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Using Open Source Health Management Information Systems in the context of Universal Health Coverage Monitoring in Malian health facilities

Gustave Karara ^{a,*}, Ousmane Ly ^{a,b}, Frank Verbeke ^a, Marc Nyssen ^a

^a Department of Public Health, Biostatistics and Medical Informatics, Vrije Universiteit Brussel, Brussels, Belgium

Keywords: ^b Mali's National Agency for Telehealth and Medical Informatics, Bamako, Mali

Background and Purpose: The Universal Health Coverage (UHC) is an important point in the 2030 agenda for Sustainable Development Goals (SDGs). In this study, the authors assess indicators allowing health services coverage monitoring in the context of UHC.

Methods: The study has been conducted in 4 Malian health facilities between 2013 and 2016. The most relevant UHC indicators are calculated on the basis of patient's administrative and health insurance data, collected via an Open Source Health Management Information System (HMIS) deployed in more than fifty sub-Saharan health facilities, *OpenClinic GA*.

Results: The results show that the patient health services coverage (PHSC) rate is 2.4% for outpatients and 18.2% for inpatients. This rate is high in the third reference hospitals where the social health insurance AMO (*Assurance Maladie Obligatoire*) is more applied to patient encounters. The patient health services payment (PHSP) rate as the proportion of total health service costs is above the 25% threshold recommended by WHO and it exceeds 80% both for inpatients and outpatients. The patient out-of-pocket payment (POOP) is below the threshold of 180USD per patient per year but remains high (70USD) for inpatients in the university hospital.

Conclusions: This study demonstrates the possibility to evaluate the level of UHC in sub-Saharan countries, by a methodology based on health services coverage indicators calculated by using routine data recorded in patient electronic health records at the level of health facilities.

Keywords: Universal health coverage, Open Source HMIS, Health coverage indicators, Health insurance schemes, Malian health facilities

1 Introduction

Universal health coverage (UHC) means that everyone receives essential health services needed, in quality and without being exposed to financial hardship [1,2]. Access to health services enables people to be more productive and active contributors to their families and communities [1,2,3]. The third Sustainable Development Goal (SDGs) concerning "Good health and well-being" includes a bold commitment of countries to achieve universal health coverage by 2030 [4,5]. UHC becomes a major point of attention, gradually integrated into health policies of countries. Monitoring of UHC is based on 2 major components: Health services coverage and financial protection coverage. Health services (prevention, curative and palliative care) must be sufficient in quality and quantity. The financial risk protection is determined by the proportion of costs that patients must themselves cover by making direct and immediate cash (out-of-pocket) payments (OOP) [1,3,6]. Under UHC framework, there would be no OOP that exceeds a given level of affordability. According to the WHO, people in developing countries should not spend an average of 25% or more of their total health expenditure as OOP or 40% (defined as non-

*Corresponding author address: Department of Public Health, Biostatistics and Medical Informatics, Vrije Universiteit Brussel, Laarbeeklaan 103, B-1080 Brussels, Belgium Email: gustave.karara@vub.ac.be Tel: +32 2 4774444

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food expenditure) of 1.25USD per capita per day (i.e. 180USD per capita per year as OOP, set at zero for the poorest and most disadvantaged people) to avoid the impoverishment [7,8].

Sub-Saharan Africa countries make remarkable efforts to move towards UHC by setting up health insurance schemes, based on either communities, on social/public institutions or on the private sector. Community-based health insurance (CBHI) schemes are initiated mostly by community leaders or corporate associations in the informal sector. Social health insurance schemes (SHI) are usually based on individuals' mandatory enrolment initiated by the governments in the context of social security programs. Private health insurance (PHI) schemes are voluntary and most often initiated by commercial health insurance companies in the formal sector [9].

