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Changing the format to landscape:

Assessing the application of information and communication technologies (ICTs) to healthcare delivery in rural Uganda and its putative association with technical and social innovation

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List of Acronyms

AAP	African Access Point
AED	Academy for Education Development
AMREF	African Medical and Research Foundation
ART	Antiretroviral therapy
CME	Continuing medical education
CPD	Continuing professional development
DDHS	Director of district health services
DHO	District health offices
GPRS	General packet radio service
GRACE	Gender Research in Africa into ICTs for Empowerment
GSM	Global system for mobile communications
HIS	Health information system
HMIS	Health management information system
HSD	Health sub-districts
ICT4D	Information and communication technology for development
ICTs	Information and communication technologies
IDRC	International Development Research Centre
IDSR	Integrated Disease Surveillance and Response
ITN	Insecticide-treated nets
MDGs	Millennium Development Goals
NGO	Non-governmental organization
PDA	Personal digital assistant
PFP	Private, for-profit
PMTCT	Prevention of mother-to-child transmission of HIV
PNFP	Private, not-for-profit
UCH	Uganda Chartered HealthNet
UHIN	Uganda Health Information Network
UHSBS	Uganda HIV & AIDS Sero-Behavioural Survey
UNDP	United Nations Development Programme
VHT	Village Health Team
WHO	World Health Organization

Abstract

With the introduction of personal digital assistants, smartphones and netbooks and their attendant support technologies in the public healthcare system in five resource-constrained rural Ugandan districts, in the face of numerous technical challenges, the Uganda Health Information Network (UHIN) project has demonstrably achieved technical innovation since its inception in 2003. The applicability of the more abstract and complex notion of social innovation – particularly its more ambitious iterations, which posit social change – is, however, less certain.

Where scarce resources, including money and human effort, are allocated to technology-centred initiatives in environments where shortages of even basic material and human resources are commonplace, a critical analysis of the purported results is warranted. In the general absence of critical assessments of technology-based international development interventions, an analysis of key dimensions of the UHIN initiative presents an opportunity to assess the limitations associated with technology-based healthcare applications in a developing-country context.

Keywords: social innovation, technical innovation, Uganda, ICT, health

Introduction

Innovation, conceptualised

Interest in the contribution of innovation to economic and social change can be traced back at least to the works of Joseph Schumpeter (1883-1950). While his analyses in this domain focused primarily on product and process innovation, Schumpeter is also credited with recognising that the organisational and societal context in which technological innovations are realised is important to their efficacy.

Today, it is generally agreed that whereas invention is the first occurrence of an idea for a new product or process, innovation is the first attempt to put an invention into practise (Fagerberg, 2006). As such, innovation is seen to include products and/or processes new to a given context, such as a sector or firm, rather than to the world or marketplace (see, for example, Aubert, 2004). As noted by Fagerberg (2006, p. 8), the process of introducing innovations into new contexts, or technology transfer, "often implies considerable adaptation (and hence, incremental innovation) and...organizational changes (or innovations) that may significantly increase productivity."

Many governments of developing countries have invested in infrastructure development to support reliable and efficient information technology transfer, which has contributed to technological development in Latin America and South-East Asia (Al-Mabrouk and Soar, 2009). However, it is well recognised that the success of technology transfer usually is tied to the recipient country's economic and political conditions, training and education facilities, national development priorities, plans and strategies (including government policies) and other social and organisational issues (Odedra-Straub, 1992). Put simply, the social context to which the technology is being transferred is integral to its success.

Schumpeter has been credited with positing that *social* innovation – which, according to Moulaert (2008, p. 12), he considered to be "structural change in the organization of society, or within the network of organizational forms of enterprise or business" – is "a necessary condition for the efficacy of technological innovation" (Novy, Hammer, Leubolt, 2008, p. 131). Echoing this view, Freeman (2002, p. 159) asserts that, while information and communication technologies (ICTs) carry enormous potential for new employment and a new wave of high investment and high growth, "all previous experience shows that when a new pervasive technology enters the economic system, it can do so only after a prolonged social process of learning, reform, and adaptation of old institutions." Likewise, North (2005) maintains that change in institutions – the humanly devised constraints that shape human interaction – is shaped by the interaction between organisations and institutions.

While the notion of technological innovation is not particularly contentious in terms of how it is defined, this is not the case for social innovation, which André, Brito Henriques, and Malheiros (2008, p. 149) describe as "an ambiguous concept with multiple meanings and vague contours." In addition to the institution-oriented framing of social innovation as exemplified by both Freeman (2002) and North (2005) this concept has also been applied in the analysis of social relations and associated with meeting human needs (Antohi, 2008).

MacCallum, Moulaert, Hillier and Haddock (2008, p. 1-2) posit that the concept of social innovation, "rejects the traditional, technology-focussed application of the term 'innovation'...in favour of a more nuanced reading which valorizes the knowledge and cultural assets of communities and which foregrounds the creative reconfiguration of social relations...social innovation is innovation in social relations, as well as in meeting human needs." Viewed from the perspective of health, this assertion resonates with Sen's claim that "Health equity cannot be concerned only with health, seen in isolation. Rather it must come to grips with the larger issue of fairness and justice in social arrangements, including economic allocations, paying appropriate attention to the role of health in human life and freedom" (Sen, 2002, p. 659). Thus, while perhaps articulating an ideal of social innovation, the definition proposed by MacCallum et al. sets the bar high, especially when applied to the broad concept of health.

Phills, Deiglmeier, and Miller (2008, p. XX) also propose a particularly clear and nuanced – if somewhat less ambitious – definition of social innovation, which they contend is the application of, "a novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals." Homer-Dixon (2001) offers a complementary perspective, asserting that ingenuity concerns the application of ideas to solve practical and social problems. In his view, a distinction can be made between technical ingenuity, which is used to create new technologies and "helps us solve problems in our physical world – such as requirements for shelter, food and transportation," and social ingenuity, "a critical prerequisite to technical ingenuity" which is "used to reform old institutions and social arrangements and build new ones," such as productive schools and universities (Homer-Dixon, 2001, p. 22).

Innovation and the Uganda Health Information Network

The relevance of the preceding discussion to the UHIN project derives not only from the fact that technological change was brought on by the initiative. Indeed, the UHIN project partners assert that the '[i]ntroduction of ICT increases the level of innovation in health sector management" insofar as the technologies can be used to carry out a variety of functions (SATELLIFE and Uganda Chartered HealthNet, 2007a, p. 29). As noted by SATELLIFE and Uganda Chartered HealthNet (2007a), an example of a "local innovation", or an application of the UHIN-provided PDAs, which was conceived by local healthcare workers and not specifically foreseen by the project developers, is the collection of information about malnourishment among children brought to the district hospital in Lyantonde, including average monthly incidence and status. This information is used to plan for the requirements of a nutrition promotion program, which involves in-hospital feeding of malnourished children and educating mothers about nutritional meal preparation with the help of a "nutrition demonstration garden" at the hospital.

Furthermore, although achieving social innovation is not explicitly stated as a goal of the UHIN initiative, insofar as, at its core, the purpose of the project is to alter individual behaviours and organisational routines, the information network can be defined as a 'social technology' as defined by Pinch, Ashmore and Mulkay (1992, p. 266). There are also echoes of social innovation in the claim that the UHIN intervention has "made significant contributions to improving women's access to ICT, which in turn enhanced their status in their community and work place, boosted their self-esteem, contributed to their overcoming feelings of isolation, built their knowledge and skill base, and, in some cases, increased their incomes" (Ladd, Gebru and Kibaya, 2010, p. 6).

Broadening the format: Moving beyond technological determinism and assessing the application of technical means to social ends

The notion of technological determinism, with its various labels, definitions and conceptualised manifestations, lies at the heart of most critical analyses of glowing[1] as well as dystopian characterisations of the relationship between society and technology. That technological developments do not simply arise in adherence to an internal, technical logic, free from the influence of human interest, is widely asserted among critics of deterministic positions[2]. Furthermore, the notion that technology constitutes an external, autonomous force which exerts influence on society has also been problematised by scholars such as Wajcman (2002, p. 351)[3], who seeks to expand options for "democratic engagement with technology" beyond "uncritical embracing of technological change, defensive adaptation to it, or simple rejection of it."

Mansell (2010) posits that "the Information Society" and related notions have been instrumental in mobilising a large number of initiatives supported by those who associate digital ICTs and globally networked information with prosperity. Beginning in the late 1990s, ICTs were "idolised as a saviour that could deliver

1 Leye (2009) offers a strong introduction to questions raised by "techno-optimist promises," including examples of the flawed assumptions and parochial perspectives on which they are sometimes based.

2 See, for example, Feenberg (1995, p. 3) on "underdetermination", Fortier (2001, p. 11) on "functional neutrality", Wyatt (2008), and Bijker (2010).

3 See, also, Wyatt (2008).

all development goals" (Heeks 2009, p. 33), and high hopes for the potentially transformative power of ICTs became reflected in the mantra of 'information and communication technology for development' (ICT4D), which became part of the mainstream of policy.

In the field of international development, such initiatives became enmeshed in a narrative in which the race was on to 'bridge the digital divide' by transferring the prosperity-enabling ICTs of the information-rich global North to the global South through the largesse of a variety of funders. This theme of 'equalising unification' is visible in descriptions such as that which portrays UHIN as an initiative that exploits Ugandan telecommunications infrastructure through the "marriage" of handheld technology and cellular telephony in order to "battle against information poverty" (AED-SATELLIFE, 2009).

Mansell (2008, p. 12) asserts that "The continuing dominance of paradigms of research that feed The Information Society vision without criticizing its assumptions and the need to find improved means of ensuring that ICTs are put into service in ways that are enabling, rather than disabling, means that the research community cannot simply turn its back either on the domains of policy or on practices where the vision plays itself out in people's lives." The approach taken in the present inquiry is consistent with this viewpoint; however, rather than framing the issue using the binary terms 'enabling' and 'disabling,' the paper is concerned with the suitability of investing in ICTs – as opposed to other means of conveying health-related information – in resource-constrained environments.

