EVALUATION OF A MATERNAL AND CHILD ELECTRONIC HEALTH RECORD IN A DEVELOPING COUNTRY

Preliminary Results from a Field Pilot

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Abstract: Introduction: The poor quality of health indicators data such as maternal and perinatal mortality prevents an adequate planning and evaluation of public health interventions.
Objective: To evaluate the viability and usability of a prototype of a maternal and child electronic health record, in Northern Mozambique.
Methods: The prototype was based on existing paper forms and the system was assessed at a maternity ard in a healthcare center of Nampula. The usability was evaluated using *in loco* observations, interviews and self-administered questionnaires to health professionals, after a 6 hours training period.
Results: During the evaluation period, 205 clinical forms were registered, corresponding to 58% of all childbirths. From a total of 19 health professionals, 9 nurses answered the questionnaire. The prototype was well accepted among these respondents but the recording time was higher than in its paper version (12 vs. 5 minutes per record). Data quality problems were identified. The absence of a unique citizen identifier was a major obstacle regarding the mother-child data linkage.
Conclusion: Although this system may contribute to the improvement of the quality of the healthcare provided to women and children in Mozambique, there are still many technical and organizational challenges to be overcome.

1 INTRODUCTION

Approximately 11 women die every day in Mozambique, adding up to 3.900 deaths in 2009, from complications related with pregnancy and childbirth. For every 1.000 live births, about 48 children die in the first 28 days of life every year, mainly from complications occurring during pregnancy and childbirth, including inadequate home practices (2009a).

Nampula is a province in the Northern part of Mozambique, covering an area of 78.197 km^2, with almost 4 million inhabitants, mainly farmers with little education and strong ties to a traditional medical system.

The inadequate infrastructure of Mozambique, such as communication and transportation networks, access roads, electricity, data processing equipment and Internet, complicates the accessibility to information, both paper-based and electronic (2007; 2008; 2009b).

During the research and the analysis of reports regarding the Mozambican context, the authors faced two main problems: the first one is connected with the tremendous lack of data concerning different health indicators, and the second one concerns the quality of available information (OMS, 2010). The number of premature deaths (mortality) is a strong indicator of this situation, as well as the high levels of suffering (morbidity) and incapacity (NEPAD, 2008); (Elizabeth et al., 2007).

1.1 Electronic Health Records

Over time, paper-based systems have become increasingly systematized and gone through several

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transformations. Paper-based medical records render the communication between healthcare providers extremely difficult, especially in developing countries (Kalogriopoulos et al., 2009); additionally, some physicians resist new technologies and prefer the paper-based recording method (Hayrinen et al., 2008).

Indisputably, individual patient data, collected and accessed at the point of care, using an Electronic Health Record (EHR), can assist clinical management (Gladwin et al., 2002); (Zandieh et al., 2008). Physicians can easily access previous records and receive alerts to potential problems, such as drug interactions (Fraser et al., 2005); (Dumont et al., 2009); (Slagle, 1999).

Several African countries still face organizational difficulties such as lack of data quality; defective data analysis; timely data delivery problems and data re-use problems by health professionals. Moreover, the data collection mechanism in Mozambican National Health Service healthcare units is based in manual survey forms, like annual questionnaires (2007; 2005; Allotey and Reidpath, 2000).

Opinions regarding the security and confidentiality of medical data differ across developing countries. In some locations, the uses of electronic databases are viewed with a good deal of suspicion (Fraser et al., 2005); (Zandieh et al., 2008). Patients can face serious risks in their communities if, for instance, their HIV/AIDS status, or other sensitive medical information, is uncovered.

These obstacles emanate from a poor medical culture, where much of the information is rarely searched for, usually unavailable and frequently uncollected (Berkowicz et al., 1997).

1.2 Motivation

Approximately 536.000 deaths worldwide relate to pregnancy and childbirth every year, and 99% of these deaths take place in developing countries, 86% of them in Sub-Saharan Africa (NEPAD, 2008; 2005). However, these estimates are collected from different systems and many of them are unreliable (Allotey and Reidpath, 2000). In order to enhance the accuracy of these estimates we need to improve the collection of data from pregnant women and health care professionals, using effective and functional health systems, capable of quickly and properly answering the health issues of the population.

1.3 Study Site

The "25 de Setembro" Healthcare Center (HC) is a public healthcare unit attended by women and men from the suburban areas of the Nampula Province. Aside from the maternity and the mother and child health wards, this HC provides internal and external general medicine services.