Persistent low national coverage of social health protection led the Malian government to elaborate a 2005-2009 action plan of health insurance policy. Among the targets were the introduction of mandatory health insurance for government and formal sector employees (*AMO, Assurance Maladie Obligatoire*), social assistance for the extreme poor (*FAM, Fonds d'Assistance Médicale*), and achievement of 3% community based health insurance (CBHI) coverage (0.31% in 2003) at country level [10]. But in 2006, national CBHI coverage was estimated between 0.29 and 0.33% [11]. In 2009, as AMO and FAM still nonoperational and national CBHI coverage still low, the Malian government launched a 2010-2014 action plan for extension of social health protection, with the same targets as the former one: re-introduction of AMO managed since 2009 by the CANAM (*Caisse Nationale d'Assurance Maladie*) and FAM (now called *RAMED, Régime d'Assistance Médicale*); and a willingness to achieve 3% CBHI coverage at national level [12]. According to the "Demographic and Health Survey - DHS 2012/2013" [13], only 6.0% of the population sample (14,723) surveyed reported to have at least one health insurance coverage: AMO (1.9%), CBHI (2.7%) and 0.9% of survey participants were covered by an individual private insurance and 0.8% had an insurance provided by the employer.

The primary information of UHC comes from household surveys and health facility data. Although most countries have functioning facility-based Health Management Information Systems (HMIS), these data continue to have a number of weaknesses: incomplete, inaccurate and not timely. Therefore, they are usually not used [14,15,16].

The Information and Communication Technology (ICT) revolution brings enabling opportunities to sub-Saharan countries in their efforts to strengthen the quality of HMIS data [17,18]. The introduction of open source IT solutions for HMIS in several sub-Saharan health facilities prove that sub-Saharan countries move towards ICT development in health facilities [17,19]. *OpenClinic GA* is an Open Source integrated hospital information management system. Implementations are recorded in several health facilities all over the world, and monitored in more than fifty health facilities both public and private in sub-Saharan countries [17,20,21].

Those health facilities joined ten years ago a project named ICT4Development initiated by the authors at the VUB (Vrije Universiteit Brussel) to improve health information management using ICT methods. The *OpenClinic GA* package was put in the public domain in 2010 [21,22], and it became gradually the first medical Open Source software project viewed all over the world [23]. The system covers management of administrative, financial and clinical patient records; lab, x-ray, and pharmacy data; and includes an extensive statistical and reporting module. *OpenClinic GA* was developed in Java connecting over JDBC to the most popular ANSI SQL 92 compliant database servers (such as MS SQL and MySQL Server). It offers an easy to use web interface facilitating HMIS deployment in often challenging technological settings commonly found in developing countries [17,22].

In Malian context, the project *OpenClinic GA* has been implemented since 2013 in 7 public and private health facilities: 2 University teaching hospitals (CHU-Gabriel Touré and CHU-IOTA), 1 regional reference hospital, 3 reference health centers and the vaccination program in Bamako (VIDA project). The *OpenClinic GA* implementation in Malian health facilities is led by the National Agency for Telehealth and Medical Informatics.

This study attempts to prove that UHC can be adequately evaluated in Malian health facilities using Open Source HMIS, *OpenClinic GA*, based on standardized patient administrative and financial data. The study analyses data from 4 health facilities that have used *OpenClinic GA* since 2013.

2 Materials and methods

The study covers a 3-year period from 2013 to 2016. The process of *OpenClinic GA* implementation is applied, which includes the following stages: (1) business analysis, (2) software installation and configuration, (3) users training and follow up; and (4) monitoring and evaluation. The implementation period is followed by a period of maintenance and assistance according to the needs of the health facilities. The patient routine data collected are for secondary use in this health insurance coverage study. Malian health facilities (HF) participating in this study are:

- University Teaching Hospital-African Institute of Tropical Ophthalmology (CHU-IOTA), a 54-bed hospital specialized in eye care and attached to the University of Bamako.
- Nianankoro Fomba Hospital of Segou (HNFS), a 160-bed public regional reference hospital.
- Reference Health Center of Commune III (CSREF3), located in Bamako-Coura commune. This health center counts 74 beds.
- Reference Health Center of Commune IV (CSREF4), located in Lafiabougou commune. It counts 60 beds of admission.

The CSREF3 and CSREF4 are the first health facilities to implement *OpenClinic GA* early in 2013. The other health facilities integrated the project in 2014.

OpenClinic GA is installed on the health facilities' servers and; administrative and financial modules are configured by standardizing health insurance formats and health service components for all health facilities to facilitate the extraction of UHC indicators. UHC-related indicators are extracted and analysed in the period between 1/1/2013 and 30/06/2016.

