Implementation and expansion of an electronic medical record for HIV care and treatment in Haiti: An assessment of system use and the impact of large-scale disruptions

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\textbf{Abstract}

Purpose: System use is a key criterion of success in an electronic medical record (EMR) implementation, and there is little research on long-term use of systems following implementation. The aim of the paper was to describe the development, implementation and use of iSanté, Haiti’s national HIV care and treatment EMR.

Methods: To build a picture of the history of iSanté, we interviewed 11 staff involved with the development and implementation of the EMR, and reviewed organization records. Data entry and report use were ascertained by querying the central patient database.

Results: By the end of 2010 there were 67 sites with iSanté installed, and the scope of the system had been expanded to include primary care and obstetrics and gynecology. New functionality includes data forms specific to subpopulations, the ability to transfer patient records among clinics, and integration with an electronic laboratory system.

We observed fluctuations in use over time, with substantial reductions in the number of active sites during times of large-scale disruptions in Haiti. A surge in report use following the January 2010 earthquake suggests that clinics found the EMR to be a valuable source of data during the recovery phase.

Conclusion: There is real potential for EMRs in developing countries to improve clinical practice and make data available for efficient reporting, quality improvement and other population health uses. An approach of continuous system improvement, combined with regular assessments of use, is necessary for achieving an effective, national implementation of a standardized EMR. We have achieved successes in terms of rolling out new functionality and expanding to new sites, but more work remains to be done to improve perceptions of data quality and increase use of population data for accurate and timely reporting.

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1. Introduction

Haiti is the poorest country in the Western Hemisphere (in terms of GDP per person), a situation made worse by the earthquake of January 12, 2010 [1]. Haiti also has the largest number of people living with HIV in the Caribbean and an estimated adult prevalence of 2.2%, one of the highest outside of Sub-Saharan Africa [2].

In Haiti, scale-up of ART began in 2002 and 2003 with large grants from the Global Fund and the President’s Emergency Plan for AIDS Relief (PEPFAR). The expansion has seen success, leading to an antiretroviral therapy (ART) coverage level of 41% prior to the earthquake [3]. However, with an estimated 634,000 persons still displaced by that disaster as of August 2011 [4] and disruptions from an ongoing cholera outbreak, there is a risk that coverage levels and treatment adherence will suffer.

The early use of ART in Haiti helped to demonstrate the feasibility of scaling up ART use in resource-poor settings. In late 2003, the World Health Organization (WHO) and the Joint United Nations Program on HIV/AIDS (UNAIDS) launched the 3 by 5 Initiative, a plan to provide ART coverage to three million people in developing countries by 2005. In order to meet this target, governmental and non-governmental organizations rapidly scaled up workforce training, built and expanded infrastructure, and established standards for HIV treatment.

The value of robust information systems in supporting an expansion of HIV care has been well documented [5–8]. They are essential tools for supporting the last of UNAIDS’s “Three Ones” key principles of HIV scale-up: “one agreed monitoring and evaluation framework for overall national monitoring and evaluation” [9].

Since 2005, the informatics group at the International Training and Education Center for Health (I-TECH), a collaborative activity between the University of Washington and University of California at San Francisco, has been implementing and improving on an electronic medical record (EMR) system called iSanté, which is being used as part of Haiti’s response to HIV. The technical development and system architecture have previously been described [10,11]. iSanté was originally implemented to assist HIV care and treatment clinics in Haiti with meeting their regular reporting requirements. It was recognized early on that clinics would be most enthusiastic about the system if it supported not only reporting, but also day-to-day clinical care, so iSanté was developed to meet both sets of needs.

System use is one of several criteria of success in EMR implementation [12], and the full benefits of adopting a system will not be realized without it. Though evaluations of EMR implementations have included assessments of system use [13–15], long-term assessments are rare. One study in Norway found an increase in EMR use three years after a hospital moved to a fully electronic system [16], though there was not a clear explanation for this beyond that of clinicians having more time to adjust to using the EMR in their practice. It should be noted that the practitioners at the hospital already had high levels of computer skills at the time of implementation, which may not be the case in resource-poor settings. We found no published examples of long-term follow up of system use in developing countries. Such evaluations are particularly important in a setting such as Haiti where there are established paper alternatives, use of the EMR is voluntary, and poor infrastructure may make availability of the EMR unreliable. These factors may undermine both uptake of the system and its continued use over time.

A long-term view also offers the opportunity to examine the impact of external factors on use of an EMR. Political instability, natural disasters and other events can have a disruptive effect on a clinic’s ability to offer care in its usual manner. Haiti has suffered from several devastating events over recent years, most notably a series of hurricanes in 2008, the earthquake of January 2010, a cholera outbreak in late 2010, and political unrest resulting from the November 2010 election. Previous studies have focused on the role of information technology during the response to medical and other emergencies [17–19] but have not looked at the effect of the emergency on use of routine clinical information systems.