In spite of the maturity of the scholarly enterprise which posits the social shaping of the design and use of technology, and which questions assumptions about the relationship between the so-called "Information Society", technological change, and the notion of progress[4], reports emanating from the development industry tend to strongly affirm the suitability of technology-based solutions with little or no scrutiny and criticism of the nature of changes the investments have engendered. These investments include financial resources, time, and effort – both on the part of the organisations that plan and help implement the intervention, and the many individuals from every point on the organisational spectrum who work to implement the initiative.

The point of departure for the analysis contained in this paper is that technology is, in the words of Wacjman (2002, p. 351), a "socio-technical product, patterned by the conditions of its creation and use." As such, the approach taken in the present paper is deliberately critical, and it challenges the view which still exists among some scholars and practitioners that communication is a linear process of information transmission, causing or contributing to changes in knowledge, attitudes, and behaviours (Melkote & Steeves, 2001).

Positionality of the researcher

I, the author of this paper, spend several hours each day using ICTs to access various forms of information and knowledge, and to consult and otherwise communicate with friends and colleagues. Therefore, in my analysis of the UHIN case, I have been cognizant of the profound usefulness of 'modern' technologies, as well as the psychosocial benefits they may facilitate.

Furthermore, in 2009, I worked as a Research Intern with the International Development Research Centre's (IDRC) Acacia Program, which supported the UHIN project for seven years. I therefore have an appreciation of the potential benefits and limitations of ICTs in general, as well as some understanding of the many challenges faced by development project partners during project implementation.

As I conducted this analysis, I was cognizant of differences between my own cultural beliefs and 'health-seeking behaviour' – including my experience with and subscription to the ideas of 'formal', 'modern', and 'Western' medicine – and other beliefs and practises which exist in rural Uganda. I also acknowledge that I lack the kind of insight that would undoubtedly come from spending time in the sites in which UHIN operates and that, as a Western city-dweller, I cannot claim to personally relate to the challenges that arise from the physical and professional isolation of living and working in rural Uganda. With that experience

4 The concept of progress may be represented by any number of what Pieterse (2005, p. 23) terms "development fads and shibboleths – such as good governance, transparency, democracy, civil society, participation, and empowerment."

and knowledge, and the intent to conduct a balanced assessment of the UHIN initiative, I employed the methodology described below.

Methodology and Scope

Of qualitative studies, Creswell (1994, p. 10) asserts, "The variables are largely unknown, and the researcher wants to focus on the context that may shape the understanding of the phenomenon being studied. In many qualitative studies a theory base does not guide the study because those available are inadequate, incomplete, or simply missing." As noted above, the concept of social innovation covers a broader and more abstract terrain, and in order to assess its applicability to a development intervention such as the UHIN initiative, one must look beyond the merits and demerits of the technical facets of the intervention, to its interplay with the context in which it operates.

Due to restrictions on the length of the present paper, and in light of the availability of technical reports relating to the project under study, as well as a diverse and informative literature on various facets of health and healthcare provision in Uganda, a desk-based analysis was undertaken. Information sources included technical reports submitted to the International Development Research Centre (IDRC) by UHIN project partners[5], as well as scholarly and journalistic articles and Health Sector Strategic Plans prepared by the Ugandan Ministry of Health.

Insofar as the bulk of the UHIN-related information analysed was written by the founders and implementers of UHIN (as well as consultants, most of whose work was commissioned by them) in accordance with terms established by IDRC, their funding partner, it is acknowledged that the reports analysed may be biased, namely in terms of the information selected for inclusion. Indeed, data objectivity within the medical informatics literature can often be challenged, given the preponderance of articles and reports written by those who developed the systems in question (Heeks, 2006). As a suggestion for future research, an empirical inquiry into the issues raised in this research paper would allow for a broader scope of inquiry as well as stronger triangulation and, therefore, a greater assurance of the internal validity of the findings.

5 This includes appended documents which were relevant to the present analysis. As of the time of writing, technical reports detailing the first three phases of the UHIN project were available online through the website of UHIN project partner Uganda Chartered HealthNet. Regarding the report for the fourth and final phase of the project, AED-SATELLIFE states, "To the extent possible under law, AED-SATELLIFE has waived all copyright and related or neighboring rights" (Ladd, Gebru and Kibaya, 2010, p. 2).

Health in Uganda

Key health status indicators

With a population approaching 32.5 million, the second-highest crude birth rate in the world[6], and one of the world's lowest life expectancies at birth[7], Uganda faces formidable challenges with regard to disease prevention and treatment, particularly with respect to communicable diseases. For example, malaria, the leading cause of mortality and morbidity in Uganda, is endemic in 95 percent of the country (Williams, Martina, Cumming and Hall, 2009), and approximately one million Ugandans are living with HIV (Ministry of Health & ORC Macro, 2006).

Uganda is also plagued by other health problems, such as acute respiratory infection, diarrheal diseases, pneumonia, tuberculosis, and problems arising during pregnancy and childbirth. According to the 2006 Uganda Demographic and Health Survey, which asked approximately 11,000 residents between the ages of 15 and 54, chosen from all districts, to recount various events during the preceding five years, only 47 percent of women reported having had four or more antenatal care visits during pregnancy, and most of those visits had begun at a relatively late stage in the pregnancy (Uganda Bureau of Statistics & Macro International Inc., 2007). Furthermore, it was reported that 42 percent of infants were delivered with the assistance of a trained health professional (that is, a doctor, nurse, midwife, medical assistant, or clinical officer), 23 percent were delivered by a "traditional birth attendant"[8], 25 percent were attended by "a relative or some other person", and 10 percent were delivered with no assistance at all (Uganda Bureau of Statistics & Macro International Inc., 2007, p. xxiv).

Uganda is not expected to achieve the health-related Millennium Development Goals (MDGs) concerning infant mortality and maternal health. Furthermore, in light of the temporal and spatial prevalence of malaria transmission, as well as malaria's status as the most commonly reported disease by both public and private health facilities (President's Malaria Initiative, 2010), the prospects for achieving the malaria-related target associated with the sixth MDG are dim. Significant gains in reversing the spread of HIV/AIDS have been achieved. The prevalence of HIV infection, which peaked at 18 percent in 1992 (UNDP, 2007a), had decreased to 6.4% in adults and 0.7% in children as of the last Uganda HIV & AIDS Sero-Behavioural Survey (UHSBS), which was conducted in 2004/05[9] (Government of Uganda, 2010). However, in spite of an increase in the number of sites throughout the country which offer antiretroviral therapy, as of December, 2007, only 39 percent (121,218) of those eligible were receiving this treatment (WHO Regional Office for Africa, 2009).

The organisation of healthcare

Uganda has a decentralised health system in which the central government's core responsibilities include policy formulation and stewardship, while implementation is carried out by the country's more than 90 districts (self-governing administrative areas), which are further divided into health sub-districts, which comprise parishes. Among the country's health facilities, 60 percent are publicly owned, 30 percent belong to the private, not-for-profit (PNFP) sector[10] and the remaining 10 percent belong to the private, for-profit (PFP) sector (Basaza, Criel & Van der Stuyft, 2010).

Health services are delivered through a referral-based public healthcare system. Villages with a population of 1,000 or fewer are supposed to be offered basic healthcare services by a volunteer-driven Village

6 Between 2005 and 2010, the total fertility rate (births per woman) was 6.4 (UNDP, 2009).

7 In 2007, life expectancy at birth was 51.9 years (UNDP, 2009).

8 This term is not defined in the survey

9 It should be noted that results from this study as well as Uganda Demographic and Health studies conducted in the last decade suggest that a high proportion of Ugandans have never been tested for HIV and are unaware of their status (Uganda Bureau of Statistics & Macro International, 2007).

10 More than 75 percent of PNFP facilities are owned by medical bureaus associated with the Catholic, Protestant, Orthodox, and Muslim faith groups (Ministry of Health, n.d.b)..

Health Team (VHT). VHT members are intended to educate community members on various health issues and other topics[11], monitor and report on households' adherence to sanitation standards, distribute medicines for common ailments, and, where appropriate, refer community members to formal health facilities. However, coverage of VHTs is described as "limited" and attrition among the volunteers, "quite high" (Ugandan Ministry of Health, n.d.b, p. 5). A lack of basic drugs for diseases such as malaria has also been cited as a common limitation of the work of VHTs (Kavuma, 2009).

Based on the population of the catchment area, more advanced healthcare services are supposed to be accessible to community members through health centres and hospitals, as outlined by the Ministry of Health (n.d.a and b):

- Health Centre-II units (parishes with a population of approximately 5,000) are intended to provide outpatient and community outreach services by enrolled comprehensive nurses.
- Health Centre-III units (sub-counties with a population of approximately 20,000) are intended to treat outpatients and offer services such as maternity care and laboratory analysis for disease diagnosis, and are supposed to be staffed by doctors and midwives.
- Health Centre-IV units (counties with a population of approximately 100,000) are to provide services such as emergency obstetric care, dental care, and palliative care, and are also supposed to be staffed by doctors and midwives.
- Hospitals: 43 general hospitals (district-level, managed by the Ministry of Local Government, populations of 500,000); 11 regional referral hospitals (managed by the Ministry of Health, populations of 2 million); and two national referral hospitals (fully autonomous, populations of 30 million).

Local governments are responsible for the delivery of health services, recruitment, deployment, development and management of human resources for district health services, for developing and passing health-related by-laws, and for monitoring overall health sector performance. The local governments manage public general hospitals and health centres and also provide supervision and monitoring of all health activities in their respective areas of responsibility.

In spite of this official structure, in practise, many areas do not have physical access to the health services they require. For example, in Katine sub-county of the north-eastern district of Soroti, although VHT volunteers have been trained and provided with bicycles by the African Medical and Research Foundation (AMREF), they rarely have access to medication, so they can only advise patients and refer them to health centres (Kavuma, 2009). Only one of six parishes in Katine has a level-II health centre, there is no level-III health centre, and the sub-county's level-IV health centre has no doctor and is run by two clinical officers, and its surgical theatre is not operable because of a lack of water, power and other smaller installations (Kavuma, 2009).

