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# Automating Indicator Data Reporting from an EMR to Aggregate Data System Using OpenMRS and DHIS2

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**Background and Purpose:** Electronic HIS are considered essential for managing health information. However, due to challenges of implementing interoperability across HIS, often electronic data are manually printed and re-entered into aggregate data systems. In 2009, World Health Organization (WHO) developed Statistical Data and Metadata Exchange for Health Domain (SDMX-HD) to facilitate health indicator exchange. To date, no documented implementation has demonstrated a practical application of SDMX-HD in automating indicator data reporting. This study demonstrates the use of OpenMRS, to generate and transmit indicator data to DHIS2 using key principles of SDMX-HD.
**Methods**: We deployed OpenMRS and DHIS2 in a test environment at the US Centers for Disease Control and Prevention (CDC) Public Health Informatics Laboratory. OpenMRS was configured to send aggregate indicator data using DHIS reporting module and DHIS2 was prepared to receive them. The two applications were then linked and data exchange process was initiated in OpenMRS using demo data.
**Results**: Fourteen data elements with disaggregation were generated and transmitted to DHIS2 successfully. A report with the 14 data elements was accurately generated from DHIS2.
**Discussions**: Results indicate that indicator data can be sent automatically from OpenMRS to DHIS2, eliminating manual data entry. The success of this test will help evaluate the impact of implementing an automated generation of reporting indicators to reduce human resources needed to fulfill reporting requirements; and to improve data quality, completeness and timeliness. These impacts demonstrate that HIS scale-up can have a positive role in improving health service delivery, M&E, and public health planning.

**Keywords:** Health information systems, Electronic medical records, Data exchange, Indicators, Resource-constrained settings, Aggregate data

## 1 Introduction

Electronic health information systems (HIS) are increasingly being adopted for managing health information and evidence-based decision-making in many developing countries. This increase may be associated with the US President's Emergency Plan for AIDS Relief (PEPFAR) initiative to combat HIV/AIDS epidemic. PEPFAR supports implementation and use of patient and aggregate level HIS to track HIV/AIDS patient care, inform rapid scale up of antiretroviral therapy (ART), and for routine monitoring and evaluation (M&E) activities [1]. At health facilities, HIS enable management of patient information over time, and across health care settings and also support health workers to improve performance, compliance with clinical care guidelines and patient safety [2][3]. Policy makers and health

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system managers can utilize aggregate level systems for on-going monitoring of plans and programs, as well as for resource allocation purposes to improve health services [4].

Indicators are used to show the presence or state of a situation or condition. An indicator is defined as a quantitative metric that provides information to monitor performance, measure achievement and determine accountability [5]. In healthcare settings, indicators are used to measure results such as number of infections, reduction of new infections, level of coverage, quality, and outcomes of interventions and also for progress and situation reporting, health policy development and planning, and advocacy in country and globally. To better monitor the delivery of HIV care and treatment, including quality and outcome, and to report on program progress, the PEPFAR Next Generation Indicator (NGI) reference guide was released in 2009 [6]. These indicators were also developed to support harmonized planning and reporting processes. Currently, a strategy is being implemented to enhance host country ownership of HIV programs through alignment of PEPFAR reporting requirements and NGI with national reporting processes and M&E systems [7].

Even with the increased adoption of HIS, there are still challenges with data quality and timeliness for decision making due to multiple challenges of implementing interoperability across disparate HIS. Often indicator data from electronic medical records systems (EMR) are printed and manually re-entered into aggregate data systems. In resource-constrained settings, the consequences are: 1) increased burden to the already scarce human resources to support public health reporting from patient-level data; and 2) potential for reduced data quality from transcription errors; and 3) availability of information from delays caused by the additional step(s).

In 2009, World Health Organization (WHO) and its partners began to adopt the Statistical Data and Metadata Exchange (SDMX) standard to facilitate exchange of health indicator data from EMRs to aggregate data systems. SDMX is an initiative that fosters electronic standards to facilitate exchange of statistical information. SDMX version 2.1 standards were released in May 2011 and published as an "International Standard" (IS) 17369 on January 2013. Statistical Data and Metadata Exchange for Health Domain (SDMX-HD) was developed based on the SDMX version 1.0 standard[1] [8][9]. Since the SDMX-HD was developed, preliminary work has been done to implement it for indicator and other aggregate data reporting from EMRs to aggregate data systems, although with only limited success.