In this paper we address the following questions: how has iSanté been rolled out in Haiti, what are some of the key features of iSanté in terms of structure and functionality, how is iSanté used in HIV clinics and how has that use changed over time, and what impact do external events, for example, earthquakes and civil unrest, have on system use?

2. Methods

2.1. Data structure and reports

iSanté was adapted from an EMR used in Seattle for HIV care and treatment. It was built as a hybrid model that supports both retrospective data entry of standardized paper forms used in the clinic and interactive use of forms and other information in the electronic system.

iSanté collects and displays the following information in tab format: Cover sheet—a summary tab that enables the clinical provider to quickly see pertinent information about a patient, including graphs of CD4 and weight history, allergies and laboratory results; Demographics; Laboratory history; Diagnosis history; Treatment history; and Forms. The forms tab is the primary method for entering data and includes the electronic versions of each of the paper forms approved by a multi-stakeholder committee for use in HIV care: registration, ART initiation, laboratory, pharmacy, adherence, counseling, referral and discontinuation. Their completion enables key HIV quality measures to be tracked. Data may be entered and used by several different types of employees at a site, depending on the workflow (see below).

Regardless of whether a site uses the remote server or their own local server, data from each site are copied to a central consolidated server, which is located in Seattle, through a custom-built replication process. This creates a single repository of data from which national-level data can be extracted. A fuller description of the development of iSanté, including the replication process, has previously been made [10,11].

Table 1 – Categories and subcategories of prebuilt reports.

<table>
<thead>
<tr>
<th>Category</th>
<th>Sub-category</th>
<th>Example report titles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data quality</td>
<td>Missing data</td>
<td>Patients with no birth year specified</td>
</tr>
<tr>
<td></td>
<td>Invalid data</td>
<td>Visit date later than data entry date</td>
</tr>
<tr>
<td></td>
<td>Data cleaning</td>
<td>Possible duplicate registrations</td>
</tr>
<tr>
<td></td>
<td>Data management processes</td>
<td>Visit date/data entry lag</td>
</tr>
<tr>
<td>Patient summary and status</td>
<td>Active and inactive patient reports</td>
<td>Active patients (visit within last 90 days if on ART, 180 days if on palliative care)</td>
</tr>
<tr>
<td></td>
<td>Patient care summaries</td>
<td>N/A</td>
</tr>
<tr>
<td>Quality of care</td>
<td>Appointment reminders</td>
<td>Visits scheduled next 7 days</td>
</tr>
<tr>
<td></td>
<td>Lab test reminders</td>
<td>Test needed in 30 days</td>
</tr>
<tr>
<td></td>
<td>Care reminders</td>
<td>Medically eligible for ART but not enrolled</td>
</tr>
<tr>
<td></td>
<td>Tuberculosis treatment eligibility</td>
<td>Patients with TB diagnosis but no treatment</td>
</tr>
<tr>
<td></td>
<td>Regimens and drug discontinuations</td>
<td>Patients on first- and second-line regimens</td>
</tr>
<tr>
<td></td>
<td>Appropriate lab tests indicators</td>
<td>Up-to-date on test</td>
</tr>
<tr>
<td></td>
<td>Appropriate treatment indicators</td>
<td>Cotrimoxazole prophylaxis among medically eligible</td>
</tr>
<tr>
<td></td>
<td>CD4 information</td>
<td>Patient CD4 rates</td>
</tr>
<tr>
<td>Program management</td>
<td>Facility reports</td>
<td>HIVQUAL report</td>
</tr>
<tr>
<td></td>
<td>Patient demographics</td>
<td>Patients by age group</td>
</tr>
<tr>
<td></td>
<td>Service delivery</td>
<td>Visits by month</td>
</tr>
</tbody>
</table>

We created several prebuilt queries that can be used to generate reports. They can be grouped into four categories: data quality, patient summary and status, quality of care and program management. Each category may have one or more subcategories (see Table 1). The reports present results aggregated at the clinic, commune, department or network level. Depending on the report, users are able to change various parameters such as date range, patient status, treatment status or test type. Users with knowledge of Structured Query Language (SQL) and the data structure also have the ability to run ad hoc queries on any data of interest.

2.2. Data collection

To build a history of iSanté, we interviewed 11 I-TECH staff members involved with the development and implementation of the EMR. The staff members had a range of perspectives and experiences, and consisted of the following people: two software developers, two managers who had operational oversight of I-TECH’s Haiti operations at different periods during iSanté’s development, two trainers responsible for educating users, the current EMR manager in Haiti, a data quality analyst, the project lead for iSanté’s development, the project lead for OpenELIS’s development, and the manager of the Clinical Informatics Research Group at the University of Washington. Interviews were conducted in person, by phone and through internet telephony; follow up was carried out in person or by email.

