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Integrated Health Information Management Resources for Global Health Care Strategies

Editors: Nicky Mostert-Phipps, Frank Verbeke, Dalenca Pottas, Ghislain Kouematchoua, Ulrich Kemloh

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Postfach 652166
D-22372 Hamburg, Germany
www.koegni-ehealth.org
E-mail: info@koegni-ehealth.org

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Editorial to the HELINA 2017 proceedings

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The HELINA 2017 Conference
The 10th HELINA (HEaLth INformatics in Africa) conference was organized from 23 to 26 April 2017 in Bujumbura, Burundi. The event was hosted and organized by the Burundi Health Informatics Association (BHIA) which is an independent organisation created to promote the application of Health Informatics in Burundi. BHIA and is a registered member of the International Medical Informatics Association (IMIA) and HELINA.

HELINA is the pan-African health informatics organization which has a tradition of organizing this event that goes back to 1993. Previous HELINA conferences were hosted in Ghana (2015), Nigeria (1993), South Africa (1996 & 2003), Zimbabwe (1999), Mali (2007), Ivory Coast (2009), Cameroon (2011) and Kenya (2013).

HELINA 2017 aimed to focus on the development and implementation of integrated e-Health plans and policies that builds bridges between existing information management silos and propose pathways to close the gaps in African e-Health developments related to infrastructure, e-health enabled human resources, international standards application, legal and ethical frameworks, sustainable funding mechanisms and the use of robust and down-to-earth ICT solutions. Special attention was paid to the role of e-Health in achieving the Sustainable Development Goals (SDG) voted by the UN in September 2015 and more specifically to goal 9, target 9c which aims to "*Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in the least developed countries by 2020"*.

Conference Themes
The call for submissions for HELINA 2017 covered a broad range of health informatics topics with relevance for Africa under the title "Integrated Health Information Management Resources for Global HealthCare Strategies". Academic research papers and case study/experience papers where solicited within the following themes:

- National and Regional e-Health Strategies and Policies
- Health Information Systems Interoperability
- Human capacity building for e-Health
- Sustainable systems implementations
- ICT-solutions for Universal Health Coverage

Submissions of papers that fell outside any of these themes were also acceptable as long as they demonstrated any relevance for the health informatics domain in Africa.

Review process
A first call for papers was published in English and in French and sent out in October 2016 with a deadline for submissions on 15 January 2017. A total of 37 submissions were received in due time for the HELINA 2017 conference. A double blind peer review process was used for evaluating each paper in a first round. All received submissions were anonymized before being submitted to at least 2 reviewers according to their expertise. The reviewers had the option to accept submissions either as full research papers or case study/experience papers. The SPC chairs based their final decision on the acceptance of each submission on the recommendations and comments from reviewers. Accepted submissions were then sent back to the authors for revision according to the reviewers' comments. The final reviewed paper

then sent back to the authors for revision according to the reviewers' comments. The final reviewed paper versions submitted by the authors were checked by the SPC chairs on technical criteria. This review process resulted in the following acceptance rates:
- Full research papers: 38% (n=14)
- Case studies and experience papers: 49% (n=18)
- Rejected or retracted papers: 13% (n=5)

In order to be included in the conference proceedings, an accepted paper had to be presented at the conference.

HELINA 2017 conference content
Conference papers were organized in a number of thematic tracks:

- National and regional e-health strategies and policies (5 papers)
- Data mining and big data analytics (8 papers)
- Capacity building and health informatics education (3 papers)
- Systems interoperability (4 papers)
- Medical devices and telemedicine (3 papers)
- Sustainable health information systems for Africa (6 papers)
- Universal health coverage (3 papers)

The most popular topics were *Data mining and big data analytics*, as well as *Sustainable health information systems for Africa*. Various workshops and panel discussions were also included in the programme. The papers presented at the conference indicated that a lot of good work is being done across Africa in terms of working towards universal health coverage supported by e-health interventions.

Frank Verbeke HELINA 2017 SPC Chair
Nicky Mostert-Phipps HELINA 2017 SPC Co-Chair

Journal of Health Informatics in Africa

10th Health Informatics in Africa Conference (HELINA 2017)
Peer-reviewed and selected under the responsibility of the Scientific Programme Committee

Facteurs associés à l'utilisation du traitement préventif intermittent par la femme enceinte en Guinée : Une analyse des données de l'enquête EDS 2012

Alioune CAMARA[a,b]*, Mamadou Dian Dilé DIALLO[c], Timothee GUILAVOGUI[a,b], Alexandre DELAMOU[b], Sidikiba SIDIBE[b], Elhadj Mamoudou BAH[d], Souleymane DIAKITE[a,], Mamadou Badian DIALLO[c]

[a] Programme National de Lutte contre le Paludisme, Guinée
[b] Chaire de santé publique, Université Gamal Abdel Nasser, Guinée
[c] Institut National de la Statistique, Guinée.
[d] Chaire de Gyneco-obstétrique, Université Gamal Abdel Nasser, Guinée

Context. Intermittent preventive treatment in pregnancy (IPTp) with sulphadoxine-pyrimethamine (SP) in Guinea is low, threatening to reduce the incidence of malaria during pregnancy. The objective of this study was to identify factors associated with under-use (≥2 doses) of IPTp-SP in women in Guinea.
Methods. Data from the 2012 Demographic Health Survey were used for the analysis. A national sample of 7,200 households was selected. This sample was stratified to provide adequate representation of urban and rural areas and the eight administrative regions of the country. The individual female survey covered 9,142 women aged 15-49 who gave birth in the last five years. Approximately 2,810 women (15-49 years) who gave birth in the last two years were selected for this study. To identify factors associated with inadequate use of IPTp-SP (<2 doses), a logistic regression was used.
Results. In this study, 2,810 women aged on average of ... mostly married (90.90%) and living in rural areas (73.50%) were included. Only 13.32% of women had no ANCs and 22.54% had received two or more doses of IPTp-SP during their last pregnancy. More than one in two women (68.30%) had not received the IPTp-SP. In multivariate logistic regression, the factors associated with the inappropriate use of IPTp-SP depended on the area of residence. In urban areas only be single [OR = 1.70; 95% CI (1.06 -2.72)] and in rural areas being single (OR = 1.83; 95% CI (1.17 -2.85)], declared Muslim [OR = 2.54; 95% CI (1.68-3.85)], very poor [OR = 2.11; 95% CI (1.28-3.47)] or poor [OR = 1.90; 95% CI (1.23-2.94)] were independently associated with inadequate use of IPTp-SP.
Conclusions. The use of IPTp-SP was low in Guinea and was associated with being single, being poor and Muslim in rural areas. There is a need to strengthen the ANC to optimize all opportunities to provide IPTp-SP and sensitize the population especially in rural areas in order to reduce the burden of malaria.

