This indirect benefit of the HIF is strengthened by the MHIF system.

It is also undesirable for the registrant, since higher total costs of registered products to patients lead to fewer patients treated, and a smaller assessed health impact of the product.

In Ravalia's informal survey of Kenyan patients, the individuals interviewed typically had to pay a bribe to obtain medicine. Out of 11 individuals interviewed, 7 reported paying a bribe for access to drugs.

> I have to palm a Kshs 50 note for the drugs to magically appear
> from the "out-of-stock" cupboard
>
> —*Mrs. J. Wairimu, fruit seller*

With the MHIF system in place, it will be easier for registrants to control mark-ups, and for informal payments to be detected. As described below, patients will have direct access to official price information through their mobile phone and will have a mechanism to report mark-ups above those permitted to the vendor. For example, suppose that the registrant contracts with a vendor to set a price ceiling. This price could be reported to the HIF, which could then set the price for the vendor through the MHIF system at the ceiling. A vendor would reveal that he was charging above the ceiling price if he required a supplementary cash payment.

In cases where the patient is obliged to make an informal payment, the MHIF system provides a channel for end customers to report this abuse. The data collected can be analyzed in order to identify potentially mismanaged medical centres that need to be audited. As explained above, the data and the results of the audits could be used by local authorities, keeping in mind the potential danger of making suppliers avoid the HIF as a result of the increased monitoring and accountability.

It must be acknowledged that the enforced transparency provided by the MHIF system has some disadvantages. If HIF drugs prohibit mark-ups over set prices, doctors and other prescribers may favour non-HIF drugs over HIF drugs. Also, if doctors and other prescribers perceive that they are being monitored too closely and fear being held accountable for this, they may reject the HIF system altogether, and refuse to prescribe HIF-registered products. These potential problems must be weighed against the benefits of the reduction in corruption that could be achieved by MHIF.

Number Manipulation

Officials can manipulate patient numbers, drug inventory numbers and incidence figures to obtain large budgets and grants that sometimes end up in private accounts. The MHIF system, however, can counteract this behaviour by recording payments from individual mobile phones and thus track precise dispensing numbers.

Our interviews reveal that hospitals and government officials sometimes exaggerate the number of patients treated by several hundred percent to increase their funding. These false claims are supported by forged signatures and false documents.

Under the Health Impact Fund regime, registrant companies (or their local staff) could have an incentive to bribe centres to report inflated numbers, both on the number of individuals treated and the impact per patient. The mobile phone payment system, however, makes fraudulent behaviour much more difficult. Rather than merely forging one hospital's records for numerous patients, a company has to target patients individually in order to inflate the recorded health impact of its product. Patients may, of course, still be bribed to buy a drug that they do not need and report that they recovered well after taking the drug. The MHIF system would, however, significantly increase the costs of bribery.

Hospitals, physicians, and pharmacists may guide patients to consume a particular drug in return for payments from the drug company. This practice could be effective in the same way that detailing of physicians has historically been effective in developed countries. However, patients who take a drug that does them no good may report that it has been ineffectual, which would lead to downward revisions of the average measured effectiveness of the product. Thus, registrants may find that while bribery increases the number of units consumed, it does nothing to increase the measured health impact.

Global positioning system (GPS) technology within mobile phones could help to provide locational information to track geographical usage and flag irregular patterns. Regional variations in usage resulting from bad behaviour by a few dishonest physicians or hospitals could prompt the HIF to audit hospitals with an unusually high assessed health impact. If the HIF were to find that an inflation of impact measurement had occurred, it could estimate the extent of such corrupt practice and adjust the impact assessment accordingly, thereby helping to deter companies from engaging in such practices in the first place.

Counterfeit drugs identified with a tracking number could be relatively easily identified with the MHIF system since counterfeit packages would be identified upon attempted sale. Thus, the MHIF system would help to reduce or even eliminate counterfeiting of HIF-registered products.