We also reviewed key organization documents including annual reports, training plans and evaluations, results from usability assessments, system change documentation, and implementation plans. Questions that arose from documents were addressed in the interviews.

We assessed system use by running SQL queries against the central patient database. External events were identified by reviewing news reports and through personal knowledge of the authors. The interviews and organizational documents provided context for the findings.

3. Results

3.1. Expansion of sites

Release 2.0 of iSanté was installed at a hospital in late 2005 and expanded to a total of 6 sites by early 2006, all of which used an application service provider (ASP) server. Fig. 1 shows the expansion of iSanté from 2006 to late 2010, at which time there were 67 sites with iSanté installed, 30 of which operated their own server locally. Data for Fig. 1 are derived from regular stakeholder reports and represent a snapshot of the number of iSanté installations at the indicated time. Actual installation of iSanté may have taken place any time from October of the preceding year.

Clinics with the largest number of patients were chosen for earlier deployment of iSanté. Subsequent roll-outs were prioritized according to ease of installation and readiness of the clinic. iSanté is now installed in almost all of the nationally funded HIV care and treatment clinics in Haiti.

3.2. Recent enhancements to iSanté

3.2.1. Pediatric HIV care and treatment forms

In May 2007, in response to demand from clinicians in Haiti, we introduced a separate intake form for care and treatment of pediatric patients. This version differed from the adult intake form in terms of the amount of information collected about family members and patient history. Later in 2007, we implemented pediatric versions of several other forms including laboratory, prescription and discontinuation.

3.2.2. Obstetrics and gynecology forms

In late-2009, we introduced electronic versions of paper forms that are used to capture information on the prevention of mother to child transmission (PMTCT). The data collected were to be used to calculate PMTCT indicators in regular reports. This extension of the system was the first instance of information being collected on HIV-negative patients (the
infants of HIV-positive mothers) and a precursor to the impending expansion of iSanté into general primary care.

Despite the involvement of a multi-stakeholder committee in the development of the paper versions of the forms, adoption of the forms was slow, and clinics complained about the form length. This situation did not change with the introduction of electronic versions of the forms. As a result, the forms were reorganized into separate obstetrics and gynecology (OB/GYN) and labor and delivery forms. We incorporated the electronic version of the new forms in the release of the software that was implemented shortly after the earthquake. We again observed slow adoption of the forms, though the reasons for this are less clear. The third iteration of the forms was released in v9.0 of the software, in December 2010. One of the key improvements has been a reduction in the length of the forms. For example, the OB/GYN form is three pages now, as opposed to nine pages in the previous version. We continue to solicit feedback on the design and use of the forms.

3.2.3. Laboratory information system

In 2007, we began work on an open-source laboratory information system (LIS). We adapted OpenELIS, an LIS developed jointly in Minnesota and Iowa [20], which had by then been modified for initial use in Vietnam. The system was configured for use at the national reference laboratory in the capital, Port-au-Prince, as well as to support a national rollout at clinical labs throughout Haiti. The software was installed at 4 laboratories in July 2009, including the national reference laboratory. The earthquake caused an interruption of training and deployment activities, and two of the most severely impacted hospitals in the country were laboratory sites. The LIS deployment has been restarted, and we plan to install the next release in a total of 1 clinical laboratories throughout the country by the middle of 2011. More information about the OpenELIS project can be found at: https://openelis.cirg.washington.edu/OpenElisInfo/. Information specific to the Haiti configuration and deployment of the system can be found at: http://haitilis.wordpress.com/.

We currently have implemented data exchange functionality for demographic information between iSanté and OpenELIS. When a lab order is processed in OpenELIS, the LIS is able to query iSanté to see if the patient is already known in the EMR. If a match is found, OpenELIS is able to import the patient’s information thus eliminating the need to enter the information manually. This may reduce data errors and ensure that a patient’s result can reliably be matched up with their medical record. We are working to improve the linkage between the two systems so that there is seamless electronic integration from when a lab test is ordered in iSanté, through the testing process, to when the results are automatically imported back into iSanté.

3.2.4. Patient transfer functionality and mobile application

For privacy and confidentiality reasons it was decided early on that iSanté would not maintain a master patient index (MPI). In the initial releases of iSanté, users at each clinic only had access to records for those on their local patient register. This was true even of sites sharing a remote server; the information on that server was partitioned so each clinic could see only their own patients. If a patient attended a clinic different from their usual one, the new clinic would typically create a new patient record, leading to unique records within a single clinic but duplication of information within the larger national system. This new record lacked relevant historical information contained in the original file, and we were concerned that clinical decisions made on incomplete data could result in poorer treatment outcomes.