The HC has only one physician, twenty five nurses, nine midwives, eight healthcare assistants and has 42 beds.

The maternity ward has 27 female workers. These workers have very little technical experience, all of the midwives have a mere elementary level and only one of them had used a computer in the past. None of the workers has any knowledge regarding the use of electronic health record systems. Despite having an Internet connection, the signal is erratic and too weak to operate Web-based electronic record systems.

2 OBJECTIVES

The objective of this work is to develop, implement and evaluate a Web-based maternal and child electronic record system in a HC located in the city center of Nampula, Northern Mozambique, in order to build a data repository or to improve the method of collecting, storing, processing, accessing, communicating and sharing information.

3 MATERIAL AND METHODS

Our approach included the following development stages: requirements analysis; prototype implementation; pilot testing and evaluation of the result.

3.1 Requirements Analysis

The requirements for the prototype were defined according to the paper-based records analysis, such as the "antenatal forms" and the "child health card" used in Mozambique. Accordingly, we can highlight the following initial requirements:

- Allow access from users with low or limited Internet speeds;
- Create forms intended for users with poor computer skills (avoiding long steps);
- Use forms and tables in data visualization;

- Include in each result interface a set of queries connected with the data;
- Build an access control, with differentiated user permissions.

During record analysis we discovered that in Mozambique there is no unique citizen identifier. For that reason, we had to cross-analyze information, using 5 fields of personal data. After the health center record analysis, we defined the following fields: first name of the patient; last name; first name of the mother; first name of the father and neighborhood of residence.

3.2 SISMI Implementation

In the Maternal and Child Health Information System (SISMI) prototype design we used UML language to build use case, activity, sequence and installation diagrams, as well as the conceptual data model.

We intentionally used Open Source technologies in both the database and the prototype development. The primary languages we used were PHP, JavaScript, HTML, CSS and AJAX; we used the MySQL database in data management.

3.3 Pilot Testing

Before the actual pilot testing, we arranged a SISMI 6 hour training program with 19 workers from the obstetric department, in the meetings room.

In order to overcome the inevitable electricity, Internet and management problems, we used an offline version installed in a single computer, equipped with a 2,10 GHZ processor, 4 Gb RAM and a 500 Gb hard drive, and with an autonomy of 2 hours in case of power failure.

The purpose of this prototype pilot test was to perform the initial test, to identify necessary improvements, to adjust the system, to identify possible problems in the EHR usage and to collect data.

3.4 SISMI Evaluation

We evaluated the SISMI usability through interviews and questionnaires, and the authors also observed. The interviews were carried out in the antenatal care room with the head of the Maternal and Child Health program (MCH), in the maternity ward with the maternity ward responsible and in the registry with the director of the HC. The general purpose of these interviews was:

- To be acquainted with the services offered and the structure of the obstetric service in the“25 de Setembro” HC;
- To know the opinion of the midwives, nurses and physicians, regarding the system;
- Understand the HC culture, and socio-economic and cultural problems.

One other activity involved the analysis of the medical files, documentation and the observation of the “25 de Setembro” HC, to:

- Verify existent records in antenatal records of the pregnant woman, childbirth medical records and existent records in the health card of the child;
- Verify the appointments log book of the pregnant woman;
- Consult the books containing the Obstetrics structure, the nominal list of workers, their roles, their educational level and their allocation.

We based our questionnaire in the Likert scale, and the workers specified their level of agreement towards the SISMI on a 5 point scale, “1 completely disagree”, “2 disagree”, “3 neither agree neither disagree” 4 agree” e “5 completely agree”.

4 RESULTS

4.1 SISMI Prototype

The SISMI is a modular system composed by a registration module, a data query module, a report module and a statistics module.

The main menu (figure 1) grants access to personal data of pregnant women, pregnant woman search, pregnancy details, antenatal appointments, childbirths, birth and appointments of the child, displays information regarding routine check-ups of the child and, finally, the “statistics” option displays indicators data.

Figure 1: SISMI graphic interface.

4.2 Interview Results

The nurses declared that the paper-based record maintenance in the HC was exceedingly time consuming.

They also reported that when a pregnant woman attends a different HC without carrying her antenatal record, all previous information is lost or neglected by the new physicians.