Furthermore, major human-resource problems within the public system have been cited by both the Ministry of Health (n.d.b) and the World Bank (2010). A World Bank project appraisal document from April, 2010 states that, "The health workforce…is characterized by low motivation, maldistribution, high rates of attrition and absenteeism, and difficulties with attraction and retention of health workers in remote and hard to reach districts. Personnel management is especially poor and is characterized by delays in recruitment, payroll entry, confirmation, appraisals and promotion, and is associated with high staff turnover" (World Bank, 2010, p. 26).

In addition to publicly-managed facilities, there are 42 PNFP hospitals and 4 PHP hospitals, and the Ministry of Health (n.d.b, p. 6) states that, "The private sector plays an important role in the delivery of health services in Uganda." Unlike their PFP counterparts, PNFP facilities are predominantly found in remote, underserved areas, where they are often the only providers of healthcare (Basaza, Criel & Van der Stuyft, 2010).

11 For example, the non-governmental organization (NGO) African Medical and Research Foundation has offered training to VHT members on topics such as budgeting and family planning (Malinga, 2010 a).

The Ministry of Health (n.d.b) notes that, officially, private facilities fall under the purview of local governments , but links between the private and public health entities are weak at the district level. The point is substantiated by the fact that private facilities in the five participating districts are not part of UHIN. Furthermore, the Ministry of Health (n.d.b, p. 8) estimates that, prior to attending "formal" health centres, 60 percent of Ugandans seek care from what the Ministry terms "traditional and complementary medicine practitioners," a category which includes a wide range of practitioners who claim to specialise in various facets of human illness prevention and healing[12].

The Ministry of Health (n.d.b) acknowledges that, although 72 percent of Ugandan households live within five kilometres of a health facility, utilisation is limited. Official reasons cited include poor infrastructure, lack of medicines and other health supplies, human resource shortages in the public sector, and lack of accommodation at health facilities.

Approximately 10 percent of the Ugandan government's budget is allocated for health, compared to the 15-percent target pledged in the Abuja Declaration[13], and the government spends approximately USD 15 per capita, compared to the USD 28 per capita required to fully finance implementation of the health sector strategic plan (Okwero, Tandon, Sparkes, McLaughlin, Hoogeveen, 2009). Although the government officially abolished user fees in the general wings of public-owned hospitals and lower-level health facilities in 2001, fees remain in private wings of government hospitals and in private facilities (Basaza, Criel & Van der Stuyft, 2010). Although exceptions are sometimes made (for example, in cases of severe malnourishment), fees are often applied to the treatment of common illnesses, such as malaria and diarrhea, even in areas in which most residents live in extreme poverty, such as the Moroto district in the Karamoja region in the northeast of the country (Keulig, Kagan, and Knaute, 2008).

Furthermore, shortages of essential drugs in health units (including public health facilities) often leave patients with no choice but to buy them from pharmacies and other drug sellers (Kavuma, 2009; Okwero et al., 2009). When malaria, a common ailment in Uganda, is suspected due to the presence of symptoms such as fever, treatment is often sought from private sources, including clinics, drug shops, provision shops which sell drugs, and practitioners who work out of their homes (Nshakira, Kristensen, Ssali, and Reynolds Whyte, 2002). Not all clinics and drug shops are registered, and private providers' professional qualifications vary, which is a disconcerting fact from the perspective of quality of care, if not public safety.

With respect to prevention, the Ministry of Health asserts that, "75 percent of the disease burden in Uganda is preventable through improved hygiene and sanitation, vaccination against the child killer diseases, good nutrition and other preventive measures such as use of condoms and insecticide treated nets (ITNs) for malaria" (Ministry of Health, n.d.b, p. 5). The Ministry also recognises that an important challenge to increasing access to information and tools to support disease prevention, and to providing treatment for extant disease afflictions, is inadequate and untimely information, as well as a dearth of tools for processing information collected.

12 As one example from this category, Jabs (2010, p. 487) notes that, "When [members of the Karimojong tribe of the Karamoja region in North-eastern Uganda] are sick or when they desire to hurt another person, they tend to go to a witch doctor to be cured or to curse the perceived perpetrator of the illness."

13 The Abuja Declaration on HIV/AIDS, Tuberculosis and Other Related Infectious Diseases resulted from a summit which convened heads of states (including Uganda) and the government of the Organisation of African Unity in April, 2001. The declaration can be viewed at: http://www.un.org/ga/aids/pdf/abuja_declaration.pdf

Mobile health technology for development

Outside of Uganda, hand-held computers commonly known as personal digital assistants (PDAs) have been successfully employed in the collection of health information in rural areas in which communications infrastructure is weak. For example, Seebregts et al. (2009) analysed the use of handheld computers in interview- and respondent-administered health surveys in South Africa and concluded that PDAs can reduce the logistic burden, cost[14], and error rate in comparison to paper-based health research data collection.

In spite of the limited evidence that is available[15], the application of mobile health applications in developing countries has been touted by some observers as having significant transformative potential with regard to the receipt and transmission of health-related information. For example, Karl Brown, Associate Director of the Rockefeller Foundation, suggests that, "because mobile phones enable multidirectional flows of information even in the most remote parts of the world, they have the power to transform health care" ("A doctor", 2009).

Conceived in a similar vein in 2003 by project partners AED-SATELLIFE[16], Uganda Chartered HealthNet[17] and the College of Health Sciences of Uganda's Makerere University, UHIN was designed to allow for two-way electronic communication of health information in Uganda's public health system to support the dissemination of health information, the collection and reporting of data, and the exchange of email (UHIN, 2009). UHIN received multiple research grants as well as non-financial support from Canadian Crown corporation IDRC. Although the IDRC-mandated technical reports for each of the four phases of the project articulated variations of similar goals in accordance with the initiative's evolution over the seven years of its development, at its core, the objective for the UHIN project was "to identify and determine cost-effective ways of enhancing access, sharing and communication of critical health and medical information in a timely and efficient manner to healthcare providers, managers and planners within the Ugandan technological and institutional context" (SATELLIFE and Uganda Chartered HealthNet, 2007 a).

The impetus for the UHIN project arose from reported inadequacies of the manual reporting system used by the Ministry of Health, especially data loss, variable data quality due to transcription errors, and slow transmission of clinical information to those who need it for planning purposes (SATELLIFE and Uganda Chartered HealthNet, 2004b). It is reported that under the manual system, information is slow to reach decision-makers due to both the labour-intensive nature of recording information on paper and inputting the data into databases, and the distances over which information must travel, especially given technological constraints relating to telephone and Internet connections (SATELLIFE and Uganda Chartered HealthNet, 2004b). As a result, health facility-generated information such as that which is required to effectively respond to an epidemic outbreak, may be out-of-date by the time it reaches district-level personnel. The Uganda Ministry of Health reported in 2003 that only 63% of health units were reporting in a timely fashion (cited in SATELLIFE and Uganda Chartered HealthNet, 2004b). Furthermore, with respect to the continuing education of healthcare providers, it is reported that there is limited access to relevant and timely health information - particularly in rural areas - due to a lack of libraries and limited or no access to telephones, fax machines and the Internet (SATELLIFE and Uganda Chartered HealthNet, 2007a).

14 The cost of the PDA survey was found to be slightly less than its paper-based equivalent when the cost of the hardware is annualised over four studies and the cost of programming – which amounted to two programmer years – excluded (Seebregts et al., 2009).

15 Heeks (2006) points out that there appears to be a publication bias in favour of health information system success stories, and that those systems which are designed for use in industrialised countries are more prone to failure when introduced in developing countries.

16 AED-SATELLIFE is a U.S.-based not-for-profit organisation. Before merging with the Academy for Education Development (AED) to form the Center for Health Information and Technology, SATELLIFE, which was formed in 1987, had used information technology to expand access to health and medical information in a variety of settings around the world (SATELLIFE, 2007).

17 Uganda Chartered HealthNet (UCH) was born out of the Uganda HealthNet Project, a joint initiative founded in 1998 by Makerere University's Faculty of Medicine and SATELLIFE (SATELLIFE and Uganda Chartered HealthNet, 2004a). UCH is a registered NGO based at the Mulago Teaching and Referral Hospital in Kampala, the teaching hospital for Makerere University's College of Health Sciences and site of UHIN headquarters.

UHIN was developed to support Uganda's Ministry of Health in its efforts to improve the country's standards of national healthcare (as articulated in the Ministry's second Health Sector Strategic Plan) by improving the health management information system (HMIS)[18] and Integrated Disease Surveillance and Response (IDSR). In addition to facilitating the timely flow of accurate and complete information specific to participating health facilities, the UHIN project partners aspired, from the initiative's first phase of implementation, to deliver and make accessible to healthcare workers informative material under the rubrics of continuing medical education (CME)[19] and continuing professional development (CPD)[20]. Public health facilities in five rural districts (Bududa, Lyantonde, Manafwa, Mbale, and Rakai) participated in the network, and approximately 700 health workers in a total of 174 health facilities were involved (Ladd, Gebru and Kibaya, 2010).

Financial and other support for the initiative was provided by the International Development Research Centre (IDRC), which, as noted by Program Officer Edith Ofwona-Adera, contributed over CAD 3 million in funding over the course of approximately seven years (Uganda Broadcasting Corporation, 2010). IDRC also supports the Mozambique Health Information Network, an analogous two-way communication initiative launched in 2006 by AED and Mozambique's Ministry of Health and Ministry of Science and Technology (Mozambique Health Information Network, 2009). AED-SATELLIFE endeavoured to "identify and document 'best practices' and lessons learned from the [UHIN] project" in case they were deemed replicable/scalable in similar settings, such as Mozambique (SATELLIFE and Uganda Chartered HealthNet, 2007b, p. 7).

A press release issued in May, 2010 indicates that AED-SATELLIFE has handed the UHIN project over to Uganda's Ministry of Health, which intends to "[incorporate] the UHIN solution into its formulation of a comprehensive strategy for a National Health Information System" (Mukooyo, Kibaya, & Gebru, 2010). Specifically, the Ministry of Health has taken responsibility for the gathering and reporting of HMIS data, and the districts will manage the other health data collected through UHIN as well as the delivery of CME and CPD material (Ladd, Gebru and Kibaya, 2010).

18 SATELLIFE and Uganda Chartered HealthNet (2004 a, p. 2) report that, "The HMIS was designed for use at the various levels of the health system for planning, management and evaluating the health care delivery system."