Summary of Monitoring Issues and How Technology Can Be Applied:
Enforcing Accountability and Ensuring Transparency

| Governance Issues	Supervisory Role of MHIF
Supplies Tracking, Drug Management and Leakage - Free medicines either sold privately or exported to other countries for private gains. - Unjust distribution of free medicines (may be "temporarily out-of-stock" until a small bribe is given).	*Asset Tracking and Inventory Control* - Packaging drugs with HIF logo and QR scan code. - Matching up the hospital's "drug inflow" against its "drug outflow". *Data analysis* - Data on drug shortages allows targeted HIF auditing. - Results published for bottom-up accountability
Funds Leakage - Complex interactions provide opportunity for theft and make it harder to track funds. - Health charities have lost up to 40%. - Global charities and NGOs are discouraged.	Payment System and Funds Tracking - MHIF allows direct receipt of payments from patients - Precise usage figures and patterns obtained - Improves reliability of health impact evaluation - Increased transparency attracts donors
Informal Payments - Encompasses "enveloped," under-the-table payments made to receive better or more care. - Bribes paid to avoid government regulation of medicines - Counterfeit drugs flood markets - Create inefficiencies in the overall infrastructure.	*Reporting Platform* - Offers a voicing mechanism to patients *Data Analysis* - Statistics and pattern matching used to detect irregularities and potential abuse
Number Manipulation - Hospitals and government officials sometimes exaggerate the number of patients treated. - Numbers made up via false names and signatures - Drug companies lobby authorities to inflate numbers	*Patient Driven Technology* - Purchases and impact reported by individual patients - Lobbying individuals is risky and cost-ineffective *Geographical Tracking* - eGPS systems provide location based data - Patient purchases exceeding threshold will raise red flags
Drug Procurement - Illegal contracts made between drug manufacturers and purchasing officers - Most scandals in developing countries, e.g., Anglo-Leasing (Hanson, 2009), revolve around paper companies	*Checks and Balance System* - Electronic bidding for contracts and tenders - Tallying inventory at different levels - Procurement counter-balanced with sales to ensure genuine patient usage.

3. M-PESA

> An accessible and intuitive solution, reflected by an unprecedented take-up rate for a service of this kind, M-PESA will serve as a blueprint for other operators around the world. Targeting the unbanked, the continuing success of M-PESA in Kenya, allows Kenyans to transfer money fast, safely and affordably using the mobile phone.
>
> —*Nick Hughes, Vodafone's Head of International Mobile Payments (IT News Africa, 2009)*

M-PESA is the product name of a mobile phone money transfer service designed to enable users to complete basic banking transactions without the need to visit a bank branch or even to have a bank account. M-PESA Customers can deposit and withdraw money from a network of agents that includes airtime resellers and retail outlets acting as banking agents. M-PESA is operated by SafariCom, a mobile network operator, and is not legally classified as a deposit-taking institution. The service enables users to deposit and withdraw money, transfer money to other users and non-users, pay bills, and purchase airtime. M-PESA does not pay interest on deposits, but maintains deposits in a regular bank account to enable transfers by customers.

In Kenya, almost all adults have their own SIM cards and access to at least one mobile phone. The deep penetration of mobile phone service in the population, general high literacy and market demand for convenient banking services has driven M-PESA (Hughes and Lonie, 2007) adoption and builds a great foundation for other services like the Health Impact Fund.

Cumulative Number of MPESA Users
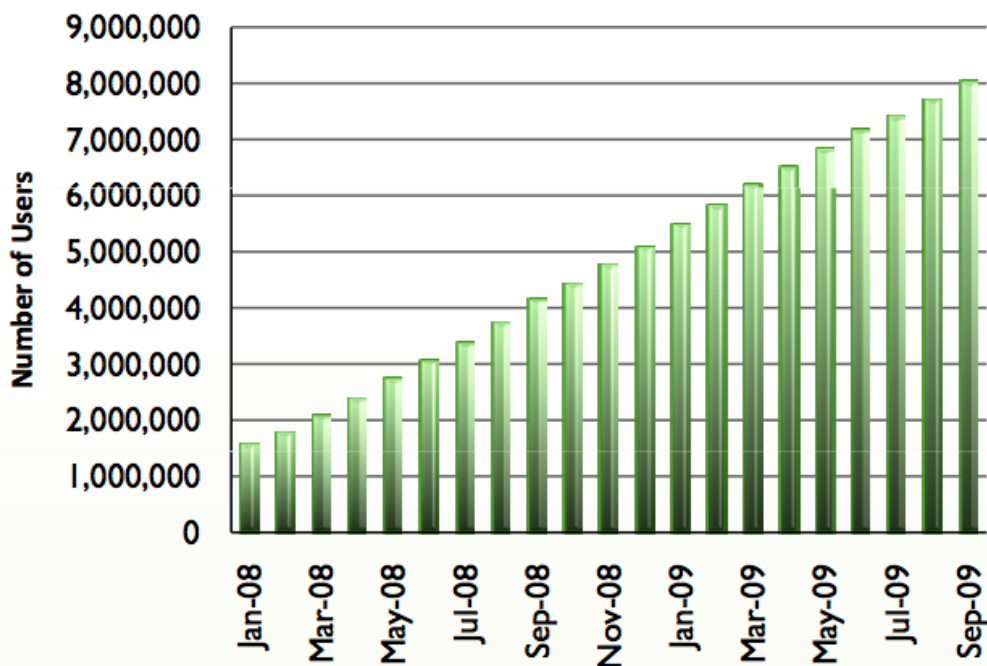
Source: Safaricom (2009).