The remote interventions and daily health indicators pass through a virtual private network (VPN) installed at the health facilities' servers using the Nagios IT Infrastructure Monitoring System [24]. The analysis of patient information collected is performed in the *OpenClinic GA* statistics module and the pertinent indicators on UHC are centralized on the Global Health Barometer (GHB), a data warehouse installed on our project servers at the VUB [21].

The essential UHC indicators analysed, are:

- The patient health insurance coverage (PHIC) by evaluating patient health insurance data and the use of health insurance schemes in hospitals.
- The patient health services coverage (PHSC) by evaluating patient's health services consumed and coverage of these services by health insurance schemes.
- The patient health services payments rate (PHSP) as the proportion of amounts paid by the patient for uncovered health services divided by total amounts of health services consumed.
- The patient out-of-pocket payment (POOP) as average amount paid directly by the patient for health services not (fully) covered by the health insurance scheme.

For the PHIC indicator evaluation, we distinguish 5 types of health insurance schemes: (1) Free health services (FREE) where the patient did not pay anything, (2) Social health insurance (SHI) represented by the AMO plan, (3) Community based health insurance (CBHI), (4) Private health insurance (PHI) and (5) No health insurance (PATIENT) where the patient pays the total of his health service expenditures. The more often a health insurance scheme is used by patients, the more this health insurance scheme participates in the UHC. This evaluation is performed to out-patient and in-patient encounters.

For the PHSC indicator evaluation we identify two categories of patients: (1) Insured patients for whom the OOP does not exceed 25% of the health services costs and (2) Uninsured patients who cover 75% or more of the total consumed health services with OOP. The higher the percentage of insured patients, the more the health facility is involved in UHC. We calculated metrics for out-patient and in-patient encounters separately.

In the framework of patient financial risk protection, we apply the PHSP not exceeding 25% of total patient health services consumption and the annual OOP not exceeding 180USD. We separately calculated these metrics for out-patient and in-patient encounters.

Comparative Chi-square testing is applied to compare the coverage rate of different health insurance schemes within the health facility and between different health facilities and the comparison of UHC indicators' means is analysed using the ANOVA test.

3 Results

3.1 Patient health insurance coverage (PHIC)

The distribution of out- and in-patients and their encounters is shown in table 1.

Table 1: Distribution of patients and encounters

Malian HF	Out-patients	In-patients	Out-patient encounters	In-patient encounters
CHU-IOTA	101 259	8 124	160 256	8 846
HNFS	143 340	935	173 396	981
CSREF3	127 276	1 180	183 432	1 372
CSREF4	188 111	473	238 832	499
Total	559 986	10 712	755 916	11 698

More than 550.000 electronic patient records have been created and updated during the 3 years’ study in 4 Malian health facilities. The database of CSREF3 and CSREF4 contain higher absolute number of outpatients than other health facilities because *OpenClinic GA* software started to be implemented early 2013 in the 2 health centers. The university hospital IOTA provided the highest volume of inpatients data due to its intensive eye surgery activities conducting to short-term hospitalizations.

For each encounter with the health facility, health services are in part paid by the health insurer and the remainder by the patient, according to the patient’s health services coverage plan.

Health insurance schemes used by patients for each out and in-patient encounter have been analysed. For one encounter, patient may use a single, 2 or more different health insurance schemes. The *OpenClinic GA* system is configured to apply, whenever possible, the health insurance scheme with the lowest patient contribution in case of availability of different eligible schemes. Figures 1 shows the health insurance schemes coverage used by patients for out and in-encounters in the 4 health facilities.