To address this potential problem, we developed the capability for regional administrators to transfer patient records between clinics. This was achieved by downloading a record as a standalone, encrypted file, transporting the file to the new clinic (either on physical media or through email) and importing the record. The clinic may learn of the need to transfer a patient’s record either when the patient presents for care and the clinic staff learns that the patient has been previously seen a different clinic, or through reports that are run on the national system to identify duplicate patients. Once the need to transfer a patient’s records has been identified, the clinic may notify a regional administrator about which records should be transferred.

In the wake of the January 12, 2010 earthquake, there was concern that a significant number of patients would seek care outside their usual clinics. At the request of Haitian Ministry of Health (MSPP), we simplified the workflow and improved
access to patient transfers by granting iSanté users at each clinic the ability to access patient records from other clinics. This was achieved by the user downloading an encrypted patient summary document from the consolidated server to the patient's new clinic. For confidentiality reasons, a single staff person at each clinic was authorized to query the consolidated server to obtain a patient's summary document if the patient had previously been seen at another clinic. The MSPP also undertook to systematically communicate with the sites about the importance of protecting patient confidentiality.

The transfer capability was also made available through a mobile application that was developed for the Android mobile phone operating system using features of the Open Data Kit framework [21]. After securely logging in to the consolidated server, a user is able to search for patients, verify demographic information, and download a summary document for the patient either directly to the local server or to their phone. The capability was designed in the immediate aftermath of the earthquake and released as finished software within six months.

Uptake of both the updated EMR transfer functionality and mobile transfer application was slow, and usage has remained very low. The EMR transfer capability does not match well with existing workflow in the clinics and there have been limited opportunities to train users on the benefits and requirements of the patient transfer process. We had been given information that physicians at the clinics would receive Android mobile phones as part of the earthquake response, but this did not occur.

To ascertain the extent of the problem of multiple clinic visits per patient, we did an exact match of name, birth date, gender, and mother’s first name within the consolidated server. Our current estimate of duplicate patient over count is 1377 duplicate records in a total patient population of 63,738, or 2%.

3.2.5. Report development
In a recent initiative, regional clinical mentors have begun engaging with clinicians to more actively use the data at a clinic level. We created a modified version of the report with monthly statistics on the quality of HIV care, based upon specifications agreed between the MSPP and HIVQUAL, an international partner that provides technical assistance on quality improvement for HIV treatment programs. Where a systemic issue is identified, clinic staff and the clinical mentors will collaboratively identify the causes and put in place a solution. This could involve modified clinic workflow, alterations to iSanté forms or an improvement to data entry procedures.

We also developed the ability for clinics to complete HIV case reporting forms using information stored in iSanté, and transmit electronic documents containing the case reports to the Ministry. Clinics are required to notify the Ministry of Health when new HIV cases arise, which allows the Ministry to track the incidence of HIV and progress of prevention efforts. Using data stored in iSanté reduces the amount of duplicated data entry and therefore reduces the chance of incomplete or erroneous data being transmitted. This feature is implemented using the HL7 Clinical Document Architecture standard [22].

3.3. System use

3.3.1. iSanté workflow
The 67 sites have adopted iSanté using different workflows to combine the paper and computerized systems. These workflows fall into several major categories:

1. Paper as primary source for clinical practice—the primary source of patient information is paper records. Clinic staff use paper records throughout their interactions with patients and record all notes on paper. The forms used are typically the Ministry of Health national HIV patient record, which are the same forms used within iSanté. Data are not reliably transferred from the paper forms into iSanté.

2. Incomplete implementation of iSanté—iSanté is installed in the clinic and users have received some training. Despite this, staff at the clinic rely almost exclusively on paper charts. Data are then entered into iSanté after the fact, mainly as a secondary repository of patient information. These data may be used to generate reports, or the paper records may be used. There may be a backlog of paper records waiting to be entered into iSanté.

3. iSanté as primary source for clinical practice—the main reference for patient information is iSanté. For a variety of reasons (for example, hardware, power, or local network limitations), paper forms are used at the point of care and then data are entered back into iSanté shortly after the patient’s visit.

4. iSanté at point of care—iSanté is used throughout the majority of patient interactions at the point of care. The iSanté data are the main reference point of patient information. A clinical summary may be printed and stored in a record as a backup system.

We were unable to identify how many clinics fall into each category. In addition, there may be additional variation within each site. Our experience has been that some clinic users have embraced the technology more readily than others. For example, in one site some nursing staff were proficient at using iSanté at point of care, while others would regularly pause during their session with the patient to ask for assistance from the data reporting officer (DRO).