4. THE MHIF SYSTEM

The MHIF can be designed for early adoption and quick acceptance, following a simple user interaction model for low-end devices with straightforward menus for carrying out a transaction. In Kenya, the M-PESA system was readily adopted, and we follow a similar style of user interaction model to quickly build trust and confidence in the system. MHIF provides a collaborative platform that connects the relevant actors in order to achieve two goals: providing healthcare services and reducing waste and corruption.

End-to-End Value Chain Scenarios

The MHIF system operates according to the following steps.
- A patent owner registers its product with the HIF.
- The registered drug is given a HIF serial number and is entitled to use a HIF logo.
- The HIF determines the price of the drug.

- The patent owner manufactures and packages the drug[3] with a QR stamp holding an incremental number affixed to the predefined serial number.

- The drugs are supplied through the normal delivery channels (at possibly predetermined distributor margins).

- A vendor uses a telephone or internet system to acknowledge receipt of the drugs bearing certain serial numbers.

- Patients purchase drugs at retail sites and pay directly using their mobile phone's HIF account.

- Vendors provide bank account details when they register with the HIF. The HIF aggregates sales for each retail site and pays the registrant's bank account at a predetermined period, such as every 2 weeks.

- At the end of the annual reward period, impact is assessed for the drug and a corresponding reward payment is made to the patent owner.

Data encoded in the quick response code—a matrix code used to encode serial numbers—allows manufacturers to track their products as they move through the process from manufacturing to end-user consumption.

The MHIF

The end user (that is, a patient) will register for a HIF account in order to obtain the HIF's more affordable and higher quality healthcare products.

An end user will typically interact with the HIF account on a mobile phone when purchasing a HIF registered drug, a subsidized or donated medical product, or when providing feedback either in terms of treatment impact or the quality of healthcare services received. The system will be localized in numerous languages and will offer a simple M-PESA-style user interaction model as detailed below. The system should be designed for low-cost mobile phones with a view to attaining ease of use and for achieving quick adoption through the confidence and trust already developed by M-PESA. The menu-driven interaction options are downloaded through the SIM card onto the handset and will work with all certified mobile phone devices. End users will be able to select their language of choice.

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[3] Manufacturing could also be outsourced to a third party through a bidding process.

End User Scenarios

In what follows, we describe in detail how end users will interact with the MHIF system on their mobile phones.

A registered end user will see the HIF option at the main menu level next to the M-PESA option. The HIF requires that each registered user should have a user ID number, usually the SIM number and a suffix digit (to allow several people, say a family, to use the same SIM card), together with a password for authentication and access to the HIF system.
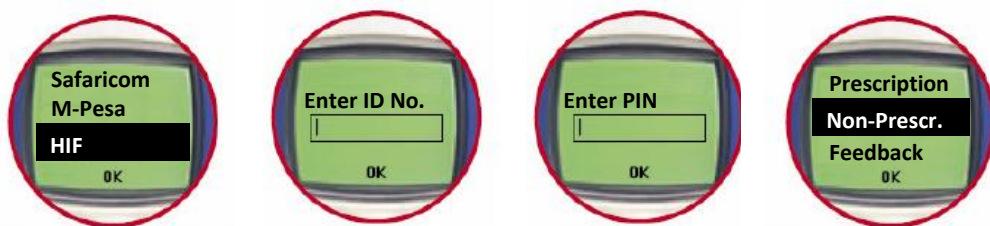
At the highest level, the user can either purchase drugs by an e-Prescription, sent by the doctor to the user's account, or by a non-prescription option at the local vendor, if possible. Some minimal payment is required in order to deter users from excessive drug purchases.