Keywords: Associated Factors, Intermittent Preventive Therapy, Sulfadoxine-pyrimethamine, Pregnancy, Guinea.

*Corresponding author address: Programme National de Lutte contre le Paludisme, B.P : 6339 Conakry. Email: aliounec@gmail.con Tel: +(224)- (628 979729)
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Contexte. Le traitement préventif intermittent à la sulfadoxine-pyriméthamine (TPIg-SP) adéquat (≥2 doses) en Guinée est faible, menaçant la réduction de l'incidence du paludisme pendant la grossesse. L'objectif de cette étude était d'identifier les facteurs associés à une utilisation inadéquate du TPIg-SP chez les femmes enceintes en Guinée.
Méthodes. Les données de l'enquête démographique de santé de 2012 ont servi pour l'analyse. Un échantillon national de 7200 ménages a été sélectionné. Cet échantillon était stratifié de façon à fournir une représentation adéquate des milieux urbains et ruraux ainsi que des huit régions administratives du pays. L'enquête individuelle femme a concernée 9 142 femmes âgées de 15-49 ans ayant accouché au cours des cinq dernières années. Environ, 2 810 femmes (15 à 49 ans) ayant accouché au cours des deux dernières années ont été retenues pour la présente étude. Pour identifier les facteurs associés à une utilisation inadéquate de la TPIg-SP (<2 doses), une régression logistique a été utilisée.
Résultats. Dans cette étude, 2 810 femmes âgées en moyenne de 27 ± 0,1 ans majoritairement mariées (90,90%) et résidant en zone rurale (73,50%) ont été inclues. Seulement 13,32% des femmes n'avaient pas réalisé de CPN et 22,54% avaient reçu deux doses ou plus de TPI-SP durant leur dernière grossesse. Plus d'une femme sur deux (68,30%) n'avaient pas reçu le TPI-SP. Dans la régression logistique multivariée, les facteurs associés à l'utilisation inadéquate de TPI-SP étaient fonction de la zone de résidence. En zone urbaine seul être célibataire [OR=1,70 ; IC95% (1,06 -2,72)] et en zone rurale être célibataire [OR=1,83 ; IC95% (1,17 -2,85)], se déclaré musulman [OR=2,54 ; IC95% (1,68- 3,85)], être très pauvre [OR=2,1; IC95% (1,28- 3,47)] ou pauvre [OR=1,90 ; IC95% (1,23- 2,94)] étaient indépendamment associés à l'utilisation inadéquate du TPIg-SP.
Conclusions. L'utilisation du TPIg-SP était faible en Guinée et était associée au fait d'être célibataire, être pauvre et musulman en zone rurale. Il est nécessaire de renforcer la CPN pour optimiser toutes les opportunités de donner le TPIg-SP et la sensibilisation la population surtout en zone rurale afin de réduire la charge du paludisme.

Keywords: Mots-clés. Facteurs associés, Traitement préventif intermittent, Sulfadoxine-pyriméthamine, Grossesse, Guinée.

1 Introduction

Chaque année en Afrique, entre 23 et 30 millions de femmes conçoivent dans les zones d'endémie palustre [1,2]. Le paludisme pendant la grossesse augmente le risque d'anémie pour la mère, le paludisme congénital pour le fœtus et de faible poids de naissance pour le nouveau-né [3,4]. Des travaux suggèrent que 75.000 à 200.000 décès de nourrissons par an et 20% des décès maternels sont dus au paludisme pendant la grossesse [1,5].

L'Organisation mondiale de la santé (OMS) recommande de donner la première dose de traitement préventif intermittent du paludisme pendant la grossesse (TPIg) à la sulfadoxine pirymétamine (SP) dès le deuxième trimestre, puis les doses ultérieures jusqu'à l'accouchement avec au moins un mois d'intervalle entre deux doses [6]. Jusqu'en 2012, deux doses de SP et trois s'il s'agit d'une femme vivant avec le VIH étaient recommandées [7,8]. Selon l'OMS, l'application optimale de cette stratégie pourrait réduire le taux d'échec de cette prévention [6] et ainsi contribué à réduire la morbidité et la mortalité des mères et leurs nouveau-nés [(9)]. La réalisation d'une couverture élevée de cette intervention préventive chez les femmes enceintes reste inaccessible pour de nombreux pays d'Afrique sub-saharien [9,10]. Dans plusieurs publications [11,12], l'âge maternel, le niveau d'instruction, la parité, le nombre et le moment des visites de la consultation prénatale (CPN), la connaissance du paludisme/TPIg, le statut socio-économique et l'utilisation des moustiquaires imprégnées d'insecticides à longue durée d'action sont des facteurs associés à l'utilisation de la TPIg-SP.

Le paludisme au cours de la grossesse continue d'être un problème de santé publique en Guinée. En effet, l'Enquête Démographique de Santé (EDS) de 2012 de la Guinée estime que seulement 24% des femmes enceintes font la consultation prénatale et ont reçu un TPIg-SP complet [13]. Cependant, on connaît peu sur les facteurs associés à la faible utilisation de la TPIg-SP.

Une meilleure connaissance de ces facteurs permettrait de guider et renforcer les interventions en cours et orienter les directives du Programme National de Lutte contre le Paludisme en Guinée.

L'objectif de cette étude était de déterminer les facteurs sociodémographiques, obstétricaux et les pratiques de prévention du paludisme des femmes ayant accouché au cours des deux années précédentes associés à la faible utilisation de la TPIg-SP en Guinée.