19 SATELLIFE and Uganda Chartered HealthNet (2007 a, p. 13) define CME as "a means by which new developments related to treatment and diagnosis of diseases, and results of empirical investigations are passed on to health practitioners."

20 The Director of Programs for AED-SATELLIFE's Center for Health Information and Technology notes that CPD encompasses a broader scope of content than CME, including management of health centres, human resources, and other topics beyond those that are specific to health or the practise of medicine (B. Gebru, personal communication, September 17, 2010).

Heeks's "ITPOSMO": Using a seven-dimension model to describe and theorise the UHIN project

Overview

Noting that the formal purpose of information systems is to affect a certain degree of organisational change in order to improve functioning, Heeks, Mundy and Salazar (1999) and Heeks (2006, 2007) posit a design-reality gap between the dominant design of health information systems (HIS) created by designers, and the local actuality of users. He contends that success and failure of information systems "depend on the size of gap that exists between 'current realities' and 'design conceptions of the HIS'", and that, excluding from consideration powerful exogenous drivers which can overcome constraints inherent in the system[21], an excessive gap can lead to failure of the HIS (Heeks, 2006, p. 128).

In 1999, Heeks and Bhatnagar elaborated the following dimensions of the design-reality gap, abbreviated "ITPOSMO", and over the course of several subsequent publications, Heeks provided a number of examples of the type of information that may be considered for each dimension:

- Information (quantity, quality, demand[22] and flow of information, and flexibility of information access[23]);
- Technology (computer hardware and software, telecommunications, and other healthcare technology);
- Processes (information-handling, decision-making, actions/transactions, and other healthcare processes, including informal processes);
- Objectives and values;
- Staffing and skills (numbers, technical skills, healthcare skills, other skills, knowledge);
- Management systems and structures, including informal ones; and
- Other resources (initial investment, ongoing expenditure, time, other healthcare resources).

Usage and limitations

Focussed as it is on what may be termed the "internal components" of information systems such as UHIN, Heeks's 'design-reality gap' model is an incomplete tool with which to treat the topic of social innovation. Furthermore, as noted previously, a significant number of Ugandans do not regularly seek care in the formal healthcare system, so this phenomenon is not captured by the model and is generally beyond the scope of the present inquiry.

Nonetheless, Creswell (1994, p. 101) advises qualitative researchers to use theory inductively, to treat it as something "to develop and [to shape] through the process of research." Accordingly, the Heeks model will serve as a framework with which to describe key components of the initiative and outline the broad contours of the technical changes it has brought about as well as some of the technical and organisational challenges its implementers have faced.

Using the seven dimensions of the Heeks framework as categories, and borrowing from the methodology proposed by Mayring (2000), an analysis of the information contained in the UHIN reports was undertaken in order to identify themes and main ideas. In light of the limitations of using solely the Heeks framework in an analysis of social innovation, other facets deemed relevant by the author of the present paper were considered during the content analysis, including the purported empowerment of women participants.

21 As an example of a driver which can overcome even significant design-reality gaps identified through his model, Heeks (2006, p. 135) cites "a strong political imperative from outside forces like politicians in central government."

22 Heeks (2006) emphasises the importance of demand on the part of users for the kind of information the system is designed to collect.

23 As noted by Heeks, Mundy and Salazar (1999), the flexibility of information access (that is, through 'fixed' sources, such as guidelines, as well as via open-ended inquiries, such as those facilitated by email communication) is also important.

It is not possible to fully assess the gaps which existed for each of the seven dimensions using the document analysis-based methodology proposed herein. Nonetheless, the far-reaching dimensions posited by Heeks touch on most salient facets of the UHIN intervention as they pertain to the notions of technical innovation and social innovation. In the sections that follow, each of the highly interconnected dimensions is addressed, with the most relevant facets of each described and, where applicable, analysed.

- ***Information***

UHIN was designed to facilitate the transmission of the following two main categories of information, both of which are described in the sections that follow:

- Clinical data collected at the point of care (that is, health centres and hospitals), which is collected in raw form and aggregated for use primarily by successive administrative levels (sub-district, district, and national).
- Educational and reference material about health and the provision of healthcare, which is destined for healthcare workers.

Reporting: Clinical data

It is reported that data captured via the UHIN system is analysed regularly and the results are compared with national indicators, and that "the information obtained assists in daily surveillance of patients and diseases, monitoring resource allocation and utilisation, and the generation of reports for management and control purposes" (Ladd, Gebru and Kibaya, 2010, p. 18). The UHIN team programmed and deployed on PDAs and smartphones 12 daily register forms used by health centres to capture and report on data about the following facets of healthcare delivery[24]:

1. Child health
2. Outpatient[25]
3. Family planning
4. HIV counselling and testing
5. Antenatal care and the prevention of mother-to-child transmission of HIV (PMTCT)
6. Laboratory
7. Antiretroviral therapy (ART)
8. Postnatal care
9. Inpatient (including all wards, such as paediatric, male and female)
10. Theatre
11. X-ray
12. Ward census

Seven aggregate HMIS forms were also programmed and deployed through UHIN (Ladd, Gebru and Kibaya, 2010). With one exception[26], these forms aggregate data compiled from the first six daily registers listed above, resulting in reports produced at the health unit and district/sub-district levels.

24 In the final-phase UHIN report, there is an inconsistency in the number of registers said to have been converted. It is noted at one point in the report that a child health register was also converted, and that some of the aggregate forms draw data from this register.

25 This was the only register for which content details could be found in the UHIN documentation. An attachment to the UHIN Phase-II final technical report notes that the outpatient register collects identification information about the patient (name, residence, age, sex, weight) as well as details about his or her diagnosis and treatment (SATELLIFE and Uganda Chartered HealthNet, 2006).

26 "Health Unit Inpatient Monthly Report" is based on a "standalone form" (Ladd, Gebru and Kibaya, 2010, p. 16).

At the district hospital and Health Centre-IV levels, netbooks and desktop computers introduced in the final phase of the project offer the UHIN system expanded functionality, including the ability to generate additional HMIS forms (for example, a form which lists staff) and greater ease of data capture, especially in high-traffic wards (Ladd, Gebru and Kibaya, 2010). These devices also enable users to send HMIS data to a server at the Ministry of Health via the Internet and generate reports for a user-defined time period, and by district, sub-district and/or health unit.

Informing: Continuing Medical Education

As part of a medical certification renewal policy, the Ministry of Health mandates the pursuit of 50 hours a year of continuing professional development for all healthcare practitioners (SATELLIFE and Uganda Chartered HealthNet, 2006). The CME portion of the UHIN initiative was originally conceived of in response to this requirement, particularly in light of limited access to medical information by many rural healthcare workers.

The project originally focussed its CME content on the prevention, diagnosis and treatment of malaria, diarrhea, and pneumonia[27], topics which had been selected by the project partners in consultation with the Ministry of Health and District Health Services in Rakai and Mbale (SATELLIFE and Uganda Chartered HealthNet, 2006). During the first phase of the project, CME materials were disseminated to users through a twice-weekly broadcast and by 2008, material was being broadcast five times per week. The project partners made efforts to determine the perceived usefulness of the content provided as well as the information needs of users. Surveys were conducted several times in order to inquire about the health topics users wanted to see covered during the broadcasts, as well as preferred broadcast frequency and presentation (e.g., full or summarised articles).

SATELLIFE invested considerable time and effort in sourcing high-quality, relevant information from credible sources such as peer-reviewed journals, the World Health Organization (WHO), UNICEF, and Uganda's Ministry of Health. They also described as particularly "labor-intensive" their efforts to compile abstracts of information that would be suitable for community health workers – as opposed to physicians and senior nurses, for whom appropriate information was more readily available (SATELLIFE and Uganda Chartered HealthNet, 2006, p. 16).

The partners also note that, when requested, additional content was sent through the network (Ladd, Gebru and Kibaya, 2010). For example, in 2005, in response to an unusually high incidence of patients presenting with symptoms of epilepsy in one of the districts, the network was used to provide health workers with information on the disorder, which was sourced from the Uganda Clinical Guidelines (SATELLIFE and Uganda Chartered HealthNet, 2006)[28].

By 2006, the number of topics treated during the broadcasts had been expanded to include parasitic infections, maternal and child health, and other health-related subjects. As noted in a 2006 technical report, some healthcare workers reported that they benefitted from the information received through UHIN, such as the clinical officer in Mbale district who indicated that he now also uses re-hydration therapy as a treatment for diarrhea, rather than only prescribing antibiotics (SATELLIFE and Uganda Chartered HealthNet, 2006).

PDAs, smartphones and netbooks distributed through the final phase of the project were loaded with a "Mobile Medical Library" which includes Ministry of Health documents such as the Uganda Clinical Guidelines and other information resources on topics including HIV/AIDS treatment and care, treatment of malaria, nutrition, mental illness, cervical cancer, diabetes, and maternal and child healthcare (Ladd, Gebru and Kibaya, 2010). A drug database and a medical calculator with formulae and scores for the calculation of drug dosages are also available on the mobile devices.

27 For example, broadcasts emphasised how to recognise the symptoms of uncomplicated pneumonia and the warning signs of severe illness (Sewankambo et al., 2006).

28 See Uganda Clinical Guidelines (2003), at http://collections.infocollections.org/whocountry/en/d/Jh4323e/5.html

Analysis of the 'information' dimension of UHIN

Without knowing more about the specific data the UHIN system is designed to collect (namely, that which is collected in all the daily registers) and the actual information needs of those who analyse the HMIS reports and other reports which are based on those data, it is impossible to comprehensively assess the reported claims about the usefulness of the resulting clinical information. Nonetheless, general information contained in the UHIN documentation and information about Uganda's public healthcare situation (as detailed in the section entitled "Key health status indicators in Uganda") offer insight about the likely practicability of both the CME content and clinical information made accessible through the system.

Heeks (2006) cites as one example of a flawed design assumption, an absence of significant demand (on the part of potential users) for the kind of information the system is designed to collect. While this kind of demand is an important consideration, in light of the substantial investments required to operationalise electronic health information systems (including hardware, software and infrastructural costs – both start-up and upgrades – as well as labour hours associated with training, maintenance and planning, etc.), another key question that should be posed is, "Does the healthcare system possess adequate human resources (including numbers of healthcare providers as well as sufficient knowledge and skills) and material resources (especially medication and equipment) to act on the information transmitted via an electronic system?"