Drug vendors have to make a "vendor registration" with the HIF. In most countries this will be related to registration with the national pharmacy association. Once registered, any computing device can be used to access the vendor details, such as a personal computer, PDA or mobile device. The vendor uses these registration details to log on to her vendor account at which point she may accept drug purchases as explained below.

Sales without Prescriptions

A drug purchase could proceed without a prescription, where permitted. A patient enters a drug store. If the patient is purchasing an over-the-counter drug or he is in a country where vendors can dispense prescription-only drugs, the patient discusses his status with the vendor and is prescribed some set medication. The patient then logs onto his account on his mobile phone and selects the disease for which he is treated and clicks on the drug recommended by the vendor. He then clicks on the

concentration appropriate for his weight and then on the number of pills, which will be chosen in consultation with the drug vendor.

By knowing the disease that the drug is used for, the HIF will be able to accredit impact to companies that find new uses for existing drugs. Arguably, it would be sufficient to ask a patient to enter the disease only in cases where a drug has been found to be effective for several diseases. However, this might lead to confusion on the side of the patients who may wonder why they sometimes have to enter the disease and sometimes do not.

The patient is prompted to enter the account number of the registered vendor. A check is done to make sure that sufficient funds are available in the patient's account and the patient is prompted to confirm his purchase. Drug vendors will also be able to take cash from patients and load it directly onto the patients' HIF accounts. (Similarly, shopkeepers in Kenya now enable people with an M-PESA account to pay cash into their M-PESA accounts.)

Once the purchase is confirmed, an SMS is sent to the mobile phone of the drug vendor. The drug vendor either confirms or cancels the purchase.

Once the vendor confirms the purchase, an SMS is sent both to the patient and the vendor informing them of the successful completion of the transaction detailing the drug purchased, quantity purchased and amount paid for the treatment.
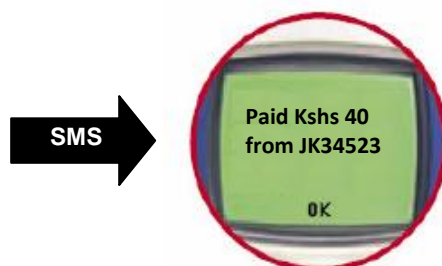
For cases where the client wrongly selects a drug option or mistakenly clicks on the wrong disease, the vendor can cancel the purchase and allow the client to resubmit her request. In some (possibly random) cases, the patient may be required to enter the serial number of the drugs being purchased.

Sales with Prescriptions

An e-Prescription consists of a tag number sent to a patient by a doctor as an SMS. When the patient goes to a drug vendor, he shows the tag number to the drug vendor who enters it in his phone or other computing device. The doctor's name, the prescription time and the prescription details appear on the vendor's phone. The

The vendor will usually follow up with the doctor for prescribing errors and the doctor can update the e-prescription by editing the details associated with the e-prescription tag number. If the vendor cannot confirm with the doctor, she will cancel the prescription and request that the client revisit the doctor.
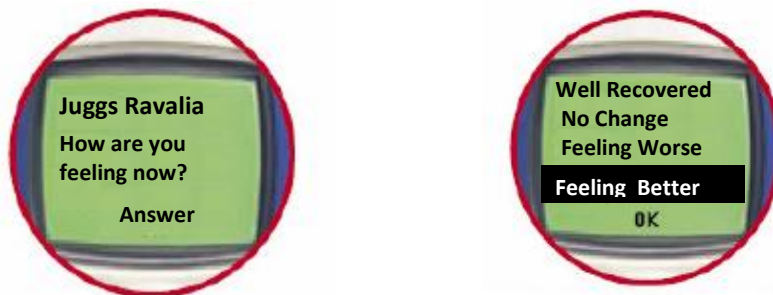
If the vendor confirms the prescription, she will fetch the drug and the patient will follow the exact steps described for the first case above to purchase the prescribed drug.

In the case of e-Prescription, the prompting schedule can pop up a notification requesting the user to take his drug at the prescribed times. A 2007 pilot in South Africa showed that with SIMpill, a device that uses mobile technology to monitor and direct medication adherence, 90% of patients complied with their medication regime, compared with the typical 22 to 60% compliance rate without the system (Vital Wave Consulting, 2009).