2 Matériel et méthodes

2.1 Cadre, type et période d'étude

La présente étude transversale de type analytique est une analyse secondaire des données de la quatrième Enquête Démographique de Santé en Guinée combinée à l'Enquête par Grappe à Indicateurs Multiples (EDS-MICS 2012). EDS-MICS 2012 a couvert l'ensemble du territoire national de la Guinée. La collecte des données s'est déroulée entre juin et octobre 2012.

2.2 Population d'étude et échantillonnage

L'EDS-MICS 2012 vise les individus qui résident dans les ménages ordinaires de l'ensemble du pays. L'échantillon de l'EDS-MICS 2012 est un échantillon aléatoire stratifié et tiré à deux degrés. Au premier degré, des grappes ou zones de dénombrement (ZD) ont été tirées sur l'ensemble du territoire national à partir de la liste des ZD établie lors des travaux cartographiques pour le troisième Recensement Général de la Population et de l'Habitation. Un échantillon national d'environ 7 200 ménages a été sélectionné. Globalement, 300 grappes, dont 107 en milieu urbain et 193 en milieu rural, ont été sélectionnées en procédant à un tirage systématique avec probabilité proportionnelle à la taille (la taille de la ZD étant le nombre de ménages). Un dénombrement des ménages dans chacune de ces grappes a fourni une liste des ménages à partir de laquelle a été tiré au second degré un échantillon de ménages avec un tirage systématique à probabilité égale. Au total, dans les 7 109 ménages enquêtés (taux de réponse de 99,5 %), 9 331 femmes de 15-49 ans ont été identifiées comme étant éligibles (vivant habituellement dans les ménages sélectionnés ou présentes la nuit précédant l'enquête) pour l'enquête individuelle.

2.3 Collecte de données et questionnaire

Toutes les procédures de collecte de l'EDS-MICS 2012 ont été prétestées. Le questionnaire a été traduit pour effectuer les entretiens en langues nationales au besoin. Les agents ont été recrutés et formés pour remplir les questionnaires et les procédures. En raison des objectifs de cette étude, les parties du questionnaire individuel femme qui comprenaient les sections des informations sur les caractéristiques sociodémographiques, la grossesse et les soins prénatals ont été considérées.

2.4 Définition des termes et des variables

Les caractéristiques sociodémographiques étudiées comprenaient l'âge, la région administrative, le statut matrimoniale (célibataire, marié), le niveau d'instruction (non scolarisé, primaire et plus) et l'appartenance religieuse (musulman et autre).

Le niveau de vie est construit en utilisant les données sur les caractéristiques des logements et les possessions des ménages, grâce à une analyse en composantes principales. Dans EDS-MICS 2012, le niveau de vie est en cinq catégories : très pauvre, pauvre, moyen, riche et très riche. Pour gagner en clarté et adapté notre échantillon, nous avons recodé cette variable en trois catégories : très pauvre, pauvre (pauvre et moyen) et riche (riche et très riche). Les caractéristiques obstétricales retenues étaient le nombre d'enfants (un contre deux et plus), âge gestationnel en trimestre au moment de la 1ère consultation prénatale (CPN) et le nombre de CPN réalisées pendant la grossesse. Les informations portant sur la prévention du paludisme étaient le fait de dormir sous moustiquaire la nuit précédente l'enquête (oui ou non) et le nombre de doses de TPIg-SP utilisées.

2.5 Plan d'analyse et saisie des données

Les données de l'enquête ont été saisies au fur et à mesure de la collecte au moyen du logiciel CSPro. Un programme de contrôle de qualité a permis d'améliorer la qualité des données.

Au moment de cette étude, le protocole de prise en charge des femmes enceintes recommandait la prise au moins deux doses de SP pendant la grossesse. Le traitement préventif du paludisme chez la femme enceinte se fait par l'administration de deux doses curatives de SP à partir du 2ème trimestre de grossesse avec un intervalle d'un mois minimum entre les deux doses. L'utilisation du TPIg-SP parmi les répondantes a été classée en deux groupes : Adéquate (≥2 doses de SP) et inadéquate (< 2 doses de SP). La catégorie adéquate a été utilisée comme référence dans les modèles de régression logistique. Une analyse de régression logistique bivariée et multivariée a été réalisée pour déterminer les facteurs associés à une utilisation inadéquate du TPIg-SP.

Les variables associées à une utilisation inadéquate du TPIg-SP (p<0,20) dans l'analyse univariée ont été introduites dans un modèle multivarié de régression logistique ascendant pas à pas pour obtenir une estimation ajustée de l'association. La colinéarité entre les variables significatives a été testée. Dans le modèle final, les termes d'interaction ont été testés et ceux significatifs à p <0,05 ont été maintenues pour le model final. Les variables ont été considérées significatives dans le modèle final au seuil de 5%.

Toutes les analyses ont été ajustées selon le plan de conception de l'enquête en utilisant le logiciel statistique Stata 14.0. Afin de minimiser les sous-estimations des effectifs qui découlent de la nature en grappe des données, nous avons utilisé la commande "svyset" dans l'analyse de régression. Les résultats ont été rapportés en utilisant les moyennes, les écart-types, les fréquences (% avec les intervalles de confiance à 95%), les odds ratio avec les intervalles de confiance à 95%.

2.6 Considération éthique

Le comité national d'éthique pour la recherche en santé du ministère de la santé a délivré l'autorisation de réalisation de cette enquête.

Tableau 1. Caractéristiques sociodémographiques des répondantes, données de l'enquête EDS 2012

Variables		N=2810	(%)	IC à 95%
Tranche d'âge en année				
	15-34	2240	(79,9)	78,0-81,6
	35-49	570	(20,1)	18,4-21,9
Milieu de résidence				
	Urbain	819	(26,5)	22,1 – 31,5
	Rural	1991	(73,5)	68,5 – 77,9
Région				
	Conakry	305	(14,2)	11,6 – 17,4
	Basse Guinée	517	(20,8)	17,9 – 24,0
	Moyenne Guinée	702	(18,6)	16,1 – 21,5
	Haute Guinée	791	(25,4)	21,9 – 29,2
	Guinée Forestière	495	(21,0)	16,9 – 25,8
Statut matrimoniale				
	Célibataire	225	(9,1)	7,2 – 11,4
	Marié	2585	(90,9)	88,6 – 92,8
Niveau d'instruction				
	Non scolarisé	2133	(75,5)	73,0 – 77,9
	Primaire et plus	677	(24,5)	22,1 – 27,0
Niveau de vie du ménage				
	Très pauvre	658	(22,4)	19,3 – 25,9
	Pauvre	1154	(42,5)	39,2 – 45,9
	Riche	998	(35,1)	31,5 – 38,7
Religion				
	Musulman	24542	(87,2)	82,1 – 91,0
	Autres	268	(12,8)	9,0 – 17,9

IC : Intervalle de confiance ;

3 Résultats

3.1 Description sociodémographique

Au total, 2810 femmes résidant majoritairement en zone rurale (73,5%) ont été interviewées. L'âge moyen des femmes était de 27 ± 0,1 ans, avec 79,9% des répondantes dans la catégorie d'âge de 15 à 34 ans. Les trois quarts (75,5%) des répondantes étaient non scolarisés et la majorité était mariée (90,9%). Le Tableau 1 présente la description socio démographique des répondantes.