3.3.2. Clinical use of data
Although originally conceived as a data reporting tool, we have iteratively developed iSanté to improve its clinical relevance. Providers have the ability to quickly see summaries for all the patients scheduled to visit that day, including medication history and graphs of CD4 levels over time. We have observed variation among the clinics in how summaries are produced. Some print sheets for each patient at the beginning of the day, others open up a browser tab for each patient. Clinics are required by the MSPP to print a more detailed summary for each patient approximately every three months to ensure continuity of care in the event that iSanté is unavailable, but we have observed that this occurs infrequently. This may be attributed to staff shortages, limited printing supplies, or variation in practice at individual facilities.

Clinics can use iSanté for local activities to improve care. For instance, the system can be used to identify patients that...
are overdue for an appointment or receiving their medication, both of which are recorded as scheduled visits. By running a report of these visits for the next 7–14 days, and comparing that to a subsequent report of patient registrations, field health workers know which patients need homes visits and can ensure continuity of treatment.

3.3.3. Data entry

Fig. 2 shows the number of active sites from 2005 to early 2011 by month. Active sites were defined as those clinics that had created or edited at least one patient form in iSanté that month, which served as a proxy for iSanté use. Using the date a record was created is a more reliable indicator of system use than ongoing activity on that record, but the create date field was not implemented until the version released in February 2007. Prior to that, there was only a field for modified date, so that field is used for measuring activity before that date. A comparison of the number of sites indicated by the create date field and the number indicated by the modified date field shows that the two are in agreement most of the time. Where the count of active clinics does differ, it is seldom by more than one clinic.

As iSanté was installed in more clinics, the number of active sites tended to increase. However, there has been a consistent gap between the number of sites with iSanté installed and those actually using it. This gap reflects sites that use the paper as the primary source for clinical practice workflow described above and, to a lesser extent, sites using the incomplete implementation of iSanté workflow. Sites in the latter category may show up as irregular users, operating for one or two months at a time before having a period of inactivity.

Across the generally upward trend in active sites, there have been monthly fluctuations and periods of sustained reduction in activity. The time period in which the decreased activity occurred was not consistent from year to year, supporting the hypothesis that external events play a role in system use. There were several reductions in use from 2008 onwards at points coincident with known large-scale disruptions in Haiti (labeled A–C in Figs. 2 and 3). There were also reductions in use in 2006 and 2007 for which we were unable to identify any specific causes (labeled as ‘Possible events’ in Fig. 2).

3.3.4. Report use

The clinics are required to report regularly to several different audiences, including funders, the Ministry of Health and HIVQUAL. One of the key benefits of iSanté is the ability for each site’s DRO to use prebuilt queries to produce data for each type of report. These indicator data can then be uploaded to a national HIV/AIDS data aggregation site (Monitoring, Evaluation and Surveillance Interface—MESI [23]) using indicator exchange format (IXF [24]). MESI is used by national bodies for disease surveillance and decision making. The intent of this capability was to generate more accurate and timely reports, and to substantially reduce the amount of time the DROs spent each month preparing reports.

The reports were introduced in early 2008, and more reports have been continually added in each of the four categories: data quality, patient summary and status, program management, and quality of care. To assess whether or not the clinics were making use of the prebuilt reports, we examined the percentage of active sites that ran at least one report in a given month (Fig. 3). Despite the use of a percentage to account for the fluctuations in number of sites actively using iSanté in a given month, we observed substantial variation in the proportion of clinics running reports over time.

Report use gradually increased throughout 2008, with the exception of a dip in September, which coincided with the series of hurricanes. Across all categories of reports, usage increased in early 2009 to 40–50% of clinics, before declining over the rest of the year. The sudden rise in February and March 2009 coincided with the implementation of the patient transfer functionality. We were unable to identify a single external event that explained the gradual decrease in report use from the peak in March 2009, which may be a reflection of waning enthusiasm among iSanté users over time following the introduction of the patient transfer functionality. There was a slight dip in some categories around the time of the January 2010 earthquake (point B in Fig. 3), but this was followed by a large increase in usage, peaking with 96% of active sites running at least one report relating to patient summary and status in April 2010.

Even though there was only a slight change in the percentage of clinics running reports at the time of the earthquake, the total number of reports run fell from 2360 in December 2009 to 1348 and 1169 in January and February 2010 respectively (data not shown). From March 2010 onwards, the number of reports climbed, consistent with the increase in the proportion of active sites running reports. The large decrease in reports run can likely be explained by the fact that several of the larger health facilities, which have more system users and therefore run more reports, are located in Port-au-Prince and were affected by the earthquake.