Recently, an Open Medical Records System (OpenMRS) module was developed by Health Information Systems Programmes (HISP)-India that implements some of the key principles of the SDMX-HD guidance document [8]. This module can support automatic indicator reporting to District Health Information System version 2 (DHIS2). The module triggers indicator data generation and transmission from OpenMRS to DHIS2. This indicator automation process can replace the need to print indicator data reports from an EMR and manually re-enter the data into an aggregate data system. As such, we wanted to test the data exchange functionality of the module to answer the following question: Is it feasible to automate indicator data reporting from an EMR to aggregate data systems? This paper reports on the test of automating indicator data reporting from one widely-deployed EMR, the OpenMRS, to DHIS2 with a subset of PEPFAR direct indicators. Using OpenMRS demo data[2], we examined whether it is feasible to send indicator data electronically from OpenMRS to DHIS2 without the need for manual data entry therefore automating the indicator reporting process.

## 2 Materials and Methods

### 2.1 PEPFAR NGI

The PEPFAR NGI reference guide released in 2013 classifies indicators in three ways [10]:

1. **Degree of importance/aggregation level** indicators are sub divided into three categories.

- Essential/Reported to PEPFAR headquarters (HQ) are considered to be of high importance and necessary to track the progress of HIV programs.

[1] SDMX version 1.0 standard is an International Organization for Standardization (ISO) published standard (ISO/TS 17369: 2005 SDMX)

[2] OpenMRS demo data used was accessed at https://wiki.openmrs.org/display/RES/Demo+Data

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- Essential/Not Reported to PEPFAR HQ are considered to be of high importance and necessary to track the progress of HIV programs, are reported to the PEPFAR country teams, and may vary by country.
- Recommended are indicators for partners and program managers who need additional information for program management.

2. **Reporting level** indicators are divided into PEPFAR direct and national indicators.

- PEPFAR direct indicators measure HIV targets or results of the PEPFAR program through its funded activities. These indicators are grouped in four technical areas namely prevention, care, treatment and health system strengthening.
- National indicators measure a country's HIV program targets and results.

3. **Standard M&E classification** indicators are divided into output, outcome and impact.

- Output indicators measure results of program activities,
- Outcome indicators measure the effect of program activities on target population
- Impact indicators measure long-term or cumulative effect of programs

### 2.2 Indicator selection

The indicator sample used was based on a subset of PEPFAR direct indicators. Based on preliminary work, we determined that indicators on care and treatment technical areas were appropriate for the test of indicator data reporting automation because data for these indicators are clinical and mainly stored in an EMR at the health facility. We excluded indicators whose data was not clinical, such as those measuring number of facilities offering a given service, and those that required facility and community based data. We included indicators whose data is collected on a routine basis.

### 2.3 Indicator data Exchange

We deployed OpenMRS and DHIS2 in a test environment at the US Centers for Disease Control and Prevention (CDC) public health informatics research laboratory (www.phiresearchlab.org). We prepared DHIS2 to receive indicator data by adding data elements for care and treatment indicators. Query statements to generate each data element from OpenMRS were created using an SQL editor. The query statements were embedded in an XML template generated from DHIS2 and the template uploaded to OpenMRS through the module. The two systems were then linked and the data exchange process initiated in OpenMRS to generate and transmit the data message to DHIS2. A report was generated in DHIS2 to confirm that data exchange was successful.

## 3 Results

### 3.1 Indicators tested

After excluding 3 indicators on nutrition whose data was not available in the demo data downloaded from the OpenMRS website, our sample included 13 indicators and 14 data elements (**Table 1**). Five indicators, C2.1D, T1.1D, T1.2, T1.3D and T1.4D, were disaggregated by age (less than 15 years and above 15 years) and gender (male and female) and one indicator, C2.2D, was disaggregated by age. Therefore the total number of data elements with disaggregation for the test was 30.