3.2 Description des informations obstétricales, de l'utilisation des moustiquaires et de la TPI

La majorité des répondantes étaient multipares (78,9%) et avaient réalisé au moins une CPN (86,7%) lors de leur dernière grossesse. Le tableau 2 indique que plus d'une femme sur deux (56,4%) a fait quatre CPN ou plus durant la dernière grossesse. Environ la moitié (47,5%) de toutes les femmes ont fait leur première CPN après le premier trimestre de la grossesse.

Le tableau 2 indique que plus d'un tiers des participantes (35,3 %) ont dormi sous une moustiquaire la nuit ayant précédée l'enquête, principalement sous une MILDA (31,2% ; IC à 95% : 28,6 – 33,9%). Près d'un tiers des participantes (31,7%; IC à 95% : 65,2 – 71,3%) a reçu une dose ou plus du TPIg-SP au cours d'une visite prénatale majoritairement (96,8% ; IC à 95% : 94,4 – 98,2%). Plus d'une femme sur cinq (22,5%; IC à 95% : 20,1 – 25,1%) a reçu deux doses ou plus du TPIg-SP.

Tableeau 2. Caractéristiques obstétriques et de prévention du paludisme des répondantes, données de l'enquête EDS 2012

Variables		N=2810	(%)	IC à 95%
Nombre d'enfants				
	Un enfant	583	(21,1)	19,2 – 23,1
	Deux enfants et plus	2227	(78,9)	76,9 – 80,8
Age gestationnel à la 1ère CPN				
	1er trimestre	1138	(39,4)	36,5 – 42,4
	2e trimestre	1128	(41,5)	38,8 – 44,3
	3e trimestre	170	(6,0)	5,1 – 7,0
	Pas de CPN	374	(13,1)	10,8 – 15,7
Nombre de CPN				
	Aucune	374	(13,2)	10,9 – 15,9
	Une CPN	135	(4,4)	3,7 – 5,4
	Deux CPN	293	(11,0)	9,0 – 12,3
	Trois CPN	442	(16,0)	14,0 – 17,2
	Quatre CPN	1566	(56,0)	53,0 – 59,8
Dormir sous moustiquaire la nuit précédente				
	Oui	1035	(35,3)	32,7 – 38,1
	Non	1775	(64,7)	61,9 – 67,4
Nombre de doses de SP				
	Aucune dose	1885	(68,3)	65,2 – 71,3
	Une dose	276	(9,2)	7,8 – 10,8
	Deux doses	330	(11,3)	9,7 – 13,1
	Trois doses et plus	319	(11,2)	9,7 – 13,0

CPN : Consultation prénatale ; IC : Intervalle de confiance ; SP : Ssulfadoxine Pirymétamine

Tableau 3. Facteurs associés à l'utilisation de la TPI pendant la grossesse en analyse bivariée, données de l'enquête EDS 2012

Variables	% TPI inadéquat (<2doses)	OR	IC à 95%	p-value
Tranche d'âge en année				
15-34	77,4	1,00	référence	
35-49	77,7	1,01	0,80 – 1,28	0,91
Milieu de résidence				
Urbain	69,7	1,00	référence	
Rural	80,3	1,77	1,33 – 2,37	<0,0001
Région naturelle				
Conakry	71,8	1,00	référence	
Basse Guinée	77,9	1,39	0,88 – 2,20	0,16
Moyenne Guinée	86,2	2,44	1,64 – 3,63	<0,0001
Haute Guinée	82,1	1,80	1,14 – 2,83	0,01
Guinée Forestière	67,6	0,82	0,57 – 1,17	0,28
Statut marital				
Marié	77,1	1,00	référence	
Célibataire	81,5	1,31	0,94 – 1,82	0,11
Niveau d'instruction				
Sans niveau	78,9	1,39	1,11–1,74	0,005
Primaire	72,9	1,00	référence	
Niveau de vie du ménage				
Très pauvre	83,6	2,12	1,48 – 3,05	<0,0001
Pauvre	80,0	1,67	1,29 – 2,16	<0,0001
Riche	70,6	1,00	référence	
Religion				
Musulman	78,8	1,74	1,59 – 2,44	0,001
Autres	68,1	1,00	référence	
Nombre d'enfants				
Un enfant	78,5	1,00	référence	
Deux enfants et plus	77,2	0,93	0,73 – 1,18	0,53
Nombre de CPN				
Aucune CPN	99,7	121,17	27,54 – 533,09	<0,0001
Une CPN	91,4	4,17	1,78 – 9,77	0,001
Deux CPN	81,7	1,74	1,25 –2,45	0,001
Trois CPN et plus	71,9	1,00	référence	
Age gestationnel à la 1ère CPN				
1er trimestre	71,4	1,00	référence	
2^{e} trimestre	75,5	1,24	0,98-1,56	0,07
3^{e} trimestre	82,1	1,83	1,14-2,92	0,01
Pas de CPN	99,6	113,64	28,60-451,55	<0,0001
Dormir sous moustiquaire la nuit précédente				
Non	78,0	1,00	référence	
Oui	76,4	0,91	0,74 – 1,13	0,41

TPI : traitement préventif intermittent du paludisme ; OR : Odds Ratio ; CPN : Consultation prénatale ; IC : Intervalle de confiance

