

# Crossing the "Digital Divide:" Implementing an Electronic Medical Record System in a Rural Kenyan Health Center to Support Clinical Care and Research

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## ABSTRACT

*To improve care, one must measure it. In the US, electronic medical record systems have been installed in many institutions to support health care management, quality improvement, and research. Developing countries lack such systems and thus have difficulties managing scarce resources and investigating means of improving health care delivery and outcomes. We describe the implementation and use of the first documented electronic medical record system in ambulatory care in sub-Saharan Africa. After one year, it has captured data for more than 13,000 patients making more than 26,000 visits. We present lessons learned and modifications made to this system to improve its capture of data and ability to support a comprehensive clinical care and research agenda.*

## INTRODUCTION

The Institute of Medicine has described the computer-based patient record as an essential technology for health care<sup>1</sup> and a necessary tool for improving patient safety<sup>2</sup> and the quality of care.<sup>3</sup> To date, comprehensive computer-based patient records that serve these functions are rare to non-existent in the developing world. This gulf has been termed the "digital divide" where even the simplest technology is often not available to promote health care delivery, patient outcomes, and public health.

We have previously reported the conceptualization and initial development of the Mosoriot Medical Record System (MMRS),<sup>4</sup> a computer-based patient record for a primary care health center in rural Kenya. In this article, we report the implementation of the MMRS within the Mosoriot Rural Health Centre as the sole means for capturing clinical data. We emphasize the technical aspects of data capture and storage and describe data from its first year operation.

## METHODS

**Site:** The Mosoriot Rural Health Center (MRHC) is run by the Kenyan Ministry of Health and provides all primary health care to a surrounding community of approximately 40,000 persons, mostly subsistence farmers with minimal financial means. There are few public utilities, and sanitation is problematic. Persons in the Mosoriot area are not allowed to receive care from any other facility run by the Kenyan Ministry of Health without first being seen in the MRHC. Hence, capture of health care delivered is nearly complete, other than that provided by midwives and "traditional healers" in the villages. The MRHC contains 6 separate clinics: Adult Medicine, Pediatrics (children 5 years old), Well Child (infants and children < 5 years old), Antenatal Care, Family Planning, and Sexually Transmitted Infections (STI). Care is provided free in the Well Child, Antenatal Care, Family Planning, and STI clinics. For the others, a nominal fee (about \$0.65 US) is charged for each drug dispensed and test performed.

**Electronic Medical Record System:** The MMRS consists of a paper encounter form and the following modules all programmed in Microsoft Access: Registration, Encounter Data, Reports, and the Data Dictionary. The Because there is no national unique personal identifier in Kenya, the Registration module captures data necessary to identify unique individuals: First (Christian), middle (Kenyan) and last names, mother's first name, sex, birth date, and the location, sub-location, and village of residence. After being registered, the MMRS assigns a unique MMRS number (with check digit) and prints a label which is affixed to patients' MMRS identity card.

After checking in and registering, patients are given a paper encounter form onto which clinic-specific information can be entered. The patient is then directed to the appropriate MRHC clinic based on their scheduled appointment, current complaint, or

specific need. That clinic then delivers care, refers the patient to the lab or pharmacy if necessary, records on its place on the MMRS encounter form a restricted set of information specific to that clinic. The patient is then directed to the financial office and then the check-out window where a clerk enters data from the encounter form into the MMRS' Encounter Data module. The main screen is divided into clinic tabs which allow targeted entry of data specific to that clinic. After data entry, the forms are given back to the patients who traditionally hold onto their records (previously hand-written in small booklets costing \$0.25), radiographs, test results, etc. There is limited storage space for paper records at the MRHC.

The Reports module contains pre-existing formats for producing the monthly reports required by the Kenyan Ministry of Health (e.g., reportable infectious diseases such as malaria, vaccinations given, etc.). Customized reports can be generated by selecting any MMRS data fields and date range.

The Data Dictionary contains a record for each term, including all diagnoses, vital signs, diagnostic tests and their results, drugs, treatments, and procedures. Fields include term ID, term name, reference term (to allow for multiple synonyms), term type (e.g. drug, diagnosis), ICD10 code (for diagnoses and procedures only), the charge for each test, drug, or treatment, and a text description of the term.

The data model for the MMRS has the visit as the identifying event, with indicators for the patient, the reason being seen, and vital signs. Separate databases, linked to the encounter by visit number, contain data on final diagnoses (can be multiple per visit), clinic-specific data (with separate tables for each clinic), and items ordered by the treating clinician (e.g. tests, drugs, and treatments).