The human-resource problems cited previously are an important consideration with respect to the possible expansion of the UHIN system across the country. On the one hand, knowledge gains acquired through UHIN's CME content could help motivate some healthcare workers, which could, in theory, contribute to job satisfaction for some. However, in light of management problems (especially their impact on fundamental issues such as pay and workload), it seems unlikely that CME would be enough to retain health workers.

It is inferred that the practicability of the CME material, specifically, would depend on several conditions, and UHIN documents provide relevant insight into the following:

a. *Practitioners who could benefit most from the knowledge of the UHIN-provided content (that is, front-line workers and those who directly oversee their work, where applicable) have, at a minimum, <u>regular</u> access to a handheld.*

   It is logically inferred that health workers who share a PDA with other personnel have fewer opportunities to read UHIN-disseminated information than those who have sole access to a PDA, and UHIN reports suggest that, throughout the life of the project, many, if not most, users were required to share a device. For example, in 2006, project partners noted that in one participating hospital, a single handheld was shared by ten personnel, including two doctors, two clinical officers, four laboratory technicians, one radiologist and one records officer, and the partners concluded that, "Acquiring additional handhelds for distribution to health workers will enhance the impact of the network in improving quality of health care in the districts." (SATELLIFE and Uganda Chartered HealthNet, 2006, p. 66). Furthermore, a UHIN-commissioned study conducted in 2009 indicates that 71 percent of users surveyed share a PDA, and that most of those who have access to an "unshared" PDA are men, most of whom "are senior executives, heads of units or just those who have personalised the otherwise institutional property which was supposed to be shared" (Madanda & Hafkin, 2010, p. 20).

b. *Practitioners have both the time to read the CME content <u>before</u> they are faced with patients requiring diagnosis/treatment, as well as the foundational knowledge required to absorb and apply the information.*

   Based on a statement made in a 2006 report by Sewankambo et al., it seems that the ability of some users to access and understand the content was limited by a lack of time, as well as problems comprehending the material.

   Acknowledging that even though the broadcast content was being tailored to the two main health cadres based on their differential skills and education, the impact assessment research

team, which was comprised primarily of medical professionals, postulated that some users perceived that the content was not useful for the following three reasons:

1. *Weekly broadcasts may have been overwhelming for busy health workers who did not have the time to read*
2. *The content may still have been confusing, especially the detailed descriptions of clinical features of each disease*
3. *The language may have been too complex and not comprehensible.*

(Sewankambo et al., 2006, p. 25)

Furthermore, based on their experience with delivering training sessions, the project partners acknowledged that residential training on how to use the technologies associated with the Uganda Health Information Network "is more effective than on-site training at their work places where they are distracted during the training exercise" (SATELLIFE and Uganda Chartered HealthNet, 2004b, p. 10). It is assumed that workplace distractions are equally problematic for CME learning.

c. *The health centres have timely access to the equipment and/or drugs required to diagnose and treat the maladies they are presented with.*

As noted previously, shortages of equipment, medication and supplies are frequent problems at Ugandan healthcare facilities. Indeed, one focus group participant from a hospital in Mbale district said, "I came here to get treatment for my child but I was told that the drugs were out of stock and was advised to buy drugs elsewhere. It is really bad for most of us since the money is scarce so you have to borrow for transport and even buying drugs", and while discussing hospitals in the districts of Mbale and Rakai, two other participants expressed similar woes *(Sewankambo et al., 2006, p. 26)*

In addition to facilitating access to information through 'fixed' sources such as clinical guidelines, the UHIN system enables users to communicate with each other via email. Discussion within the UHIN technical reports of email-based communication between users is relatively minimal, and it focuses primarily on official communication about the network itself[29]. An assessment of the value of the information *exchange* which is facilitated by the network's email module would necessitate a discussion with users.

In summary, it appears from the UHIN documentation that when the system is functioning, high-quality and timely information is being collected and transmitted to users. However, UHIN-commissioned reports suggest that workloads are very heavy among healthcare workers and that in some cases, devices are being shared by a number of workers, which presumably limits their ability to read and absorb the CME content provided. Furthermore, it is unclear from the literature on the healthcare system in Uganda that it possesses adequate human and material resources to systematically act on the information acquired and conveyed via this system.

Although these circumstances do not obviate the need for collecting and disseminating the kinds of information conveyed through UHIN, they do raise questions about the appropriateness of the decision to devote resources to an *electronic* information system when fundamental facets of the healthcare system are wanting. This decision becomes even more questionable when technical limitations raise important barriers to the efficient operation of the system, as is discussed in the following section.

- ***Technology***

The UHIN project partners aspired to adapt the chosen technologies to the infrastructural realities they faced in Uganda, and although the core idea of employing mobile ICTs remained consistent, based on

29 Ladd, Gebru and Kibaya (2010, p. 43) note that there is an email list comprising the network's developers and managers as well as key HMIS-related staff, and that the email exchange "allows those using handhelds or with questions about handhelds to engage with each other."

experimentation and new opportunities, a number of support technologies were introduced and suppliers engaged during the course of the project. As the purpose of the present paper is not to judge the merits of the technical decisions made by the project partners, an exhaustive account of all devices and providers employed during the seven years is not provided. However, as technical factors are central to the basic functioning of costly technology-based interventions such as the UHIN project, they are important to consider. As such, the following is an overview of the system's key components and the technical limitations encountered.

Technical design and components

The initial technical design of the two-way communication network was based on the integration of PDAs, the GSM/GPRS (global system for mobile communications/general packet radio service)[30] cellular telephone network, and "Jacks" developed by an American company called WideRay, Inc. Jacks, relay devices through which information passes from one user to another via a centrally-based server in Kampala, are self-contained computers consisting of a router, a battery, components of a cellular telephone, a GSM/GPRS modem, and a data cache (SATELLIFE, 2007). With respect to software, the project partners experimented with a handful of form-development products before settling on one that met their needs for data validation, branching, many field types, and synchronization. Ultimately, forms development and data management tools such as Microsoft Access, Microsoft Excel, and Epi-Info were employed (Ladd, Gebru and Kibaya, 2010).

The project partners originally envisaged providing users with individual email accounts, but the WideRay Jacks did not have sufficient memory to allow for this function (SATELLIFE and Uganda Chartered HealthNet, 2004b). To rectify this, AED-SATELLIFE developed the "African Access Point" (AAP) as an alternative to the WideRay product. The AAP was built on an open source platform, "allowing users to expand the device's utilities and maintain it locally" (Ladd, Gebru and Kibaya, 2010, p. 8).

One of the key weaknesses of the AAP system is that the user must bring the PDA to an access point in order to send and receive data. The PDA interfaces with the Jack through infrared beaming and the Jack exchanges information with the central server in Kampala via the GSM cellular telephone network[31] and Internet service providers. The distance of access points from health centres was cited as one reason for data access limitations experienced by PDA users (AED-SATELLIFE & Uganda Chartered HealthNet, 2008).

As of 2010, Ladd Gebru and Kibaya described the UHIN system as having four major modules:

1. HMIS data entry module that allows users to enter HMIS data from health facilities;
2. HMIS report module that allows users to generate HMIS reports from the local HMIS database or from a central database at the Ministry of Health by remotely accessing the server over the Internet;
3. Email module that allows users to send and receive email; and
4. Content module that allows users to access the aforementioned CME content.

Infrastructural and other technical limitations

At the most basic level of infrastructure, inconsistent access to electricity, which is necessary for recharging PDAs and access points, has been a formidable challenge for the UHIN project since its inception. Even health centres connected to the national grid have had significant power shortages, so UHIN partners

30 In order to take advantage of an upgrade by major cellular providers MTN and Celtel, by March, 2006, UHIN Jacks had been converted to GPRS connection, thereby reducing the cost of data transfer, and resolving issues with unsuccessful scheduled calls from Jacks to servers (SATELLIFE and Uganda Chartered HealthNet, 2006).

31 Even the WideRay technology, which had been built to operate on frequencies used in North America, had to be modified for communication over Uganda's GSM cellular network (SATELLIFE and Uganda Chartered HealthNet, 2004b).

acquired some solar chargers for PDAs and access points. Solar power units were also deployed for Jacks in health centres not connected to the national grid[32] (SATELLIFE and Uganda Chartered HealthNet, 2006).

Furthermore, some users have reported experiencing problems accessing information because their PDAs require repairs or because access points do not function properly due to intermittent electricity in the districts; indeed, late-stage UHIN documentation cites problems in the form of "acute electricity shortage that limits use of the system" (Madanda & Hafkin, 2010, p. 3) and the "always failing" network (AED-SATELLIFE & Uganda Chartered HealthNet, 2008, p. 29). Periodic power outages also delay or prevent daily news content broadcasts initiated from the UHIN office in Kampala (Ladd, Gebru and Kibaya, 2010). The network is also inaccessible to health centres in areas which lack Internet and cellular network coverage (SATELLIFE and Uganda Chartered HealthNet, 2007a).

- ***Processes***

In a discussion of how clinical information travels upward from the health centres and hospitals, it is noted that, "The electronic data transmission system principally uses the same structure as that of the paper-based system" (Ladd, Gebru and Kibaya, 2010, p. 31). Data collected at health centres at the level II and III levels are sent to either the health sub-district or directly to the District Records Office on a weekly and monthly basis. Much of the data sent to the Ministry of Health is captured on two aggregated forms which are summaries of over 20 forms and registers, and submissions are made on a monthly basis.

Under the UHIN system, primary data is collected manually using paper forms, and then entered into the health unit registers[33] (SATELLIFE and Uganda Chartered HealthNet, 2007 a). Ladd, Gebru and Kibaya (2010, p. 15) cite as a "major disadvantage" the fact that the workload of health workers has increased as a result of this redundancy. After the register-entered data are validated, the information is entered on a PDA or netbook for transmission and aggregation.

However, at the level of the DHO, aggregation has become simpler and more efficient. Whereas previously, completed paper registers were physically transported to the health sub-districts (HSD) or DHOs for use and aggregation, under the UHIN system, reports containing aggregated data are produced automatically based on information entered in the electronic registers. It is reported that this automation eliminates aggregation and transcription errors at the HSD and DHO levels (Ladd, Gebru and Kibaya, 2010).