Juggs Ravalia

It's 2:00 PM, Please take your Halfan

OK

Once the patient has obtained the drugs, the HIF system tracks the dispensing transaction and prompts the patient for a treatment impact assessment according to set rules.

For short-term treatment, depending on the disease and medication, a prompt can appear after a preset number of days requesting the end user to enter a treatment recovery profile. This could help to assess the impact of specific drugs.

Juggs Ravalia

How are you feeling now?

Answer

Well Recovered
No Change
**Feeling Worse**
Feeling Better

OK

For long-term treatment, again depending on the disease and medication, a prompt could be displayed every set number of weeks requesting the patient enter productivity information in order to calculate impact of the product.[4] In these cases, a periodic e-Prescription could be sent by the doctor to the patient to avoid long-distance recurring trips to clinics.

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[4] The questions used could be designed to match specifically with the clinical profile of the disease.

For the HIF's impact assessment, the effect a drug has on the patient must be quantified. One example of a set of questions that could be asked to obtain information for the assessment of the patient's health status is shown below:

For this example, a baseline of health is required, so the first instance of recovery status probing will involve additional questions. These baseline questions could be:
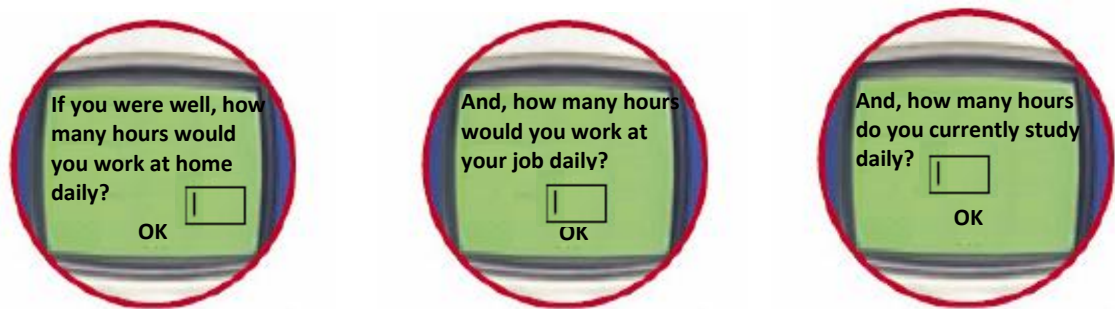
The impact assessment logic would be defined and designed by experts; the above is merely an example of a possible dialogue.

The MHIF system could also be used to alert the HIF (or a country's health ministry) of drug shortages. If a patient visits a pharmacy only to find a lack of medicine, she may select a menu option to report the drug shortage. This option will alert relevant actors to provide inventory, and possibly implement inventory control training, to sites to ensure a smooth flow of needed drugs. This function also allows patients to act as watchdogs against corrupt practises.

To assist in controlling corruption, there could be a menu option at a high level that empowers the patient to report feedback about the quality of the healthcare services received. The end user can:

- Provide feedback via SMS detailing his or her comments (example shown below),
- Opt to thank the services, or
- Opt to report abuse for cases where the patient had to offer informal payments or bribes to obtain drugs.

The patient may even decide to report health staff absenteeism.

Additional data on recovery status, drug adherence and corruption could be collected by directly calling patients, subject to adherence to national privacy laws. These calls could be targeted to particular patients or done randomly.

Data on the quality of healthcare could be offered to local authorities so that they can tackle the issues at the root of the problem. This data could be analyzed, allowing the identification of severe cases of corruption or bribery. Badly governed centres could potentially be excluded from the programme.

The mobile health-payment system could also be extended to other uses, such as to obtain other medical products. These possibilities are further explored in Section 6 below.

MHIF would use "smart search" to facilitate working through the menu. After the user has entered a sequence of digits, available menu items are reduced to words

with matching letters corresponding to the digits entered. This smart filtering is a common feature of mobile phone software and is well understood in the developed world.

MHIF software will also keep records of the user's entries in the "History" option on the menu level of "Assay", "Medicine", "Vaccine" and "Other". When "History" is opened, the patient's drug purchases and the disease that they were taken or prescribed for are time-stamped and listed in chronological order. This data could be streamed from the central transaction database to the patient's mobile phone. The "history" function could provide medical professionals with at least partial access to a patient's medical records.