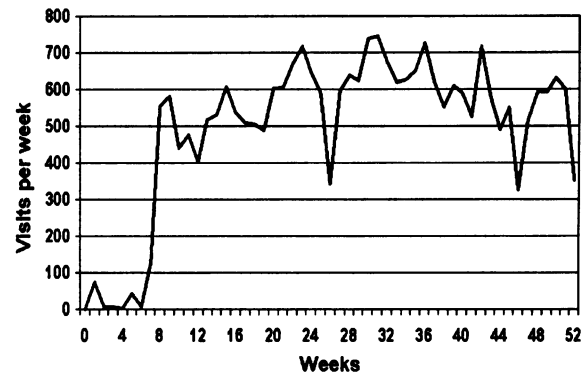
Designed to be low cost to ensure sustainability, the system runs on two IBM-compatible microcomputers linked by a crossover cable connecting their network ports. One computer is used to check-in and register patients, while the other is used to check-out patients and enter encounter data. Because local electric power is unreliable, there are multiple redundant back-up systems. In order of use, the MMRS runs on the local power grid, a 45-minute UPS battery, and a 4-hour solar-powered battery. If all of these sources fail, all data captured on the paper encounter forms can be back-entered into the MMRS.

## RESULTS

We installed the MMRS and trained the personnel

between November 2000 and January of 2001. The system was "turned on" and first began registering patients on February 1, 2001; it has been in continuous use since. On only three occasions has the system been inoperable, once because of a disk crash, once because of the theft of the solar backup system, and once because of the failure of a video card.

As shown in the Figure below, initial capture of the encounter data was limited, owing to the unavailability of a sufficient number of paper encounter forms and the patients' taking completed forms home rather than turning them into the check-out window. However, after the first month, a system for redirecting patients to the check-out window and efforts by the clinical staff resulted in capture of data from a mean of more than 600 visits into the MMRS per week, more than 95% of all visits made.



During the first year, more than 18,000 patients were registered, 13,349 of whom made 26,071 visits to the various MMRS clinics. (A can visit more than one clinic on a single day, and each visit is considered a separate event.) Table 1 (below) shows encounter data by clinic. Adult Medicine and Pediatrics clinics accounted for more than half of the patients seen, while the Well Child and Antenatal clinics had more visits per patient. Drugs were dispensed during most visits to the Adult Medicine, Pediatrics, and STI clinics. Tests were performed infrequently.

Table 2 shows the most common diagnoses made and drugs prescribed. Clearly, the MRHC is delivering primary care and preventive care. Infectious diseases and trauma were the dominant problems treated. The most common drugs prescribed included analgesics, antibiotics, vaccinations, and contraceptives. Interestingly, despite a prevalence of HIV of more than 15% in Kenya nationally and >20% among pregnant women screened anonymously at the MRHC, there were diagnoses of HIV and only 12 diagnoses of TB, which is also highly prevalent and mostly seen among MRHC patients with HIV/AIDS.

Clinic	# (%) of Patients	# (%) of Visits	# Visits per Patient	% Visits with a DRUG	% Visits with a TEST
Adult Medicine	5638 (43)	7767 (30)	1.4	89	32
Pediatrics	1968 (15)	3740 (14)	1.9	90	32
Well Child	1716 (13)	6171 (20)	3.6	62	1
Antenatal	1002 (7.6)	2767 (11)	2.8	33	19
Family Planning	984 (7.4)	2010 (8)	2.0	96	1
STI	92 (0.7)	181 (0.7)	1.0	91	43
Unspecified	1949 (15)	3440 (17) *	1.8	63	23
<b>Total</b>	<b>13,349</b>	<b>26,071</b>	<b>2.0</b>	<b>74</b>	<b>20</b>

\* 2683 (78%) of these unspecified visits were to the Pharmacy or Lab

Diagnosis	# (%) of Visits	Drug	# (%) of Visits
Clinical malaria *	3642 (14)	Paracetamol	8106 (31)
Upper respiratory infection	2996 (11)	Penicillin	5054 (14)
Malaria	1156 (4.4)	Fansidar	3622 (14)
Broncho-pneumonia	653 (2.5)	Amoxicillin	3168 (3.3)
Wound, septic	464 (1.8)	Oral polio vaccine	2825 (11)
Tonsillitis	392 (1.5)	Piriton	2583 (9.9)
Gastroenteritis	361 (1.4)	Depo-progesterone	1915 (7.3)
Myalgia	282 (1.1)	DPT vaccine	1898 (7.2)
Wound, type not specified	261 (1.0)	Tetanus toxoid	1892 (7.2)
Conjunctivitis	242 (0.9)	Brufen	1239 (4.8)

\* Malaria signs and symptoms with a negative blood smear

Table 3 shows visit charges for drugs and tests along with payments for each clinic. Charges were rare in the Well Child, Antenatal, Family Planning, and STI clinics, where free care is mandated. Overall, only 15% of the 2 million Kenyan shillings charged (approximately \$27,000) were paid by these indigent patients. For the first time, MRHC is able to document to the Kenyan Ministry of Health the amount of required uncompensated care being delivered in both "free" and "non-free" clinics.