Following the April 2010 peak, usage gradually declined until it was at levels seen in late 2009. The exception to this was the category of patient summary and status. Though it also experienced a decline, 60% of active clinics ran at least one report in December 2010, well above any levels of usage seen before the post-earthquake peak. Since the start of 2011, there has been a general upward trend in use among all report categories.

Although sites make use of the prebuilt queries in iSanté, anecdotal observations suggest that the data teams seldom use them to prepare the monthly reports. Instead, data staff continue to use hand tabulation to calculate each indicator. This, along with the information in Table 2, suggests that clinics are using the reports for other purposes such as patient management, clinical care or data quality.

Table 2 lists the five most frequently run reports. By far the most commonly run report is one that details the number of patients at each clinic and whether or not the patient is still actively visiting the clinic.

3.4. Impact of disasters on system use

It is clear from Fig. 2 that large-scale disruptions have an impact on the ability of clinics to use iSanté. Even when there were no explanations for downturns in use related to large-scale disruptions, there were events that may have contributed to the trend. For example, there was an uptick of
Fig. 2 – Number of clinics using iSanté in a given month.

Fig. 3 – Percent of active clinics running at least one report.

Table 2 – Most commonly run reports in iSanté between April 2008 and March 2011.

<table>
<thead>
<tr>
<th>Report category</th>
<th>Report sub-category</th>
<th>Report name</th>
<th>Number of times run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient summary and status</td>
<td>Active and inactive patient reports</td>
<td>Active/inactive patients</td>
<td>16,654</td>
</tr>
<tr>
<td>Patient summary and status</td>
<td>Patient care summaries</td>
<td>Patient care summary</td>
<td>8318</td>
</tr>
<tr>
<td>Data quality</td>
<td>Data management process</td>
<td>Forms recently entered</td>
<td>6674</td>
</tr>
<tr>
<td>Data quality</td>
<td>Data cleaning</td>
<td>Forms with errors (consolidated error report)</td>
<td>1984</td>
</tr>
<tr>
<td>Data quality</td>
<td>Missing data</td>
<td>Patients with no gender designated</td>
<td>1745</td>
</tr>
</tbody>
</table>
violence in Haiti in July and August 2006 [25], and Hurricane Ernesto caused damage in late August 2006 [26].

The series of hurricanes that devastated Haiti in 2008 reduced use by 37%, from 32 active sites in June to 20 by August. Recovery was gradual; there were not 32 active sites again until January 2009. Fig. 4. shows the spatial distribution of active sites before and after the hurricanes, along with the paths of the major hurricanes to hit Haiti. Clinics in the south and southwest of Haiti, particularly those along the coast, were most affected by Hurricane Gustav whereas sites in the north were disrupted by Hurricane Hanna.

There was also a 33% decline in the number of active sites between December 2009 (57 sites) and February 2010 (38 sites) due to the earthquake. The full extent of this reduction in usage was not observed until February because some sites that were damaged during the earthquake had generated some activity in the 12 days of January prior to the earthquake, and therefore were counted as active in the January statistics. Fig. 5 shows which sites were active before and after the earthquake. Not surprisingly, many sites around the epicenter, including those in Port-au-Prince, ceased operating. The other major area affected was the northern region, though the reasons for this are less clear.

By mid-2010, activity was beginning to return to the levels reached in the latter part of 2009. However, a cholera outbreak that began in October 2010 and political instability in the run-up to and aftermath of the November 2010 election appear to have had a disruptive effect on the clinics’ recoveries. Despite the fact that the cholera outbreak was still continuing as of March 2011 [27], these disruptions may have only caused a temporary setback in efforts to fully recover from the earthquake.

3.5. Future plans for iSanté

3.5.1. Primary care module

The expansion of PEPFAR’s mandate has led to calls for a broader EMR that would support activities beyond HIV care and treatment. Working with the CDC and in-country partners, we issued another major release of iSanté in December 2010, which includes primary care forms and reports. This will allow greatly improved collation of patients’ medical records into one system. With the expanded functionality, iSanté will be relevant to significantly more clinic sites throughout Haiti.

As with the HIV component of iSanté, the primary care module will be gradually deployed among clinics in Haiti, beginning with the larger hospital sites, and extending eventually in paper or computerized form to over 600 “dispensary-level” facilities. I-TECH has developed an implementation plan that includes training, deployment, and maintenance in collaboration with the government of Haiti, NGO, and other partners.

3.5.2. Interoperability

A number of care providers in Haiti have introduced electronic systems, some predating iSanté and some following it. Partners in Health (PIH) uses a web-based EMR hosted on a central server in Boston [5], though they are transitioning to use of OpenMRS [28]. Others have implemented OpenMRS, most frequently at a single site. The Haitian Group for the Study of Kaposi’s Sarcoma and Opportunistic Infections (GHESKIO) operates an EMR in its clinics [29].