Antenatal records, and maternity records in general, are kept in the log books of the HC, and some of them reveal a bad conservation state. Many of the fields of paper-based records are kept empty or filled with assumptions made by the nurses, since pregnant women frequently do not know the answer or cannot remember the details, even for basic information such as age. In some cases, nurses will manufacture the information without even asking the pregnant woman, erroneously assuming that she will not know the answer. Records are rarely scrutinized in detail afterwards, contributing to the sense of irrelevance given to an adequate data collection.

4.3 SISMI Training

The training included a presentation of the system and a demonstration of use. Subsequently, structured and semi-structured exercises were performed, simulating the reception of patients.

The initial reaction of the workers to the system was quite positive, and they were all willing to witness its implementation and to learn how to use the SISMI.

The process of learning how to use the SISMI was very difficult, and the workers seemed more comfortable learning from their colleagues. Although all of the workers did receive training inside the maternity ward, only three of them were able to effectively introduce data and use the system.

The main problems we found during training were the misspellings, the typing speed and the general speed when using the computer.

4.4 Pilot Testing Results

In the first day the SISMI was used several necessary improvements were identified in the interface, in order to enhance and simplify data entry. The adjustment of the system to the reality of the HC was immediately carried out by the author.

We observed that the maternity deals with a great number of pregnant women every day, and the data entry speed and agility of the worker were not enough to register all women. Consequently, in order to solve this issue, we introduced daily visits to guide its use; additionally, we recommended that the HC should use the off-peak hours to introduce records from previous days, that hadn't been introduced yet.

It was registered 205 medical files from pregnant women childbirths, corresponding to the month of March, 2011. These records were entered in 11 days of software usage, and after that stage we produced electronic forms with some maternity indicators.

In any case, the 205 files registered in this period represent 58% of the total 354 births that took place. Figure 2 shows the number of appointment files introduced in the SISMI and births per day.

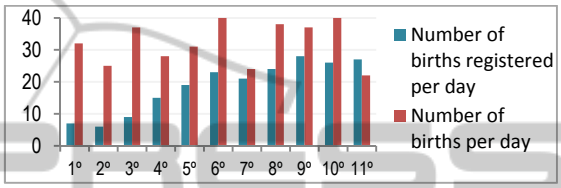

Figure 2: Number of files introduced per day.

We can clearly observe a gradual increase of the registered files, illustrating the agility improvement in the system usage.

4.5 Record Analysis

After a record analysis we identified the introduction of data inconsistencies in the system, such as: age, gestational age, weight of the newly-born child, etc.

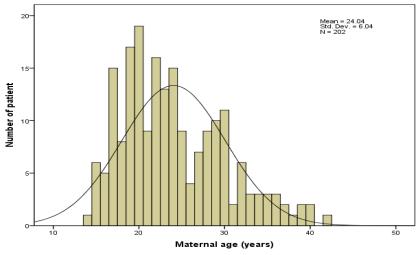

Figure 3: Age of the women at the time of delivery.

According to the data collected we concluded that the ages registered for pregnant women ranged from 14 to 42 years old. However, as we have already mentioned, the ages were frequently guessed. The age graphic for pregnant women (figure 3), shows a small number of registered patients with 18, 21, 26 and 31 years of age, suggesting that these were the least ascribed ages. Therefore, pregnant women with unknown ages were probably aggregated in the peak categories.

Fetal maturity at the time of birth was another insufficiently registered or blank field, and in this

case only 190 of the 205 files displayed this information. Table 1 shows a tendency to be born in the 36th week (4% to 12%) and a high tendency to be born in the 38th week (25% to 38%); accordingly, the likelihood of being born in the 37th week could never be 0%, as indicated. This phenomenon suggests estimates and guesses from the staff.

Table 1: Expected delivery according to gestational age.

Gestational age (weeks)	Births (N=205)	[95% CI]
31	0.5%	[0;2]
32	0	[0;2]
33	0	[0;2]
34	0.5%	[0;2]
35	0	[0;2]
36	7%	[4;12]
37	0	[0;2]
38	32%	[25;38]
39	58%	[51;65]
40	0	[0;2]
41	1%	[0;3]
42	1%	[0;3]

None of the workers remembered the last time the scales used in birth weightings were calibrated. Most of the midwives did not trust the values obtained with the scales and some of them declared they were prepared to "guess" the weight of the infant based on their experience; this is noticeable in the rounding of all birthweights to the hundreds and thousands.

Figure 4 shows that more than one quarter of the newly-born children (28%) were registered as having exactly 3000 grams (15%) and 2500 grams (13%); again, this suggests estimates and gross rounding.