Moreover, the history function could also be helpful for patients who are unable to work through the menu themselves. These patients can hand their phone over to the drug vendor who will work through the menu to purchase the drug for the patient. The vendor may have an incentive to record false drug purchases in order to privately use or sell drugs not handed over to the patient. In such a case, however, the patient would at least have the option of having trusted friends or family check their phone's history to determine what was paid for. Giving the software the capability to speak purchases aloud would also reduce the opportunity to cheat patients.

Distribution of free SIM cards. As noted above, not everyone owns a mobile phone. This need not be a barrier to use of MHIF, however, since an individuals' MHIF account is actually stored on a SIM card. The MHIF system could therefore sponsor the distribution of free SIM cards, which would be roughly analogous to health account banking cards. Vendors could have a central computing device, much like a Mobile Internet Device (MID), that provides cellular connectivity. Patients could insert their SIM cards into the device to finish their transactions.

Allowing cash payments. One way of ensuring an adequate flow of information through the MHIF system is to grant discounts for mobile-based payments, while allowing a certain percentage of cash transactions at each vendor. The discounts would incentivise the citizens to own mobile phones as good assets for obtaining more affordable medication.

5. DEPLOYMENT CHALLENGES

MHIF, like other technical systems, exhibits many deployment challenges. We discuss these challenges in this section.

Mobile Coverage

Mobile penetration is predicted to increase drastically over the coming years. One prediction holds that 90% of the population of Sub-Saharan Africa will have mobile phone coverage by 2012, up from 60% in 2007 (Heeks, 2009). This growth is plausible given that mobile phones in rural settings are used as communal resources.

ITU (2007) estimates that 45% of Sub-Saharan African villages were covered by mobile signal in 2006. Mobile carriers have been extending their telecommunication bases extensively and many Sub-Saharan African countries like Kenya have reached nationwide coverage (Cellular News, 2009b) today. We foresee a fast uptake in both the usage of mobile phones and the broadening of signal coverage in the coming years.

Technical advances in cellular and chip designs have enabled mobile phones to be cheaper, easier to use and more tailored for local needs. For example, parts of tropical countries have already launched solar powered mobile phones in order to ease the need for regular access to the electrical grid (Cellular News, 2009a).

In rural areas where mobile phone penetration is sparse, a number of options are available to increase the usefulness of the MHIF system. First, in the developed world, thousands of mobile phones are recycled annually. They could be collected and re-distributed at a relatively low cost. Second, as described above, the HIF could sponsor distribution of free SIM cards.

Technology Adoption

One potential concern is that some patients, and especially older persons, may be unfamiliar with technology and feel intimidated by it. In the current digital era, citizens are becoming more technologically sophisticated. The M-PESA system in Kenya has exceeded its expected number of customers. M-PESA has established training camps to educate citizens on using this menu-driven technology. We have modelled the MHIF after the M-PESA interaction model to facilitate adoption.

Illiteracy

Some patients, particularly those who are illiterate, may depend on vendors to complete transactions for them. As explained in Section 4, a history option with audio feedback could be provided to mitigate possible misuse. This could also be useful for persons incapable of working through the menu because of poor eyesight or other impediments.

Languages

In some countries there are many languages in use. The MHIF could be translated for most local languages. However some languages are not commonly used on mobile phone menu systems,potentially limiting the universality of the MHIF system somewhat. We note that despite multiple languages used in Kenya, the M-PESA system has been successfully offered throughout the country.

Lobbying Government and Operators for Smooth System Deployment

Corrupt officials may unite to erect opposition to the MHIF, particularly if they fear that the system will require greater accountability. As a result, the MHIF will require government support to be implemented and used effectively.

6. MHIF AS A SPRINGBOARD

We describe some possible expansions of MHIF that could be implemented by third parties to transform the system to a broader MHealth—mobile health—platform.

Distribution of General Healthcare Products

Under certain well defined recurring programmes for targeted scenarios, a health agency may directly purchase healthcare products and distribute them, through select charities or government clinics, to the needy. Consider the following scenario, where an agency wants to distribute mosquito nets to a site around Lake Victoria.

- The agency bids for mosquito nets and arranges for bulk purchases to be transported to the site.

- The agency sends an e-Voucher token to the mobile phone accounts of the citizens registered at that site.
- The e-Voucher shows up on the citizen's mobile phone's MHIF extended menu.
- The citizen can then go to the site to collect the product in exchange for the e-Voucher.