Tableau 4. Facteurs associés à l'utilisation de la TPI pendant la grossesse en analyse multivariée, données de l'enquête EDS 2012

Variables	Guinée			Strate Urbaine			Strate Rurale		
Milieu de résidence	ORA	IC à 95%	p-value	ORA	IC à 95%	p-value	ORA	IC à 95%	p-value
Urbain	1,00	référence							
Rural	1,36	0,86 – 2,16	0,18						
Niveau de vie du ménage									
Très pauvre	1,80	1,10 – 2,93	0,02	0,44	0,16 – 1,15	0,09	2,11	1,28 – 3,47	0,003
Pauvre	1,54	1,03 – 2,33	0,04	0,68	0,38 – 1,22	0,20	1,90	1,23 – 2,94	0,004
Riche	1,00	référence		1,00	référence		1,00	référence	
Religion									
Autres	1,00	référence		1,00	référence		1,00	référence	
Musulman	2,09	1,45 – 3,01	<0,0001	0,98	0,47 – 2,02	0,95	2,54	1,68 – 3,85	<0,0001
Situation matrimoniale									
Marié	1,00	référence		1,00	référence		1,00	référence	
Célibataire	1,75	1,26 – 2,42	0,001	1,70	1,06 – 2,72	0,03	1,83	1,17 – 2,85	0,008

TPI : traitement préventif intermittent du paludisme ; IC : Intervalle de confiance ; ORA : Odds-ratio ajusté

3.3 Facteurs associés à l'utilisation du TPIg-SP parmi les répondants

Dans le tableau 3 qui présente l'analyse bivariée, les facteurs associés statistiquement significative à l'utilisation inadéquate du TPIg-SP étaient: résider en zone rurale, avoir été interviewé en moyenne ou haute Guinée, avoir aucun niveau d'instruction, être pauvre ou très pauvre, être musulman, avoir réalisé moins de 3 CPN et avoir fait la première CPN au dernier trimestre de la grossesse.

En analyse multivariée, les facteurs qui sont restés indépendamment associés à l'utilisation inadéquate du TPIg-SP dans le modèle final étaient : résider en zone rurale, être musulman, être célibataire et être pauvre ou très pauvre (Tableau 4). Les interactions d'une part entre la zone de résidence et le niveau de vie et de l'autre entre la zone de résidence et être musulman a conduit à la stratification en fonction de cette variable. Ainsi, on note que seul être célibataire était indépendamment associé à l'utilisation inadéquate du TPIg-SP en zone urbaine. En zone rurale, être musulman, être pauvre ou très pauvre et être célibataire étaient indépendamment associés à l'utilisation inadéquate du TPIg-SP.

4 Discussion

La présente étude réalisée à partir des données de l'Enquête Démographique de Santé combinée à l'Enquête par Grappe à Indicateurs Multiples (EDS-MICS 2012), a permis de déterminer les facteurs associés à une utilisation inadéquate du traitement préventif intermittent du paludisme à la sulfadoxine pirymétamine (TPIg-SP) en Guinée. Dans la présente étude, seulement 22,5% des femmes ont reçu au moins deux doses du TPIg-SP pendant leur dernière grossesse. En 2013, la couverture moyenne d'au moins deux doses TPIg-SP dans les pays d'Afrique subsaharien était de 24%, bien en deçà des objectifs nationaux et internationaux [14]. De récentes études africaines ont indiqué que la couverture de la TPIg-SP variait de 12,5% à 86% [15–17]. Il est admis que les femmes ayant pris seulement une dose du TPIg-SP ont un risque plus important d'échec à la prévention du paludisme [18,19]. En effet, le temps de protection optimal ne se produit que si une femme enceinte reçoit au moins deux doses du TPIg-SP [17].Selon Hill et al. [12], les raisons invoquées par les femmes pour ne pas recevoir une deuxième dose du TPIg-SP sont : ne pas revenir pour une deuxième visite de CNP, être malade, timide ou d'une faible position sociale conduisant à un retard à la CPN. Sur la base d'une méta-analyse récente montrant que trois doses ou plus de TPIg-SP sont plus efficaces que deux doses [20], l'Organisation Mondiale de la Santé (OMS) a récemment mis à jour ses directives pour recommander l'administration de TPI-SP aux femmes enceintes à chaque visite prénatale programmée à partir du deuxième trimestre [6]. Les défis du système sanitaire liés à la prestation de ≥ 2 doses du TPIg-SP comprennent les pénuries de personnel, le retard de l'approvisionnement en médicaments, les pratiques inadéquates des agents de santé et l'accès insuffisant à la consultation prénatale [12,21–24].

Dans cette étude, une faible couverture en CPN était associée à une utilisation inadéquate du TPIg-SP (<2 doses). Ce constat a été fait dans d'autres publications [8,21] dont la méta-analyse réalisée par Hill et al.[12]. Un début tardif de la CPN pour la femme enceinte pourrait être incriminé puisque le TPIg-SP est administré au décours de celle-ci. Dans cette étude, 72,0% des femmes ont assisté à des CPN au moins trois fois. Cette observation est supérieure à celle observée dans d'autres études africaines dans lesquelles cette proportion variait de 45,8% à 58,7% [22–24]. Ce taux pourrait traduire un manque d'opportunités des agents de santé à donner le TPI-SP lors des CPN, d'autant plus que sa mise à disposition est gratuite en Guinée. Par conséquent, des stratégies telles que le renforcement de la formation et le recyclage des agents de santé doivent être mise en œuvre ou être encouragées pour accroître l'accès aux soins prénatals et ainsi à la TPIg-SP. Des études qualitatives supplémentaires consistant en des entrevues approfondies auprès des femmes et des agents de santé devraient être menées pour déterminer les obstacles existants à la couverture adéquate du TPIg-SP en Guinée.