Finally, in terms of the handling of information, neither encryption nor security are mentioned in the technical report for the final phase of the project, even though, as noted above, patient-identifiable diagnosis and treatment information are captured on at least one of the electronic registers (the outpatient register). While SATELLIFE and Uganda Chartered HealthNet (2007b) refer to training offered on data encryption and password protection of all IP protocols of the system, it is mentioned in relation to the AAP. The risk of security breaches associated with UHIN-provided PDAs is unclear. Especially in light of the handhelds' portability (and the fact that some users bring them home and even show family members how to use them), as well as the rapidity and ease with which electronic information can be transmitted, technical security measures warrant further discussion.

- ***Objectives and values***

Although the values of the project's initiators and implementers are not explicitly stated, some can be inferred from the facets of the project which are discussed in the project documentation, and the terms used to frame them. At the beginning of the project, there was a strong emphasis on technological considerations, perhaps owing to the formidable task of establishing the network.

32 It is noted in the project's "Best practices" report that some health units cannot afford the commercial rates for electricity which are associated with recharging the devices, and that, "Although this has been solved in some cases by providing solar panels this is in limited cases" (SATELLIFE and Uganda Chartered HealthNet, 2007 a, p. 24).

33 Reasons cited for this redundancy include limited Internet coverage, a limited number of PDAs with which to input data, and legislation-related restrictions on phasing out paper forms entirely (SATELLIFE and Uganda Chartered HealthNet, 2007a).

At a 2004 conference entitled "Handheld computers in Africa: Exploring the promise for the health sector", the director of the UHIN project, Dr. Patrick Okello, articulated the lessons from the pilot study and challenges facing the initiative in technical terms. Dr. Okello highlighted the benefits of "marrying" the technical components of the network and noted that the technology could be used by all cadres[34], and he identified "scaling up" as an objective, as well as "identifying and demonstrating the effectiveness of other technological options" ("Handheld computers in Africa", n.d.).

In the "Cost Effectiveness Analysis Study" appended to the final technical report for the first phase of the project, it was asserted that, "The benefits from the project were to be defined in terms of direct benefits, such as benefits resulting from savings or changes in the composition of inputs (paper costs, printing costs, transport costs, storage costs, staff time, etc), and indirect benefits such as...increased productivity as a result of getting timely information" (SATELLIFE and Uganda Chartered HealthNet, 2004 a, p. 6). Even at this early stage, during which the results of the pilot phase were being reflected on, there was no thorough discussion of the appropriateness of the technology tested, or of the suitability of substituting the transmission of educational content via PDA for in-service training.

From the very beginning, project partners indicated a desire to "[assess] the impact of information access on the quality of care delivered by health professionals using the network"... "as a result of improved district-level health planning, CME, and other information sharing activities" (SATELLIFE and Uganda Chartered HealthNet, 2004b, p. 21). However, beyond a handful of general, favourable quotations obtained during UHIN inquiries, there is little concrete evidence that the information made available through the UHIN system can be linked to any quality-of-care improvements realised in the participating districts. Causation may be difficult to establish in light of the number of factors that can impact on quality of care. However, a more evidence-based approach to analysing the results of providing access to CME content (for example, testing users on what they have learned, or observing their practice) may provide a more complete picture of the initiative's efficacy than relying solely on user surveys.

Another important stakeholder, the Ministry of Health, has, in the past, attempted to emphasize the timeliness and completeness of HMIS reports on its website. Specifically, the Ministry's HMIS Resource Center has published quarterly national performance reports relating to HMIS reports on inpatient and outpatient data[35]. According to the reports, for the period from October, 2009 through June, 2010, the excellent performance – as measured by timeliness and completeness of forms submitted to the Ministry – of four of the five UHIN-participating districts[36] was on par with that of several other Ugandan districts (Ministry of Health, 2010a, 2010b).

However, the kind of numeric accountability that may be fostered by such comparisons is of little use without the following:

a. Data quality.[37] Assuming the automated processes which aggregate and otherwise manipulate data are valid, the source becomes critical in an electronic HMIS

b. Data relevance; and

c. Capability (resource-wise and in terms of administrative limitations) and motivation on the part of Ministry to act on the information collected.

34 Although the term "cadre" is not defined in the document containing this reference, it is assumed that Dr. Okello was referring to what Ladd, Gebru and Kibaya (2010) refer to as the two tiers of health workers, including nursing assistants, junior nurses and midwives (tier-I) and clinical officers, registered nurses and midwives (tier-II). Community health workers were identified in an earlier document as another cadre (SATELLIFE and Uganda Chartered HealthNet, 2006).

35 The webpage can be accessed at http://www.health.go.ug/hmis/index.php/reports/performance.

36 In both reports, Lyantonde consistently lagged behind in terms of timeliness, at 67 percent.

37 An assessment of the perceived usefulness, and practicability, of the forms converted for the UHIN project is beyond the scope of the present paper. Using the example of an analogous HIS project in the Cape region of South Africa, Thompson (2002) offers a detailed treatment of the collection and use of health data that is meaningful to data gatherers and users, as well as the 'web of social relations' which plays a key role in the practical success of HIS.

- ***Staffing and skills***

At several points, the project partners inquired with end users about their training needs and preferences, both with respect to technical facets of system use and the nature and frequency of broadcasting of CME materials. By the time the project was handed over in 2010, over 700 health workers had been trained to use the mobile devices provided through UHIN (Ladd, Gebru and Kibaya, 2010), even if not all of them gained access to a PDA following training (Madanda and Hafkin, 2010). Furthermore, in terms of ensuring the network itself could be supported on an ongoing basis, efforts were made to build the capacity of technical teams in the participating districts for providing user support, training new end users, creating and deploying forms, and troubleshooting the network (Ladd, Gebru and Kibaya, 2010).

With respect to the learning material made available through UHIN, project partners assert that the decision to develop CME content for dissemination via PDAs was motivated by the fact that many young health workers practising in rural areas, such as those served by UHIN, do not benefit from "[supervision] by consultants on a regular basis," or from access to library facilities[38] (SATELLIFE and Uganda Chartered HealthNet, 2007a, p. 13). In the final report, they note that the UHIN project "helped in reducing performance gaps among health workers without disruption of service due to excessive residential training workshops" (Ladd, Gebru and Kibaya, 2010, p. 20).

However, the partners do not elaborate on the degree of medical/nursing education and clinical practise most health-worker users possess, making it difficult to assess the ability of users to comprehend, assimilate, and put into practise information obtained through the network. Furthermore, considering that the material is conveyed in a unidirectional fashion, there is no structured approach to soliciting users' questions/feedback on the material[39], and there is no testing mechanism to assess users' comprehension and retention of the material.

- ***Management systems and structures***

Although reporting relationships within the districts are not outlined in the UHIN reports, appendices relating to project evaluation activities undertaken during the first phase indicate that the directors of district health services (DDHS) were considered by UHIN designers to be key to influencing the adoption of PDAs by the intended users. Ladd, Gebru and Kibaya (2010) indicate that these directors, along with district HMIS officers and health sub-district directors, were consulted by the project partners when selecting PDA users.

In terms of broader management concerns, beyond the reporting requirements noted in the preceding section, the practical relationship between the Ministry of Health and the local governments which administer the participating health centres and hospitals is not explicated. UHIN operates within a governmental structure which has seen a remarkable proliferation of districts, the highest level of sub-national administrative unit, in the years since President Yoweri Museveni took office. It is reported that in 1986, the country was divided into 33 districts, and that the number of districts stood at 112 as of September, 2010 (Kavuma, 2010). The current number represents a 100 percent increase from the 56 districts that existed at the time of the 2002 Population Census (Uganda Bureau of Statistics, 2006). The splitting of districts directly impacted the UHIN project when, during the third phase, the original three districts – Manafwa, Mbale and Rakai – became five, including Lyantonde and Bududa.

Although Museveni's aggressive decentralisation program has won praise from observers who consider it democratising, it is reported that under the current, decentralised framework, districts are seriously

38 Notwithstanding this assertion, based on the findings of a UHIN-commissioned assessment of the impact of health information on healthcare service delivery, it appears that most health workers did have access to a health facility library, and most were able to obtain relevant information through various other means. Indeed, most had access to the National Treatment Guidelines in print form, and some attended workshops, while others obtained medical information by consulting with peers or a personal library (Sewankambo et al. 2006).

39 The network is bi-directional insofar as users can communicate via email. However, with respect to education, this functionality would appear to be a poor substitute for the kind of interaction that can occur via synchronous communication with an instructor who is an authority on the content as well as fellow practitioner-learners (that is, in-person, or through technology-based instructional applications).

constrained by insufficient funding and capacity with which to execute their mandate for the delivery of healthcare (Okwero et al., 2009). Signs of dysfunction are evident in the Health Minister's recent announcement that healthcare would be recentralised in Kampala in a bid to attract more doctors to rural areas by offering them more training and career mobility than local governments can promise (Malinga, 2010a).

In light of the Ministry of Health's takeover of the UHIN following the end of the project by AED-SATELLIFE and UCH, it could be of significance to the future of the network that in April, 2010, the Minister of Health announced plans to table in parliament a paper proposing to recentralise health services (Malinga, 2010b). Specifically, this would entail "recentralising the recruitment of health workers, as well as bringing the management of hospitals and the general provision of health services under Kampala's control" (Malinga, 2010b).

If recentralisation does occur and if it results in a greater allocation of financial resources to district facilities such as the ones which participated in the UHIN project (as well as other benefits, such as the ability to attract and retain more doctors, as suggested by the Minister in April), the context in which the Uganda Health Information Network operates may become more conducive to supporting the improvement of healthcare. Furthermore, the management of healthcare provision by Kampala will presumably necessitate strong information and communication links between the capital and all districts, which may present an opportunity for strengthening and broadening the reach of an electronic HIS such as UHIN.