Similar programmes for immunization could be implemented, for which e-Vouchers for vaccines would be sent to the selected needy. The same mechanism could be used to load up a few dollars onto the HIF accounts of selected patients for the sole use of purchasing medicines in cases where the patients are extremely poor and cannot afford the low prices set or in cases where citizens have been displaced or immobilized.

In certain cases, the government may want to mass purchase HIF drugs for distribution to areas in crisis because of war, famine, or disease. While we recommend such schemes to use the E-Voucher mechanism for better treatment tracking, the MHIF system allows for non-mobile purchases where drugs are essentially given free by the state. In these cases, MHIF still allows improved health impact assessment relative to the non-MHIF baseline, since MHIF systems could be used to track patients' recovery process.

The MHIF system could also work well for vaccines. As an extension to the system, one could require all deliveries of vaccines to drug vendors to be reported to the central database. As a result, it would always be precisely known how many vaccines each drug vendor has in stock. Assuming that all patients have a HIF account, it will be accurately known for each drug vendor how many people live in its vicinity. This information could help to effectively distribute vaccines and contain the outbreak of diseases. To help to optimise effective drug allocation, governments could distribute E-Vouchers precisely in those regions in which the vaccination has the greatest health impact. Real-time data collection has proved very valuable in Kenya and Zambia, where health workers collected information about infections using PDAs (Ansari, 2009).

Additional benefits include:

Improving the Availability of Information to Doctors about Patients

As noted above, MHIF will record individuals' drug purchase history. This could be useful to doctors, particularly when patients change doctors.

Telemedicine

Rural patients can dial a toll-free national health service line to receive medical advice over the phone. Doctors could register as e-doctors to provide this service, enabling them to send an e-prescription to patients' phones. This would help in specialised cases, especially in places where health professionals are scarce.

Educating and Enhancing Awareness via SMS Dissemination

SMS communications show great promise for public health campaigns more generally. A report by the United Nations Foundation and the Vodafone Foundation on mobile health found that "formal studies and anecdotal evidence demonstrate that SMS alerts have a measurable impact on and a greater ability to influence behaviour than radio and television campaigns" (Vital Wave Consulting, 2009).

SMS can be very effectively used to disseminate information. Claire Thwaites, head of the partnership between the UN Foundation and Vodafone, noted that: "A group called Text to Change operating in Uganda sends SMS text to the population to improve awareness of HIV Aids treatment and prevention. We have seen that encouraging the population to participate in a quiz is raising awareness of the disease and how to prevent it. We are actually seeing a 40% increase in those going in for HIV tests" (Saran, 2009).

The data collected using the mobile system could enhance the effectiveness of information provision via SMS. For example, messages sent to patients could be prioritized based on the information available about the patient's diseases and the diseases that the other people have in the area. Moreover, the information sent to health workers could also be prioritized according to the data about diseases in the relevant region.

7. CONCLUSION

In adopting the Millennium Declaration in the year 2000, the international community pledged to "spare no effort to free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty" (United Nations, 2008). We are now more than halfway towards the target date – 2015 – by which the Millennium Development Goals are to be achieved, yet global health care accessible to all remains a core challenge. Technological breakthroughs fuelled by billions of dollars of investment have transformed health care for the wealthy[5], yet patients in resource-poor countries cannot afford high quality care. Each year more than 10 million people in the developing world die of infectious diseases. Millions more suffer from debilitating parasitic diseases, which often incapacitate people in their most productive years. The resultant weaker economies plague these nations with poor infrastructure, creating a vicious cycle that has kept poorer nations struggling at the bottom. But simply increasing funds available for health care isn't enough; interventions need to be well designed and carefully implemented. Some research has indicated that a significant share of healthcare budgets is "siphoned off to private pockets" with only 60% (Stover, 2006) of the budget making it to the final intended patients.

To make medicines accessible to all, we have examined the proposed Health Impact Fund's deployment model. The proposed solution, as studied, comprises of 3 distinct elements:

1. a business model shift to foster pharmaceutical innovation;
2. a collaborative system to help materialize the desired innovation;
3. a long term sustainable development approach.

The MHIF program described here can improve assessment of health impact of new drugs, create a better reporting channel, and enhance transparency within this program.

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[5] Ninety percent of the world's spending on healthcare only benefits the richest fifth of the world's population.

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