En zone rurale, les femmes qui étaient célibataires ou de religion musulmane étaient plus susceptibles d'avoir un TPIg-SP inadéquat. Un constat similaire a été fait au Kenya où l'appartenance religieuse a joué un rôle important dans l'application des mesures de prévention du paludisme [25]. Une étude réalisée en Tanzanie [26] n'a montré aucune association entre les facteurs individuels et la couverture de la deuxième dose du TPIg-SP. Aussi, une meta-analyse [12] a montré qu'il n'y avait pas d'association entre la couverture du TPIg-SP et la zone de résidence. Cependant, les auteurs de cette étude [12] ont souligné qu'il y avait une grande hétérogénéité entre les études et une variation importante selon les pays pour ce qui concerne la résidence. D'autres études sont nécessaires pour quantifier l'impact de la religion sur l'utilisation des mesures de prévention du paludisme en Guinée. La stigmatisation de la société en générale et plus particulièrement les musulmans envers les femmes célibataires qui sont enceintes peut expliquer un faible recours à la CPN/TPIg-SP. Aussi, Acquah et al. [27] a montré qu'il existe une association entre la couverture de la TPIg-SP et l'état matrimonial, l'emploi et le niveau d'instruction. En effet, au Nigeria, des auteurs [11,28] ont signalé que certaines femmes enceintes de confession musulmane ont refusé d'utiliser le TPIg-SP sans le consentement préalable de leurs maris.

La présente étude a quelques limites, bien que celles-ci ne soient pas assez importantes pour invalider les résultats. En effet, les différentes périodes de rappel de deux années considérées dans la mesure de l'utilisation de la TPIg-SP dans l'enquête EDS pourrait limiter la validité. Nous utilisons des réponses individuelles des femmes pour interpréter les pratiques des prestataires de soins qui ne reflètent peut-être pas des événements réels.

5 Conclusion

Cette étude identifie quatre principaux facteurs associés à la couverture du TPIg-SP en 2012 en Guinée: être célibataire, résider en zone rurale et être musulman, être moyennement ou très pauvre. Elle renforce la nécessité d'avoir une approche de lutte intégrée permettant une couverture adéquate du TPIg-SP en Guinée. Pour se faire, les programmes nationaux de santé devraient continuer d'éduquer les femmes sur les avantages de recevoir des soins prénatals dès le début et pendant toute leur grossesse et de prendre la dose complète du TPIg-SP. Toutefois, afin d'accroître l'utilisation du TPIg-SP, les agents de santé devraient être encouragés à rassurer les femmes admissibles que le TPIg-SP est sûr et efficace.

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Tous les auteurs déclarent n'avoir aucun conflit d'intérêt.

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Faisabilité et perspectives d'introduction d'une GMAO au Ministère de la Santé du Bénin

Myszkowski Marc [a*], Verbeke Frank [b]

[a] Coopération Technique Belge, Bénin
[b] Département de Bio-statistique et d'Informatique Médicale, Vrije Universiteit Brussel, Bruxelles, Belgique

Contexte : le MS du Bénin est aujourd'hui confronté à un nombre de défis majeurs pour la mise en place d'une gestion efficiente et effective de ses ressources matérielles : (i) il n'existe pas d'inventaire global fiable du patrimoine, (ii) les données fragmentaires existantes sont peu exploitables par manque de standardisation, (iii) le rapportage sur l'état fonctionnel des infrastructures et équipements est extrêmement difficile et (iv) l'absence de plans solides de maintenance préventive est à l'origine de nombreuses pannes évitables des équipements biomédicaux
Objectif: l'introduction d'une solution logicielle de gestion de la maintenance assistée par ordinateur (GMAO) à un niveau national contribuera de façon significative à (i) garder les équipements biomédicaux en état fonctionnel, (ii) à mieux cibler les investissements matériels futurs et à (iii) organiser un accès plus équitable aux technologies diagnostiques pour les patients
Méthodologie : une étude documentaire de guides de bonne pratique GMAO (OMS), des normes des infrastructures et équipements pour les structures de soins au Bénin, du PNDS 2009-2018 et une analyse de la littérature sur l'utilisation des nomenclatures des équipements biomédicaux ont été réalisées, suivies par une identification des besoins et des défis à travers d'interviews semi-structurés avec les nombreuses parties prenantes dans la maintenance biomédicale au Bénin et à l'occasion d'une série de visites de terrain dans les zones d'intervention du PASS-Sourou
Résultats : l'étude a permis de faire une analyse approfondie des besoins en termes de gestion des inventaires, des procédures de maintenance, du renforcement des capacités humaines et des préalables à la mise en place d'une GMAO. La gestion de la maintenance biomédicale au Bénin est aujourd'hui organisée de façon archaïque et peu efficiente. L'adoption de nomenclatures nationales et/ou internationales pour l'identification des infrastructures, des équipements biomédicaux et des structures de soins est un préalable important pour la mise en place d'une gestion harmonisée du patrimoine sanitaire à travers le pays. La mise en place d'une GMAO permettrait (i) l'application de normes quantitatives existantes pour les équipements dans les structures de soins aux différents niveaux de la pyramide sanitaire, (ii) l'utilisation de procédures standardisées au niveau national pour la maintenance préventive, (iii) l'organisation d'un suivi plus effectif des pannes en fonction de la criticité des équipements affectés et (iv) une planification des investissements futurs basée sur des besoins réels.
Conclusion: une gestion plus efficace de la maintenance biomédicale permettra de mieux rentabiliser les investissements du pays dans les équipements diagnostiques et thérapeutiques coûteux et ainsi d'améliorer l'offre de soins dans différentes parties du pays sur base de normes équitables.

Keywords: Mots clés : GMAO, maintenance biomédicale, GMDN

1 Introduction

Le Ministère de la Santé du Bénin est actuellement confronté à plusieurs défis dans la matière de gestion de ses ressources matérielles.

*Corresponding author address:
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Il s'agit d'abord d'un manque de vue globale et fiable sur le patrimoine du ministère, y compris les (i) infrastructures, (ii) les équipements biomédicaux et le mobilier médical, (iii) le matériel roulant, (iv) les équipements informatiques et (v) d'autres immobilisations comme le mobilier banalisé ou les outillages.

En plus, les données des inventaires existants sont peu exploitables. Ces inventaires sont tenus sur papier et manquent de l'harmonisation entre les différentes structures du MS.

Un autre problème constituent les plans annuels d'investissement développés par la Direction des Infrastructures, de l'Equipement et de la Maintenance (DIEM), qui ne sont actuellement pas basés sur des normes pour les structures de soins aux différents niveaux de la pyramide sanitaire, mais qui sont souvent directement dérivés des besoins (justifiés ou pas) exprimés par les utilisateurs dans ces formations sanitaires.