- ***Other resources***

As the cost-effectiveness of the UHIN system – in comparison with the 'traditional' system which used paper forms – was a key concern of the project partners, a few cost-effectiveness studies were conducted during the life of the project. Based on the findings of a cost-effectiveness study conducted by Isaac Shinyekwa, a PhD student in economics at Makerere University whose analysis was formally reviewed by Frederic B. Jennings of EconoLogistics, the project partners assert that the cost of managing information electronically through UHIN is 25 percent lower than performing analogous functions through the paper-based manual system. The study, which was to provide "vital evidence for the development of the National Health Information System strategy" was premised on the proposition that, "By choosing the scenario with the least cost associated with a given or improved outcome, the districts and [Ministry of Health] can use resources more efficiently and potentially expand the network to other districts" (Ladd, Gebru and Kibaya, 2010, p. 30).

However, as indicated by Shinyekwa (2010, p. vii), the 25 percent-savings figure is based on "running costs" and does not consider "establishment costs."[40] This echoes the first cost effectiveness study, conducted six years earlier, in which "the project start-up costs were omitted from the analysis so as to capture the operational abilities of the PDA system" (SATELLIFE and Uganda Chartered HealthNet, 2004a, p. 22) - in spite of both report authors' acknowledgement of the importance of start-up costs to any planned expansion of the network across the country.

Furthermore, an analysis of the second cost-effectiveness study raises questions about apparent significant cost omissions and discrepancies. For example, the report is silent about costs associated with frequent network interruptions attributable to power outages, as well as licensing costs associated with CME content and any applications required to develop PDA-based surveys/reports. It is also deduced from the report excerpt provided below that maintenance/servicing costs associated with the hardware and software - which, in a study by Seebregts et al. (2009), was calculated at 10 percent of capital cost per annum, for PDAs alone - were not considered in the final cost-effectiveness study. In addition, it is unclear how any time savings realised by healthcare staff can be "transferred" to costs associated with acquiring and maintaining the electronic system.

40 While neither term is defined explicitly in the report, Shinyekwa (2010, p. vii) states that:
A comparative study of start-up costs for both [health management information systems (that is, the paper-based and electronic systems)] is crucial to establish what would be needed financially to get them started, especially countrywide. Doing this in addition to the running costs of the present study would enhance policy makers' ability to make the most informed decisions on which system is the best in the long run.

> *The fact that UHIN HMIS at this phase does not require manpower to conduct aggregation demonstrates a window for cutting costs, although these costs may be transferred to the acquisition and maintenance of the electronic systems. At a later stage, this comparison will be made to establish which of the two HMIS minimizes costs significantly. (Shinyekwa, 2010, p. 40-41)*

From the very beginning of the project, cost-related sustainability – including costs associated with acquiring PDAs[41], maintaining connectivity, and conducting repairs – was cited as a challenge ("Handheld computers in Africa", n.d.). In order to achieve both of the network's broad objectives (that is, facilitating the transmission of clinical information as well as providing CME content to both cadres of health workers), a large amount of equipment will be required, especially considering that approximately 700 health workers were trained in the five participating districts. If the project is to be expanded to cover the entire country, another 95 districts remain, and reports suggest that the UHIN initiative was not successful in providing trained healthcare workers in participating districts with their own mobile devices.

41 Based on information obtained from a report produced in the early days of the project, it is estimated that the unit cost of a PDA is USD 100 ("Handheld computers in Africa", n.d.).

Discussion of key accomplishments reported by UHIN project partners

Accomplishments reported by Ladd, Gebru and Kibaya (2010) include improved data quality at the point of collection and more timely access to data that inform decision-making relating to policy, resource allocation, and response to disease outbreaks. However, the claim that data quality has improved deserves closer scrutiny vis-à-vis the front end of the data entry process, given that, as noted by the report's authors, health workers continue to first enter data in paper-based daily registers.

Regarding the network's dissemination of health information via PDAs, the project partners indicate that UHIN "[reduced] performance gaps among health workers without disruption of service due to excessive residential training workshops" and that the network "enhanced the health care provider skill base by promoting life-long and continuous learning through the use of ICT" (Ladd, Gebru and Kibaya, 2010, p. 6). Sewankambo et al. (2006) conducted an impact assessment of health information on healthcare service delivery which reached favourable conclusions based on interviews with healthcare workers and supervisors as well as focus groups with patients and patients' caretakers in four districts, two of which were participating in the UHIN project.

However, it is inferred that the results of such an assessment would have been more reliable if the study's designers had also tested healthcare workers on the relevant information, especially given that, as the research team acknowledged, some results could have been affected by factors unrelated to the UHIN intervention, such as the availability of medication. Furthermore, the accuracy of some results, such as the fact that less than 50 percent of health workers found the PDA-accessible content to be useful in their provision of patient care, was compromised by the fact that the results included responses by administrative personnel and other individuals who were receiving the medical content broadcasts but did not have a need to use it.

SATELLIFE and Uganda Chartered HealthNet (2006, p. 5) maintain that the CME materials provided through UHIN respond to the Ministry of Health's desire to provide "non-conventional approaches [to addressing "performance gaps among health care providers"] such as those that do not lead to the disruption of service." Although the alternative provided by UHIN may spare the Ministry some expenses, including those associated with transporting healthcare workers to general hospitals for training and paying trainers, etc., it is not clear from reading the UHIN reports how overworked healthcare workers can find the time to educate themselves through self-directed reading. Furthermore, beyond cost comparisons, the comparative *value* of reading content – as opposed to the kind of structured instruction that could be undertaken through in-service training – deserves closer scrutiny. Furthermore, regular in-service CME sessions may be associated with other benefits that may help motivate and retain healthcare workers, such as allowing networking among peers and breaking the routine of day-to-day work in a stimulating and educational way.

Other key, transcendent dimensions of information systems

The UHIN documentation suggests that, in addition to the dimensions discussed above, the 'in-practise' access to resources (that is, the allocation of devices and the other ways in which system use is enabled and promoted) and gender considerations deserve inclusion in any in-depth discussion of information systems. Both are transcendent dimensions insofar as they can affect all other aspects of the information system, and as such, each is discussed in turn.

In-practise access to resources provided by the intervention

As a basic point of departure, the equitable and practical allocation of end-user devices provided through any technical intervention is fundamental to the success of all seven dimensions cited by Heeks. As previously noted, in spite of the large number of healthcare workers trained in using the UHIN system, it seems that a significant number of would-be beneficiaries were forced to share handhelds, which undoubtedly put them at a disadvantage in terms of gaining knowledge as envisaged by the project's designers. Beyond physical access to devices and the basic training that facilitates their use, in-practise access to the informational resources provided through ICTs necessitates sufficient time and concentration on the part of the user to read and comprehend the material.

Gender considerations: UHIN and women's empowerment

The scope of the present paper does not allow for a comprehensive treatment of the relationship between gender relations and technological design and application. However, because the inquiry is concerned with the potential connection between technical and social innovation, the issue of women's empowerment as it pertains to the UHIN initiative is of particular interest.

The results of a 2009 study conducted by Aramanzan Madanda , Assistant Lecturer of Women and Gender Studies at Makerere University, and Dr. Nancy Hafkin, Senior Research Advisor, are presented in a report entitled "Assessment of Uganda Health Information Network for the Empowerment of Women." This analysis is especially salient in light of aforementioned conceptions of social innovation as providing solutions to social problems and fostering changes in social relations; accordingly, the following is a brief analysis of some of the key aspects of this issue, including the main findings of Madanda & Hafkin's report as presented by the UHIN project partners in the Phase-IV technical report.

Based on Madanda & Hafkin's report, Ladd, Gebru and Kibaya (2010) note that women users experienced a number of benefits as a result of having access to ICTs through the UHIN initiative, including enhanced status within the community and the workplace, increased self-esteem, overcoming feelings of isolation, developing a knowledge and skill base, and, in some cases, increasing incomes (Ladd, Gebru and Kibaya, 2010). While it is encouraging to see positive results such as increased self-esteem among some users, less isolation, and greater awareness of various health-related matters, some of the highlighted conclusions are based on weak findings, as noted below.

With respect to heightened status, Madanda & Hafkin (2010) focus primarily on some users' perceptions of their own status in the home, workplace and wider community (for example, through their disease-related education work in the community), as well as their self-confidence. Of the three measurable, socio-economic forms of status improvement outlined in the Longwe paper cited by Madanda & Hafkin, one is addressed in the report and highlighted by UHIN project partners, namely income[42]. However, Madanda & Hafkin (2010, p. 26) note that only 12 percent of women surveyed said that PDA use had helped them to earn an extra income, and that "some of the users[43], especially records assistants, said they had been hired to offer

42 Longwe (2002) also cites improved nutritional status and shelter as indices of improved socio-economic status.

43 Male and female users were surveyed for the study cited.

their skills in data collection while a few, [sic] had used the PDAs in their other businesses – drug shops or clinics – to carry out business activities."[44]

Even though the authors acknowledge an overarching power structure of health professionals in Uganda which "privilege[s] male over female workers and influence[s] distribution of PDAs in a way that excludes women professionals" (Madanda & Hafkin, 2010, p. 3), they appear to assume that there is a linear path leading from time savings realised with the use of PDAs to significant social change. For example, they assert that, "The time saving contribution of PDAs...implies a significant contribution to women's empowerment as it frees their time for other tasks," and they suggest that reports of increased time spent with family may have "to some degree improved family bonds and spousal relations in a country where studies have shown that up to 70% of the women experience violence from their intimate partners" (Madanda & Hafkin, 2010, p. 25).

Furthermore, considering that the workload of front-line health workers has increased because they now have to enter register data on paper *and* electronically, and considering that PDA users must travel to access points on a regular basis, it is unclear how most workers are saving so much time that they can leave work early and spend more time with family. Indeed, as the authors themselves point out, "most health workers are faced with long queues of patients that they have to attend to," and they credit the UHIN system's facilitation of the restocking of drugs with the increased uptake of health services by community members (Madanda & Hafkin, 2010, p. 25).

The bulk of Madanda & Hafkin's report focuses on reported benefits experienced by users themselves. The healthcare provided at the community level is also mentioned, including users' increased access to disease-related information and their ability to sensitise community members about disease prevention. Assuming that health workers share the knowledge gained with community members and incorporate it in their healthcare practise, it would seem that these kinds of gains are most likely to help empower health workers *and* community members.