While we have developed the ability to transfer patient records between the public sector clinics and others using the I-TECH iSanté system, patients may also move to other clinic networks. Currently the various EMR systems used in Haiti do not have the ability to share patient information electronically with one another.

To address this issue, I-TECH and PIH have launched an effort to establish interoperability between EMRs in use in Haiti. A key aspect of the project will be developing and enhancing a standards-based medical record summary, which will contribute to the start of a national eHealth architecture.

3.5.3. Assessment of data quality

Although there are considerable efforts made to maintain data quality, including the use of prebuilt queries, alerts in the system interface when entering data and regular quality control efforts, anecdotal reports from system users indicate their continued concerns over quality. Part of that concern may stem from a lack of specific metrics to characterize quality, and to show its improvement or degradation. We have begun a more methodological investigation of data quality assessing timeliness, completeness and accuracy of iSanté system data. We are particularly interested in developing and implementing routine use of quality metrics and in assessing the impact of data quality levels on treatment practices and care outcomes.

4. Discussion

We have demonstrated the ability to implement a reliable, multifunctional EMR that has changed workflow and data management in many of Haiti’s HIV care and treatment clinics. Physicians have more ready access to a patient’s history and can treat accordingly. The ability to easily review and analyze aggregated data has allowed clinical mentors to identify key areas for providers’ professional development and address systematic issues in the clinics.

4.1. Lessons learned from implementation

Our work has highlighted both pathways to successes and challenges encountered when implementing an electronic system in resource-poor settings. The follow are a set of recommendations for implementing an EMR in a developing country setting.

4.1.1. Build in an approach of continuous development

Implementing an EMR in a resource-poor country can involve the same facility-level stakeholders, such as administrative and clinical staff, as in a better-resourced setting. However, additional stakeholders may also be involved including ministries such as health, labor, communications/technology, and others; other governmental, international, and non-governmental organizations; and government and private donors. These additional stakeholders add layers of complexity to the already challenging task of designing a system that works in resource-poor settings. We found that...
adopting an approach of continuous improvement, rather than the traditional one-off or “waterfall” method of development and deployment, has provided the ability to adapt to changing stakeholder and national needs, though it requires a deeper commitment to the EMR in terms of time and staff resources. It is important to allow for such a commitment early in the planning of an EMR.

4.1.2. Centralize development and support where possible
Like others [30], we found centralized development and support to be an efficient way to expand iSanté. This obviates the need for IT staff at each clinic to have the skills necessary for system development, such as programming. Instead, they can focus on supporting EMR users and identifying opportunities for system improvement, which are then fed to the developers. In their experience with an EMR in Cameroon, Kamadjeu et al. [31] found that staff turnover and management changes affected system use; as enthusiastic early adopters left the clinic, momentum was lost. The efficiencies gained from centralizing support and training functions, which allow one or more persons to be solely dedicated to these tasks, may help maintain enthusiasm for using the EMR.

Fig. 4 – Active sites in June 2008 (Panel A) and August 2008 (Panel B).
4.1.3. *Incorporate a mechanism for local feedback*

The manner in which the OB/GYN and pediatric forms were developed and implemented provides a good example of the importance of considering local conditions when implementing an information system in a developing country. Because maternal-to-child transmission and pediatric HIV are not widespread issues in the USA, they were not specific features of the EMR in Seattle that was adapted for the creation of iSanté. Both the OB/GYN and pediatric forms were implemented in subsequent releases of iSanté as a result of feedback from staff in the clinics indicating that these were two significant gaps in the utility of iSanté, both for clinical and reporting purposes.

Total centralization also has some drawbacks. iSanté was deployed in increasing numbers of clinics while central staffing levels remained relatively constant. It is possible that such a rapid expansion of iSanté came at a cost to support offered to sites, such as site visits from data quality staff, which made it more challenging for sites to regularly use iSanté. One possible solution is to ensure that each site has at least one individual who has information technology knowledge and competence, even if it is not at an administrator or programmer level. This will reduce the burden on regional and national support teams and allow for continued development of local expertise. Such an approach would require competency-based user training to be ongoing.

Fig. 5 – Active sites in December 2009 (Panel C) and February 2010 (Panel D).
4.1.4. Evaluate why the system is not being used routinely
We found that simply installing iSanté and providing training on its use does not necessarily lead to regular data entry into the system. As others have noted, a lack of skills and computer literacy among clinic staff [32], staff resistance to an electronic system [33], inadequate benefits accrued at the facility level [34], continued duplication of work to support parallel reporting requirements [35], or irregular electricity and Internet availability [8] all impact the value and use of the system. We also found damage to the site from natural disasters, a lack of computer maintenance (e.g., viruses may infect the site’s computer, rendering it unusable), and a shortage of printing materials needed to produce patient summaries to be contributing factors. There is no systematic and conclusive evidence available to evaluate the relative contributions of these and other factors. Indeed, the importance of a particular driver will vary depending on the setting. It is therefore important to gather and analyze such evidence for each implementation of an EMR.