A l'heure actuelle, des plans de maintenance ne sont pas formellement élaborés pour le patrimoine du ministère. Ceci est à l'origine de nombreuses pannes évitables et contribue à une sous-exploitation de certains équipements.

Finalement, il existe différents besoins de rapportage sur l'état des immobilisations de la santé chez différentes parties prenantes. Un rapportage flexible et multi-acteur qui, à partir d'un même inventaire, pourra satisfaire les attentes des (i) structures de soins, (ii) des directions du ministère de la santé, (iii) des partenaires techniques et financiers et (iv) des programmes de santé, est absent mais fortement souhaité.

Les outils de gestion de la maintenance assistée par ordinateur (GMAO) sont souvent avancés comme des solutions essentielles pour pouvoir arriver à une gestion efficace et efficiente des infrastructures et équipements. Malgré les défis importants liés à cette gestion dans le secteur de la santé (publique) en Afrique, peu d'expériences convaincantes avec l'implémentation d'une GMAO à l'échelle nationale ont vu le jour aujourd'hui. Le Ministère de la Santé du Rwanda a introduit la solution MEMS depuis quelques années, mais l'implémentation du logiciel reste encore très fragmentaire. Le MSPLS du Burundi vient d'introduire une GMAO nationale, sous forme d'un module d'un système d'information hospitalier (SIH), mais ceci se trouve encore dans un stade de déploiement précoce et des données sur l'impact ne sont pas encore disponibles. La majorité des implémentations Africaines réussites se situent principalement dans les formations sanitaires privées et donc à une échelle plus petite qu'une solution nationale. Pourtant, l'OMS continue à insister sur les avantages importants de l'utilisation d'une GMAO dans toutes les structures de soins à partir d'une certaine taille. Il est à noter que dans les structures sanitaires des pays développés, la GMAO est effectivement devenu un outil de routine indispensable.

2 Objectifs

Dans cette étude, l'objectif principal est d'évaluer le rôle que pourrait jouer une GMAO dans l'amélioration de la gestion du patrimoine du ministère de la santé du Bénin.

3 Méthode

Au début de l'étude, un nombre de documents réglementaires et normatifs ont été étudiés :

- Le *Guide de bonne pratique GMAO* de l'OMS
- Les *normes des infrastructures et équipements* pour les structures de soins au Bénin
- Les *inventaires* faits dans les zones sanitaires de Mono, Coufo, Donga et Atacora
- Les *nomenclatures* internationales par rapport aux équipements biomédicaux comme la GMDN, la nomenclature CNEH, l'UMDNS et la ClaDiMed
- L'*organigramme du Ministère de la Santé* du Bénin
- Le *PNDS* 2009-2018 du Bénin
- Le *shéma directeur informatique* de la Direction de l'Informatique et du pre-Archivage du Ministère de la Santé

Cette étude documentaire a été suivie par un nombre d'interviews semi-structurées avec les principales parties prenantes dans la matière comme le Programme d'Appui au Secteur de la Santé (PASS), les directions pertinentes du Ministère de la Santé (équipements et infrastructures, planification, gestion des hôpitaux, informatique), la représentation nationale de l'OMS et Unicef. Des visites de terrain ont été réalisées dans différents structures de soins dans les zones sanitaires Mono et Coufo et dans les centres

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hospitaliers universitaires HOMEL et de Porto Novo. Finalement des réunions techniques et des démonstrations ont été organisées avec/par différents développeurs et distributeurs de solutions GMAO.

4 Résultats

4.1 Inventaires

L'identification des besoins des différentes parties prenantes a mis en évidence que dans une GMAO, toutes sortes d'items doivent pouvoir être gérées. Un nombre d'éléments d'information seront communes à tous ces items (par exemple un numéro d'identification ou une dénomination), d'autres informations peuvent être très spécifiques et ne s'appliqueront qu'à une seule catégorie d'items (par exemple le numéro cadastral pour les infrastructures ou le type de carburant pour les véhicules).

Pour les infrastructures, il est de bon usage d'utiliser une nomenclature pour l'identification des différents composants des constructions, surtout utile pour la standardisation de l'évaluation de la qualité du patrimoine. Ces composants peuvent être regroupés dans des catégories comme (i) les infrastructures, (ii) les superstructures, (iii) les façades, (iv) les toitures, (v) les équipements techniques, (vi) les éléments de second œuvre et (vii) d'autres éléments comme l'évacuation des eaux.

Les équipements biomédicaux constituent un élément crucial dans l'inventaire des immobilisations des structures de soins. Ils existent plusieurs nomenclatures utilisables pour l'identification des équipements biomédicaux (GMDN, CNEH, UMDNS, CIH…). Il est proposé, pour des raisons de facilité d'utilisation, de se référer au Bénin à une nomenclature nationale constituée de dénominations et de libellés qui font partie du langage commun des techniciens de maintenance. Une table de correspondance entre cette nomenclature nationale et un standard international comme la GMDN pourra également être établi par après.

Mais aussi les équipements non-biomédicaux doivent être gérés. Il s'agit d'outils techniques, du mobilier et d'autres équipements utilisés en dehors du cadre des soins aux patients. Sur base des informations recueillies sur terrain, les besoins de documentation relatifs à cette catégorie d'items s'approchent fortement de ce qui a été inventorié pour les équipements biomédicaux, exception faite pour la nomenclature internationale GMDN qui ne pourra pas être appliquée à la nomenclature nationale dans le cas des équipements non-biomédicaux.

Pour le matériel informatique, il n'existe actuellement ni une nomenclature nationale officielle, ni de nomenclature internationale répandue. Dans ce cas, il est proposé de développer une nomenclature nationale basée sur la CPV, qui est le vocabulaire commun pour les marchés publics de l'Union Européenne. Cette approche permettrait d'introduire un vocabulaire simplifié, facile à comprendre et à maîtriser par les gestionnaires et techniciens de maintenance tout en gardant une référence à une codification internationale (bien que l'usage de ce dernier soit géographiquement limité à l'UE).