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**Table 1.** Care and treatment indicators selected for indicator data reporting test automation

| | Indicator No | Indicator | Data Element | Disaggregation |
|---|---|---|---|---|
| **Care Indicators** | | | | |
| 1 | C2.1D | ***Number of HIV-positive adults and children receiving a minimum of one clinical service*** | ***Number of HIV-positive adults and children receiving a minimum of one clinical service*** | ***Age and Gender*** |
| 2 | C2.2D | ***Number of HIV-positive persons receiving cotrimoxazole prophylaxis*** | ***Number of HIV-positive persons receiving cotrimoxazole prophylaxis*** | ***Age*** |
| 3 | C2.2N | Percentage of HIV-positive patients who are given cotrimoxazole preventive therapy | Calculated | |
| 4 | C2.4D | Percentage of HIV-positive patients who were screened for TB in HIV care or treatment settings | Number of HIV-positive patients who were screened for TB in HIV care or treatment settings | |
| 5 | C2.5D | Percentage of HIV-positive patients in care or treatment who started TB treatment | Number of HIV-positive patients in care or treatment who started TB treatment | |
| 6 | C2.6D | Number of eligible HIV positive patients starting Isoniazid preventive therapy (IPT) | Number of eligible HIV positive patients starting Isoniazid preventive therapy (IPT) | |
| 7 | C3.1D | Number of TB patients who had an HIV test result recorded in the TB register | Number of TB patients who had an HIV test result recorded in the TB register | |
| 8 | C4.1D | percentage of infants born to HIV positive women who received an HIV test within 12 months of birth | Number of infants born to HIV positive women who received an HIV test within 12 months of birth | |
| | | | Number of infants born to HIV positive women | |
| 9 | C4.2D | Percentage of infants born to HIV-positive women who are started on CTX prophylaxis within 2 months of birth | Number of infants born to HIV-positive women who are started on CTX prophylaxis within 2 months of birth | |
| **Treatment indicators** | | | | |
| 10 | T1.1D | ***Number of adults and children with advance HIV infection newly enrolled on ART*** | ***Number of adults and children with advance HIV infection newly enrolled on ART*** | ***Age and gender*** |
| 11 | T1.2D | ***Number of adults and children with advance HIV infection receiving ART*** | ***Number of adults and children with advance HIV infection receiving ART*** | ***Age and gender*** |
| 12 | T1.3D | ***Percentage of adults and children known to be alive and on treatment 12 months after initiation of antiretroviral therapy*** | ***Number of adults and children known to be alive and on treatment 12 months after initiation of antiretroviral therapy*** | ***Age and gender*** |
| | | | Number of patients started on ART treatment in the last 12 months | |
| 13 | T1.4D | ***Number of adults and children with advanced infection who ever started on ART*** | ***Number of adults and children with advanced infection who ever started on ART*** | ***Age and gender*** |

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### 3.3 Indicator data exchange

A total of 30 pieces of aggregate data for the 13 HIV care and treatment indicators were generated and transmitted to DHIS2 successfully (**Table 2**).

**Table 2.** Report results in OpenMRS after indicator data generation and transmission

| Report result<br>DataSet: HIV_CARE_TX<br>OrgUnit: Eldoret<br>Period: 200605 | |
|---|---|
| Data Element: T1.4, Value: 66 | Data Element: C2.2, Value: 136 |
| Data Element: T1.4, Value: 124 | Data Element: T1.4, Value: 12 |
| Data Element: T1.4, Value: 8 | Data Element: C2.1, Value: 1271 |
| Data Element: T1.1, Value: 124 | Data Element: C4.2, Value: 0 |
| Data Element: C2.5, Value: 6 | Data Element: C3.1, Value: 0 |
| Data Element: T1.3, Value: 0 | Data Element: C4.1DEN, Value: 168 |
| Data Element: T1.3DEN, Value: 0 | Data Element: T1.2, Value: 90 |
| Data Element: T1.1, Value: 8 | Data Element: C4.1, Value: 0 |
| Data Element: C2.2, Value: 1455 | Data Element: C2.1, Value: 2463 |
| Data Element: T1.3, Value: 0 | Data Element: T1.2, Value: 1760 |
| Data Element: C2.1, Value: 116 | Data Element: T1.1, Value: 12 |
| Data Element: C2.4, Value: 6 | Data Element: T1.2, Value: 896 |
| Data Element: T1.3, Value: 0 | Data Element: C2.1, Value: 232 |
| Data Element: T1.3, Value: 0 | Data Element: T1.2, Value: 162 |
| Data Element: C2.6, Value: 61 | Data Element: T1.1, Value: 66 |
| Status; SUCCESS<br>Description: Import process completed successfully<br>DataValue count: [imports=30, updates=0, ignores=0] | |