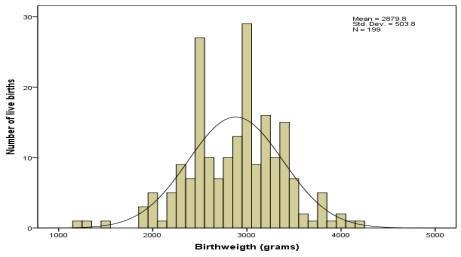

Figure 4: Birthweight distribution.

4.6 Usability Evaluation Results

During observation we concluded that nurses spent less time (5 minutes) filling paper-based records, while taking approximately 12 minutes to register data in the SISMI.

Table 2: Usability evaluation questionnaire and median classifications (N=9).

Questions concerning usage difficulties	N	Mdn
I prefer to work with paper records	5	4
My paper record is more complete	4	2
The paper record is more convenient	4	2
I have trouble using the EHR	4	4
Questions concerning the perceived utility		
EHR can be more effective in child care	5	4
EHR can improve my medical practice	8	4
EHR graphics are easy to understand	5	4
EHR is safer than the one in paper-based	5	4
EHR displayed are organized in a clear manner	6	4

(Mdn: Median of answers)

The questionnaires, containing information concerning the acceptability and usability of the system, were handed to 19 workers, as well as a detailed explanation on how to answer the questionnaire. Only 9 of them answered the questionnaire, and out of these only 4 answered all questions. After the questionnaires were returned we carried out interviews in order to understand why some of the questions were left unanswered; several answers followed these lines: "I was afraid that the questionnaire would jeopardize my place in the institution", "I did not understand how to answer the questionnaire" and "I did not perceive the utility of the questionnaire".

The analysis of the questionnaire and the interaction with the system proved positive, and this reveals that the majority of the staff agrees that using this system can be beneficial to health. However, considering the low frequency of answers and the difficulties experienced in their filling, no real conclusion can be derived from these answers. The questions we presented proved to be unsuitable given the educational level of the workers; the evaluation method was thus inconclusive.

5 DISCUSSION

This system can guarantee the access to the first maternal and child health indicators based in pregnant women and serve as an example in overcoming difficult computer conditions, like the ones experienced in Nampula, Mozambique.

This system gave way to a simple and effective method of creating several database query visualizations while the access to patient data became quicker once located in a set of database tables. Unfortunately, the records from the HC of Nampula are not cross-referenced, and establishing

associations between them is practically impossible, leading to data redundancy and an extremely difficult data recovery process.

The single tests we ran to check the degree of correspondence between personal health records and antenatal care records revealed sufficient discrepancies to raise validity questions to any analysis based in these records. This entails serious implications for maternal and pediatric policy and planning in this Province.

Despite our method, developed in order to create a unique identifier, establishing associations across records is still difficult, and this happens because many women use different names according to the purpose of their visit.

The result analysis revealed that the participants are interested in the implementation of the SISMI. The interaction with the SISMI proved to be positive but inconclusive, considering the general lack of experience with computers.

The workers identified the following benefits connected with the SISMI and their work in the health unit: it saves time in the monthly collection of data; it gives way to a more detailed data analysis; it ensures an accurate and error-free reporting process, based in accurate; it stimulates the staff to collect complete forms.

6 CONCLUSIONS

This system underlines the potential of health information management in Northern Mozambique, which can benefit millions of women and children in the upcoming years by absorbing minimum resources, saving both time and money. Furthermore, this system holds unprecedented and brand new possibilities in the healthcare quality improvement, especially regarding maternal and child survival.

However in Mozambique, several socio-economic and cultural issues need to be answered before action plans for the implementation of EHR systems can be enacted, such as: (a) the scarcity of human resources, both in quantity and quality; (b) the educational level of the health sector workers, mostly basic and intermediate; (c) inadequate facilities; (d) high level of illiteracy; (e) insufficient communication and transportation networks; (f) lack of a single patient identifier.

6.1 Future Works

At present, The Nampula Provincial Health Direction (PHD) is evaluating the proposed SISMI with the intention of working together with us, designing and implementing a new test in the "25 de Setembro" HC or carrying out new pilot tests in other HC of the Province, in order to develop a manageable and financially sustainable program. We also underline the development of additional functionalities, namely: a partograph, information regarding the prevention of vertical transmission, implementing a unique patient identifier technology, and so forth.

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