The report contains no direct reference to care relating to maternity, a highly valued and often precarious facet of most rural Ugandan women's health. The authors do, however, note that most male and female PDA users reported that the educational material received through UHIN "is relevant to the health needs of women" (Madanda & Hafkin, 2010, p. 25). However, providing healthcare workers with access to health information is not a panacea that will solve the health problems faced by many women in rural Uganda.

Bantebya-Kyomuhendo[45] (2003, p. 16) identifies a number of reported barriers to women's access to formal healthcare, including a commonly-held distrust of the formal health system; a lack of funds on the part of families to cover the costs of visits, medication, and, in some cases, bribes; and "abuse, neglect and poor treatment in hospital and [women's lack of understanding of] reasons for procedures, plus health workers' views that women were ignorant." Similarly, Gray (*in press*) observed verbally abusive treatment of women presenting for children's vaccinations by healthcare workers in the north-eastern district of Moroto. Thus, the key to ensuring the provision of high-quality, compassionate healthcare to women and their dependents is much more complex than informing healthcare providers about women's health.

Summary: In-practise access to informational resources and gender considerations

In-practise access to the resources provided by the information system and gender considerations are important facets of an information system, and both effectively transcend the seven dimensions posited by Heeks. The former dimension includes regular and sustained usage of the ICTs through which critical information is conveyed, as well as sufficient time and the foundational knowledge required to read,

44 The fact that some public health workers moonlight as owners of clinics and drug shops raises questions about conflicts of interest. The use of UHIN-supplied PDAs by workers in personal business activities perhaps deserves closer review by those who manage the initiative.

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comprehend and assimilate that information. UHIN documentation suggests that these elements are lacking in the sites in which the system operates, warranting further inquiry into possible solutions to these deficiencies, which may enhance the effectiveness of the system.

In terms of gender dimensions, UHIN documentation has presented some dubious connections between reported time savings and harmonious gender relations. Nonetheless, users have reported benefits such as enhanced status within the home, workplace, and broader community, and a small percentage of users have reported an increase in income as a result of the resources they have acquired through the intervention.

Furthermore, UHIN has provided health workers with information about women's health issues which have reportedly been shared within communities. However, many rural Ugandan women do not avail of public health services due to important structural barriers which cannot be resolved simply by helping to inform healthcare providers about the nature, prevention and treatment of maladies facing women and children. These barriers, and the ways in which systems like UHIN can help to overcome them, deserve closer consideration.

Conclusions

Particularly in light of the distribution of health planning and administration across long distances, information deficiencies are often considered especially problematic in rural areas of developing countries due to physical isolation and poor transportation and telecommunications infrastructure, as well as limited opportunities for continuing/in-service education. Under such circumstances, ICT-based development initiatives such as the UHIN project aim to redress what may be described as 'gaps' in the knowledge of health workers and administrators in five rural districts.

During the seven-year UHIN initiative, project partners AED-SATELLIFE and Uganda Chartered HealthNet aspired to promote the cost-effective and timely transmission and exchange of accurate point-of-care clinical information and educational content. Using over CAD 3 million in funding provided by IDRC, the UHIN partners invested significantly in procuring and deploying technologies – including PDAs, smartphones and netbooks, and supporting devices such as solar chargers and access points – for the primary purpose of transmitting clinical data. They also invested time and money in the sourcing and packaging of high-quality, relevant health and medical information as well as news content for transmission to UHIN users, namely healthcare workers.

The seven dimensions of Heeks's design-reality gap model (information, technology, processes, objectives and values, staffing and skills, management systems and structures, and other resources) served as flexible and useful categories with which to describe and analyse key techno-organisational elements of the UHIN project. Analyses of the 'technology' and 'information' dimensions were particularly integral to the present paper's concern with technical and social innovation.

Given the central role of ICTs as the carriers of information in projects like UHIN, the accessibility and functionality of the technology employed – and, critically, the reliability of supporting infrastructure such as electricity supply – are at least as important as the information communicated, or any other dimension. Although the technical facets of an intervention, alone, cannot transform an environment in which knowledge deficiencies are a significant problem, when ICTs are the vehicle through which desired changes are supposed to be affected (as they were in the case of UHIN) infrastructural limitations can effectively foreclose such changes.

UHIN documentation suggests that technical limitations acted as significant barriers to realising the full and consistent effectiveness of the network. Frequent power outages are cited in a number of UHIN reports as being responsible for delays in sending and receiving content through the system. Furthermore, smaller facilities continue to rely on asynchronous PDAs, which must regularly be brought to access points – some of which are several kilometres away – for the purpose of sending and receiving stored clinical information and CME content.

It also appears that there was an ongoing shortage of devices, which necessitated extensive sharing of devices. This raises questions about the aggregate value and efficacy of investments in compiling, packaging and electronically disseminating CME content, considering the uneven access among frontline health workers.

In terms of information conveyed through the network, the main innovation achieved was in the provision of high-quality CME content to users. Whereas the clinical information inputted in electronic registers had been collected on paper prior to the commencement of the UHIN initiative, it was reported that many healthcare workers in the participating sites had not had regular access to the kinds of disease prevention, diagnosis and treatment information provided through UHIN.

However, even if all technical constraints were overcome and all required ICTs were available, questions would remain about the suitability of relying on technical devices to deliver CME to healthcare workers, especially in comparison with in-service training. The relative value of using UHIN to provide this kind of

ongoing educational material is especially dubious, given that instructional methods[46] do not appear to be employed and healthcare workers are burdened with heavy workloads, which presumably leave them with little time for this kind of mediated learning.

Furthermore, as elaborated in the foregoing discussion, important flaws and omissions were identified in arguments put forward in key reports commissioned by UHIN partners, including the gender study and cost-comparison reports. These inadequacies raise doubts about some of the claims made about UHIN's empowerment of female users and the network's cost-effectiveness relative to the paper-based information system, both of which were highlighted in UHIN technical reports and appear to constitute keystone justifications for the maintenance and expansion of the network, both within Uganda and beyond.

Given the time, the will on the part of the intervention's implementers, and the resources with which to invest in technology and its supporting infrastructure, technical innovation is relatively achievable, although the effects of the resulting information system may be uneven. Returning to Fagerberg's (2006) definition, the UHIN project realised technical innovation insofar as it put mobile ICTs into practise in a new context: the public health system. As discussed in the "Technology" section, this implementation necessitated minor but sometimes costly technical adaptation in order to counter limiting circumstances encountered in the participating sites, such as the introduction of solar chargers in response to the absence of a steady supply of electricity. Although the electronic network more-or-less replicated the paper register-based reporting system, it is reported to have had some time-related implications, including time savings in terms of data aggregation, but also a greater time investment at the health facility level, owing to the maintenance of a parallel manual reporting system. The reports also suggest that much time was invested in technical training in the use and maintenance of the devices on which the network depended, as well as their actual maintenance.

On the other hand, considering UHIN's influence within the five participating districts from the perspective of reconfiguring social relations (MacCallum et al., 2008), reforming old institutions or social arrangements (Homer-Dixon, 2001), it does not appear that UHIN achieved social innovation according to the more idealistic conceptions. With the exception of the automation of report aggregation and the provision of access to some previously inaccessible CME content, the UHIN system essentially replicates the paper-based system. Considering the whole of the foregoing analysis, it seems that UHIN has not met all of Phills et al.'s (2008) criteria for achieving social innovation, namely providing a novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions.

Although UHIN aspires to provide decision-makers with more timely access to information, in light of the numerous and significant resource challenges which plague the healthcare system in Uganda, it seems that, in many cases, the means with which these decision-makers can react to timely information are limited. Although no single intervention can be expected to resolve all of a system's problems, especially in light of the ongoing evolution of technologies, it would seem more logical to focus on improving basic facets of healthcare – such as providing healthcare providers with high-quality, dedicated education and training – before investing significant sums of money in technologies which can quickly become outmoded, and whose immediate added value is limited.

Under the right requisite conditions, fully operational ICTs can be used to effect positive change in the delivery of healthcare, especially by giving health workers broader and more timely access to potentially useful information about the prevention, diagnosis and treatment of illness. Indeed, in the hands of trained and motivated healthcare providers who have the will to learn and to improve their practise, and who are equipped with the materials - such as medications and equipment - which are required to deliver the desired standard of care, ICTs can undoubtedly enhance the quality of healthcare.

Based on an analysis of the documentation, it is concluded that the UHIN initiative brought some benefits to participating districts. These benefits include helping to inform some healthcare providers on the

46 In their meta-analysis of computer-mediated learning among health-professions learners, Cook, Levinson, Garside, Dupras, Erwin & Montori (2008) cite the following as examples of instructional methods: interacting with the learner and using practise exercises, discussion, and repetition.

prevention, diagnosis and treatment of various illnesses; expediting some administrative processes; and helping administrators respond more quickly to epidemics and other issues.

However, in many parts of Uganda, the usability of the kinds of information transmitted through UHIN is ultimately constrained vis-à-vis healthcare workers *and* patients. In many cases, healthcare providers face shortages of resources required to act, including material resources, such as essential drugs and procedures, and immaterial resources, such as foundational knowledge and skills. Many would-be patients face structural barriers to healthcare, such as fees and policies which serve to discriminate against marginalised groups. Regardless of how it is conveyed, information is not enough to resolve these formidable challenges to improving the health of Ugandans.

In summary, it is a truism that information – including that which can be gathered from accurate and timely clinical data, as well as educational material which can possibly improve healthcare providers' practise – is an essential ingredient in the planning and provision of high-quality and cost-effective healthcare. However, in the absence of adequate human and physical resources, even the most relevant, helpful and timely information cannot transform a deficient and disjointed healthcare system. Moreover, the investment of time and resources in ICTs which replace or alter other, less costly and arguably more effective processes deserves scrutiny, especially in severely resource-constrained countries.

The present research paper has raised a number of issues and questions. Some are specific to the design of electronic information systems such as UHIN, while others concern more macro-level problems which plague the health landscape in many developing countries and which, unresolved, severely constrain the ability of costly electronic information systems to improve health outcomes. The full clarification of these issues and questions would best be served through observation and primary data collection at intervention sites such as those in which UHIN and its Mozambican-counterpart project have been implemented.

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