Clinic	Drug Charges	Test Charges	Total Charges
Adult Med.	760,920 (98/visit) Paid: 147,810 (19%)	148,210 (19/visit) Paid: 63,140 (43%)	909,130 (117/visit) Paid: 210,950 (23%)
Pediatrics	349,160 (93/visit) Paid: 6,750 (2%)	50,710 (14/visit) Paid: 2,150 (4%)	399,870 (112/visit) Paid: 8,900 (2%)
Well Child	229,160 (37/visit) Paid: 1,780 (0.8%)	3,820 (0.6/visit) Paid: 80 (2%)	232,980 (38/visit) Paid: 1,860 (0.8%)
Antenatal	54,120 (20/visit) Paid: 5,420 (10%)	65,450 (24/visit) Paid: 30,050 (46%)	119,570 (43/visit) Paid: 35,470 (30%)
Family Plan.	2,880 (1.4/visit) Paid: 350 (12%)	1,630 (0.8/visit) Paid: 480 (29%)	4,510 (2.2/visit) Paid: 830 (18%)
STI	14,160 (78/visit) Paid: 1000 (7%)	6,660 (37/visit) Paid: 1,870 (28%)	20,820 (115/visit) Paid: 2,870 (16%)
Unspecified	247,480 (72/visit) Paid: 23,330 (9%)	51,520 (15/visit) Paid: 18,170 (35%)	299,000 (58/visit) Paid: 41,500 (14%)
<b>Total</b>	<b>1,657,880 (64/visit) Paid: 186,440 (11%)</b>	<b>328,000 (13/visit) Paid: 115,940 (35%)</b>	<b>1,985,880 (81/visit) Paid: 302,380 (15%)</b>

\* There are approximately 75 Kenyan shillings to the US dollar.

Satisfaction with the system is high among patients (who for the first time have a token, their ID card, that provides them with meaningful "membership" to a health care system), the MRHC director (who has stated that the report generating feature of the MMRS saves him two weeks of time for one individual for each clinic who previously had to generating reports by hand for the Kenyan Ministry of Health – the MRHC now ranks number one among all Kenyan health centers in the speed and completeness of its reporting), medical records clerks (who no longer have to hand-enter data for each clinic), and clinicians (who do not have to spend their time generating reports by hand for the Ministry of Health). The Head Nurse of MMRS has used MMRS' reports to identify one village where STIs are highly prevalent and another where vaccinations are low. Community-based public health interventions are being planned to rectify both of these problems.

## DISCUSSION

These results show that, despite significant logistical and cultural barriers, the "digital divide" can be crossed using a simple, inexpensive electronic medical record system. Importantly, the MMRS is seen as a Kenyan system, designed and maintained by Kenyans (JKR and JB) and serving the needs of a Kenyan rural health center.

By providing summaries of diagnoses seen, drugs used, and free care provided, the administration of MRHC is better able to advocate (and compete among the other health centers) for the scarce resources available from the Kenyan Ministry of Health. Administration and clinicians can also plan their quality improvement and educational efforts around data indicating which clinical problems are most prevalent. For example, it is clear to the MRHC clinicians that the diagnosis of "clinical malaria" is being overused, resulting in over-treatment with antimalarial drugs (with their attendant costs and toxicities).

The MMRS is also a powerful tool for research. A Kenyan pulmonologist has initiated a study of patients with respiratory infections, using the MMRS to identify patients and adding additional data fields to the paper encounter form and a special tab to the Encounter data entry screen. His plan is to describe the clinical epidemiology and outcomes of such infections and design guidelines for their cost-effective management. A second Kenyan investigator interested in motor vehicle trauma is adding fields to the encounter form (and MMRS database) for the location of accidents. He intends to analyze these data with a geographical information system (GIS) to identify sites for potential traffic control interventions (e.g., stop signs, road bumps).

The local medical school, Moi University Faculty for the Health Sciences, operates a public health training and research in the communities surrounding the MRHC. The MMRS is now able to provide clinical outcome data for these public health studies by linking survey data assessing health risks with clinical data from the encounter forms. It can be used to identify eligible patients for clinical trials.

Clearly, there have been problems. The flow of patients in the MRHC had to be redirected for the patients to visit the new check-out window (they used to leave after visiting the pharmacy and financial office) to deposit their encounter forms. Text data entry for test results was difficult to manage statistically; menu-driven data-entry fields have

replaced the text fields.

There are also cultural barriers to capturing accurate data. The lack of diagnoses of HIV infection or AIDS, and minimal cases of tuberculosis, despite known high prevalences of all three conditions, reflects cultural stigmas that will need to be overcome if the MMRS is to contain useful information on these conditions for clinical care and research.

However, the MMRS works and is a stable resource for improving care and performing research. This simple, inexpensive electronic medical record system has narrowed the "digital divide" in sub-Saharan Africa.

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