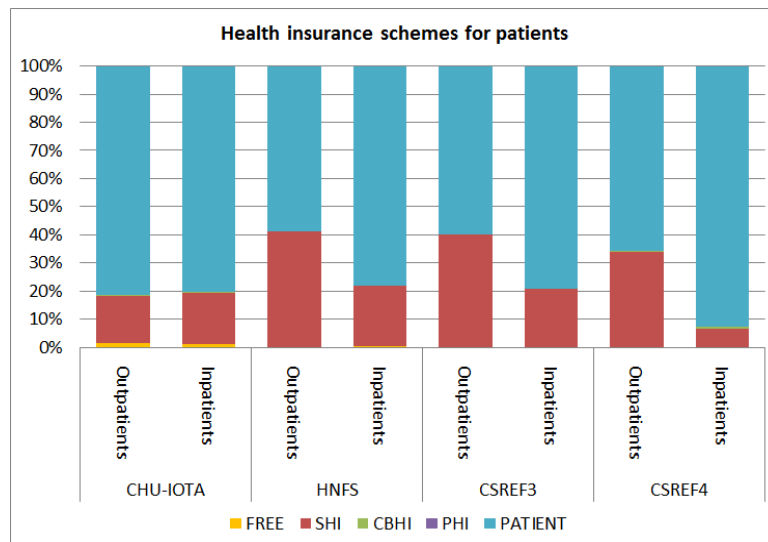


Figure 1: Health insurance schemes for out- and in-patient encounters

The Social health insurance (SHI) scheme is used most in all health facilities for both out- and inpatient encounters. The use of the SHI scheme is more associated ($p=0.0501$) with out-patients (average: 33.0%) than with in-patients (average: 16.8%). The AMO plan is the main SHI insuring patients. The use of the PATIENT (no health insurance) scheme remains very dominant in Malian health facilities. It varies

between 59% to 93% of the patient encounters and is more frequently ($p=0.0415$) used for inpatient encounters (average: 82.6%) than for outpatient encounters (average: 66.5%). The other health insurance schemes are negligible in the Malian health facilities studied. Free care (FREE) scheme (1.3%-1.6% of encounters) at CHU-IOTA is supported by the hospital through its social department and is funded by NGOs and projects that support the hospital in its operation activities. Community health insurance (CBHI) scheme is essentially included the UTM (*Union Technique de la Mutualité*) used by 0.3%-0.6% of encounters at CSREF4.

3.2 Patient health services coverage (PHSC)

Table 2 shows the health services coverage situation for out- and in-patients in the 4 Malian health facilities during the study period.

Table 2: Out- and In-patient health services coverage

Malian HF	Outpatient		Inpatient		Statistical significance*
	Insured ($POOP \leq 25\%$)	Un-insured ($POOP > 75\%$)	Insured ($POOP \leq 25\%$)	Un-insured ($POOP > 75\%$)	
CHU-IOTA	3.3%	81.9%	20.0% (+16.7%)	79.0% (-2.0%)	$P < 0.0001$
HNFS	4.1%	81.4%	36.9% (+32.8%)	61.2% (-20.2%)	$P < 0.0001$
CSREF3	1.9%	74.1%	11.4% (+9.4%)	82.8% (+8.7%)	$P < 0.0001$
CSREF4	0.3%	79.7%	6.4% (+6.1%)	92.8% (+13.1%)	$P < 0.0001$
Mean	2.4%	79.3%	18.7% (+16.3%)	79.0% (-0.3%)	$P < 0.0001$
Statistical significance **			$p=0.0545$	$p=0.0004$	

*Proportion comparison χ^2 test comparing health services coverage between in- and outpatients for each hospital

**Single factor ANOVA test between averages of insured (uninsured) out and in-patients

The PHSC varies between 0.3% for outpatients at CSREF4 and 36.9% for inpatients at HNFS. The proportion of insured patients is globally lower for outpatients (2.4%) than inpatients (18.2%). Proportions of insured inpatients for the 2 reference hospitals (20.0% and 36.9%) are higher than the 2 health centers (6.4% and 11.4%). The proportion of non-insured patients decreased very little in hospitalizations. The overall picture of the PHSC in the 4 Malian health facilities is that inpatients are in absolute terms better covered in health services than outpatients.

3.3 Patient health services payment rate (PHSP)

The PHSP in the 4 Malian health facilities is shown in table 3.

Table 3 - Out- and In-patient health services payment rate

Malian HF	Out-patients	In-patients	Difference
CHU-IOTA	88.1%	82.6%	-5.5%
HNFS	83.9%	64.6%	-19.3%
CSREF3	70.4%	84.4%	+14.0%
CSREF4	80.8%	96.2%	+15.4%
Mean	80.8%	82.0%	+1.1%
Statistical significance*			$p=0.8837$

*Single factor ANOVA test between averages of out- and in-PHSP

The PHSP for consumed health services averages 80% in the studied Malian health facilities. In the framework of UHC, it must not exceed 25%.