An HIV care and treatment report (**Table 3**) was created in DHIS2 with the 14 data elements sent from OpenMRS. The data in this report was identical to the report results transmitted from OpenMRS.

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**Table 3.** Report exported from DHIS2

| HIV care and treatment<br>Eldoret May 2006 (Generated: 2013-09-10) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Data element name** | | **Disaggregation (gender and years)** | | | | | | |
| | | ***(15 +)*** | ***(< 15)*** | ***(< 15, Female)*** | ***(< 15, Male)*** | ***Value*** | ***(Female, 15 +)*** | ***(Male, 15 +)*** |
| C4.1DEN[3] | Infants born to HIV Positive women | | | | | 168 | | |
| C4.2 | Infants born to HIV positive women who are started on CTX prophylaxis within two months of birth | | | | | 0 | | |
| C4.1 | Infants born to HIV Positive women who receive an HIV test within 12 months of birth | | | | | 0 | | |
| T1.3 | Number of adults and children known to be alive and on treatment 12 months after initiation of ART | | | 0 | 0 | | 0 | 0 |
| T1.1 | Number of adults and children with advance HIV infection newly enrolled on ART | | | 12 | 8 | | 124 | 66 |
| T1.2 | Number of adults and children with advance HIV infection receiving ART | | | 162 | 90 | | 1760 | 896 |
| T1.4 | Number of adults and children with advanced infection who ever started on ART | | | 12 | 8 | | 124 | 66 |
| C2.6 | Number of eligible HIV positive patients starting Isoniazid preventive therapy (IPT) | | | | | 61 | | |
| C2.1 | Number of HIV-positive adults and children receiving a minimum of one clinical service | | | 11 | 11 | | 12 | 11 |
| C2.5 | Number of HIV-positive patients in care or treatment who started TB treatment | | | | | 6 | | |
| C2.4 | Number of HIV-positive patients screened for TB in HIV care or treatment settings | | | | | 6 | | |
| C2.2 | Number of HIV-positive persons receiving cotrimoxazole prophylaxis | 1455 | 136 | | | | | |
| T1.3DEN[3] | Number of patients started on ART treatment in the last 12 months | | | | | 0 | | |
| C3.1 | Number of TB patients who had an HIV test result recorded in the TB register | | | | | 0 | | |

## 4 Discussion

This test for automating reporting of indicator data demonstrates that this data can be sent electronically from OpenMRS to DHIS2 eliminating the need for manual data entry. The indicator data element report (**Table 3**) generated in DHIS2 was identical to the result report (**Table 2**) of indicator data generated and transmitted from OpenMRS signifying that data was exchanged between the two systems accurately. This indicator data was available in DHIS2 for use after transmission. This test show that automated data reporting has the potential to increase data availability and quality by reducing delays and transcription errors often introduced during manual data entry [11]. The ability to successfully automate indicator data reporting from EMRs to aggregate data systems will help evaluate the impact of these process improvements on both human resources needed to fulfill reporting requirements, and on data quality, timeliness and completeness, thus supporting HIS scale-up for health service delivery, M&E, and public health planning.

Feasibility for automating indicator data reporting from other EMRs used in resource-constrained settings to DHIS2 should be assessed, and conducted to map and document their automation process. This will help guide development of standardized indicator reporting from health facilities to the ministry of health and funders. The indicator data exchange feasibility is the first step in evaluating automation of indicator data reporting at a health facility. Future work should entail: 1) review of the PEPFAR indicators with monitoring and evaluation experts to identify appropriate indicators to exchange; and 2) configuration and automation of indicator data reporting for each indicator identified in a field test environment.

[3] DEN denotes denominator

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**Disclaimer:** The findings and statements in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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