4.2. Report use
Though we have not systematically identified reasons for low report use, anecdotally we found a perception among clinical staff that the quality of data in iSanté could not be relied upon to replace manual processes for the monthly government and donor reporting, which is tied closely to financial support. This is consistent with the findings of other evaluations [34]. The perception of quality may be due to a significant backlog of paper forms not entered in iSanté, mistakes during data entry that are not identified during quality control activities, or a feeling among clinic staff that the key indicators are not reflective of actual clinical practice. This reticence to rely on iSanté may explain why DROs in most clinics continue to tabulate reports by hand using paper registers. Future studies of iSanté would greatly benefit from exploring these issues in more detail.

4.3. The impact of disasters
The major disruptive events, particularly the January 2010 earthquake, demonstrated both the limitations and potential benefits of using an EMR in this setting. There was a clear pattern of decreased data entry following the events. Physical damage to sites and staffing disruptions are two possible causes of this. For example, during the series of hurricanes in 2008, the space where one site’s server was located was flooded with mud. The national hospital had its computers, and backup tapes, located in a building that was condemned and could not be entered. The earthquake damaged many buildings throughout the capital, Port-au-Prince. Wider infrastructure damage also made connection to the Internet unreliable, which is particularly disruptive for sites that do not operate their own server. Sites with local servers that appear to be inactive may, in fact, still be using iSanté but without Internet they are not able to replicate their data to the central server at the University of Washington. Major disruptions also reduced staffing availability at clinics while at the same time increasing demand for services. If an EMR is not already a well-established part of clinic operations it is unlikely that staff will begin to rely on it during a crisis. The increased patient volume may necessitate a change in clinic layout (e.g., overflow patients may be seen outside) that prevents the use of an EMR at the point-of-care. Such considerations are important when designing the EMR interface. Plans for accommodating a surge in paper forms should be built into contingency planning for EMR implementations, particularly in resource-poor settings such as Haiti. One noteworthy success has been our ability to restore several sites to either full operation on new local servers, or on remote servers, through data that had been replicated to the national centralized server, despite damaged or inaccessible backup tapes and hardware.

Controlling for variability in the number of active sites, there was substantial variation in the use of iSanté as a reporting mechanism over time. The variation in reporting was not as strongly related to major disruptive events as data entry, except during the time after the earthquake. In the months following that disaster we observed peaks in use of the reporting function. This suggests that clinics found value in the electronically stored information for maintaining and/or reestablishing clinic operations.

To the best of our knowledge, this is the first paper to examine the effects of disasters on use of an EMR in a developing country setting. Future studies could add value by identifying mitigation strategies that could be put in place to ensure continuity of system use.

5. Conclusion
We have demonstrated the value of taking a long-term view when assessing EMR use. It enables those involved with EMR systems to more accurately measure the success of an implementation and challenges any assumptions made of sustained use following installation. Evaluators can use observed reductions in use to identify barriers to system use and opportunities for system and/or workflow improvements. Taking a long-term view is critical for measuring the impact of external factors on system use. This approach can be extended beyond the major disruptions examined in this paper to include other influences such as policy and personnel changes. Where appropriate, multiple metrics should be examined. This allows for a more granular assessment of EMR use and its impact on health outcomes.

Authors’ contributions
AM, JB, SW, GO and WL conceived and designed the paper. AM, SW, EE, GZ and NC participated in acquisition of the data. AM, JB, SW, NP, EE and JMDF analyzed and interpreted the data. AM and JB created the original draft, with critical revisions from SW, GO and WL. All authors reviewed the manuscript for important intellectual content and approved the final version for submission.
Summary points
What was already known on the topic

- Information systems, including EMRs, can be used to support scale-up of HIV treatment.
- System use is a key component of assessing the success of an EMR.
- Information systems play a critical role during the response to medical and other emergencies.

What this study added to our knowledge

- EMRs used for HIV treatment can be maintained and improved over time in developing country settings.
- Monitoring system use over time is important for evaluating long-term success of EMR implementation.
- Disasters can disrupt routine EMR use but these same systems are valuable for recovery of patient information.

Conflicts of interests

The authors declare that they have no competing interests except that all authors are employees of the University of Washington and/or I-TECH. Employee salaries and the work described in this article were supported by funding from the Centers for Disease Control, Health Resources and Service Administration, and the President’s Emergency Plan for AIDS Relief.

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