These higher rates of PHSP are explained by the lower rates of PHSC because the role of health coverage is only played by AMO plan which covers a minority of patients (public agents and their families).

The PHSP is slightly higher (+1.1%) for inpatients but the difference is not statistically significant

3.4 Patient out-of-pocket payment (POOP)

In the framework of UHC, the annual average amount directly paid by the patient should not exceed 180 USD. The POOP in studied Malian health facilities is shown in table 4. The largest difference of POOP between in- and out-patient is observed at CHU-IOTA (+654%), indeed inpatient health services are expensive in university hospitals.

Table 4 – Out and In-patient out-of-pocket payment

Malian HF	Out-patients	In-patients	Difference
CHU-IOTA	9.30 USD	70.11 USD	+654%
HNFS	7.60 USD	12.00 USD	+58%
CSREF3	4.55 USD	8.21 USD	+80%
CSREF4	4.39 USD	5.80 USD	+32%
Mean	6.46 USD	24.03 USD	+272%
Statistical significance*			p=0.2991

**Single factor ANOVA test between averages of out and in-POOP*

And in general, health service costs in third reference hospitals are higher than in health centers, thus POOPs in CHU-IOTA and HNFS are higher than POOP's in reference health centers of Communes III and IV of Bamako. The POOP for the all health facilities studied is below the threshold of 180USD but remains high for inpatients at CHU-IOTA because the health service tariffs applied in hospitalization were also high in this university hospital.

4 Discussion

Despite the growing concern of the Malian authorities to move towards UHC, the public participation in the social health insurance was still low and the private health insurance shows a weak participation. On the national level, the population covered by a social health insurance is 1.9%, 2.7% by CBHI and 1.7% by private health insurance schemes [13]. Globally, the population health insurance coverage is less than 6%. More than 94% don't have any health insurance coverage. This situation is reflected on the level of studied health facilities where between 59% and 93% of patient encounters are not insured.

The most applied health insurance scheme, as registered by the participating health facilities is the social health insurance represented by the AMO. Patients covered ranged 2.4% for outpatients and 18.2% for inpatients in the studied health facilities. This PHSC indicator is higher in the 2 third reference hospitals, showing that insured patients more consult the CHU-IOTA and HNFS than in the health centers. The same situation is observed in Rwandan and Burundian hospitals and in many developing countries, where social or private insured patients prefer the third-level reference or private hospitals more specialized and equipped than second- or first-level reference hospitals [1,20,25].

Regarding the financial risk protection, the World Bank and WHO statistics (2014-2015) report an OOP of 25.90USD representing 61.7% of total expenditure on health in Mali [8,26]. The OOP expenditure as proportion of total expenditure on health is above the 25%-threshold as it is also for patients studied in the 4 health facilities (80.8%-82.0%). The PHSP is a little higher for these patients than for the general population because health services are either less covered by AMO or in totality paid by the high number of uninsured patients. On other hand, the POOP in these facilities (6.46USD-24.03USD) is little lower than the average for the general population. This situation is due to the costs of health services that are more covered for patients in these health facilities than in the general population.

Although POOP was below the threshold of 180USD per patient per year, it remained high for inpatients in university hospital IOTA, due to the high costs of health services in this kind health facility [20].

This study focuses on the health services coverage monitoring by using HMIS data collected and analysed using *OpenClinic GA*, an Open Source software implemented in 4 Malian health facilities. The routine utilization of this Open Source-HMIS for the collection of patient administrative and financial data enables the monitoring of UHC indicators for secondary use in this health insurance coverage study. Results show that the patient health services coverage is higher for inpatients than outpatients. This indicator is also high in third reference health facilities where the patients are more covered by the social health insurance AMO plan. This study demonstrates that further efforts are still needed in Mali to achieve financial protection for all citizens. Additional broader studies involving more health facilities are needed in order to draw further conclusions on the role of health insurance schemes in UHC in Malian health facilities.

With this pilot study, we demonstrated the feasibility of evaluating the level of UHC in developing countries using an Open Source-HMIS routine patient data recorded by the health facilities themselves.

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Statement on conflicts of interest

None

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