4.2 Procédures de maintenance

Globalement, les procédures de maintenance peuvent être groupées en activités de planification d'un côté et des activités d'intervention d'un autre côté. Dans ce rapport, les activités de planification sont appelées des plans de maintenance et les activités d'intervention les opérations de maintenance. Les plans de maintenance peuvent être sous-divisés en 3 catégories :

- Les plans d'inspection, qui sont censés d'organiser les évaluations périodiques des états fonctionnels des immobilisations du MS. Exemples : planification des inspections annuelles des bâtiments, de visites de contrôle des incinérateurs, du contrôle technique des véhicules, de la détection de fuites de rayons ionisantes dans les locaux de radiologie, inspection des matelas des lits d'hospitalisation. La périodicité des plans d'inspection est d'habitude basée sur le temps (inspection mensuelle, trimestrielle, annuelle…)
- Les plans de maintenance préventive, qui organisent les interventions de maintenance préventive (en absence d'un disfonctionnement spécifique) avec comme but de maintenir les immobilisations en bon état de fonctionnement. Exemples : planification du nettoyage périodique de caniveaux, prévoir de changer l'huile moteur d'un véhicule tous les x kilomètres, remplacement de joints, calibrage périodique d'appareils de laboratoire. La périodicité des plans de maintenance préventive peut être basée sur différents critères comme (i) le temps (hebdomadaire, mensuelle, annuelle…) ou (ii)

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l'utilisation (tous les x kilomètres, tous les x heures d'utilisation/fonctionnement, tous les x examens ou analyses…)

- Les plans de maintenance corrective ou curative, qui sont établis au moment d'un constat d'une panne ou d'un disfonctionnement d'un item. Le plan correctif sera souvent matérialisé par un bon de demande d'intervention qui spécifiera le disfonctionnement en détail. Exemples : demande de réparation d'une fuite d'eau dans un toit, demande de remplacement d'un pneu crevé, demande de réparation d'un appareil de radiologie défectueux, demande de réparation d'une ambulance accidentée.

Chaque plan de maintenance est obligatoirement lié à un élément de l'inventaire. Il est clair que plusieurs plans de maintenance doivent pouvoir être rattachés en même temps à un même élément de l'inventaire, permettant de satisfaire aux (i) combinaisons de plans d'inspection, maintenance préventive et/ou de maintenance curative ou (ii) les combinaisons de plusieurs plans de maintenance préventive pour un même item mais avec des périodicités différentes.

Chaque plan de maintenance générera un nombre d'opérations de maintenance à réaliser avec une certaine périodicité (plans d'inspection et plans de maintenance préventive) ou à la demande explicite (plans de maintenance curative). Une opération de maintenance devra par conséquent toujours faire référence à un plan de maintenance ; une opération de maintenance « sans raison » ne devra jamais être acceptable.

L'analyse situationnelle a démontrée qu'à l'heure actuelle, plusieurs outils sont utilisés pour la gestion des inventaires et de la maintenance dans les structures du Ministère de la Santé, dont les outils papier constituent encore l'outil dominant. A certains endroits, des outils basés sur Microsoft Excel ont été introduits ; ceci est le cas pour les inventaires réalisés par le PASS ou pour la gestion de la chaîne de froid. A quelques endroits, des vrais logiciels métiers pour la GMAO ont été introduits, avec des résultats plutôt variables et décevants.

4.3 Analyse des besoins

Le niveau central devra pouvoir accéder à la totalité des inventaires, des plans de maintenance et des opérations de maintenance. Cet accès se limitera par défaut à un accès en lecture seule pour de besoins de rapportage et planification (des rapports d'inventaire quantitatif et qualitatif pour le pays, par département, zone ou structure sanitaire, rapports sur le vieillissement du patrimoine, rapports financiers sur l'amortissement, la valeur résiduelle et les coûts des interventions de maintenance préventive et curative, rapports sur la performance des interventions).

Pour permettre la production de la planification matérielle et budgétaire, le niveau central devra disposer en plus d'un inventaire quantitatif et qualitatif des immobilisations, de normes précises pour le patrimoine des structures de soins à chaque niveau de la pyramide sanitaire. Ces normes (principalement quantitatives) doivent être établies pour (i) les infrastructures, (ii) les équipements biomédicaux, (iii) le matériel roulant, (iv) le matériel informatique y compris les logiciels, (v) le personnel de maintenance et (vi) l'outillage de maintenance. Actuellement, des normes qui couvrent une grande partie de ces besoins ont déjà été élaborées et validées par le MS du Bénin.

Un même besoin de normalisation se fait sentir au niveau des plans d'inspection et de la maintenance préventive. Il revient au niveau central de déterminer la périodicité et le contenu minimal des plans de maintenance préventive pour les infrastructures, les équipements biomédicaux et le matériel roulant courant et/ou pertinent dans les différentes structures du MS. Ainsi une harmonisation globale de l'approche de la maintenance préventive pourra être promue à travers le pays, en utilisant systématiquement les normes établies par le niveau central comme base de planification de la maintenance « par défaut » pour chaque item enregistré dans l'inventaire en périphérie. Aujourd'hui, la normalisation des plans de maintenance préventive n'a pas encore été réalisée au Bénin.

Les besoins du niveau départemental se situent à la fois sur le plan opérationnel et sur plan administratif. Le niveau départemental gère les inventaires et les procédures de maintenance pour ses sous-structures mais supervise également les activités dans les zones sanitaires. Pour cette raison, le niveau départemental devrait avoir accès en lecture seule aux outils de rapportage et planification et

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également aux modules de gestion des inventaires et des procédures de maintenance pour le patrimoine qui est directement géré à son niveau.

Les besoins du niveau périphérique sont principalement liés à la gestion de l'inventaire, des plans et des opérations de maintenance pour le patrimoine qui appartient à la structure de soins.

4.4 Modules d'une GMAO

Plusieurs modules peuvent trouver une place dans une solution de GMAO élaborée. Ce qui suit est une liste de fonctionnalités qui ont été retenues comme pertinentes pour le MS au Bénin. Ils ont également été organisées par priorité (allant de 1 = « indispensable pour démarrer la GMAO » à 2 = « intéressant mais à plus faible valeur ajoutée au début du projet »)

- Gestion des inventaires (priorité 1). La GMAO devra permettre la gestion complète des inventaires des infrastructures, équipements biomédicaux et matériel roulant.
- Gestion des normes (priorité 1). La GMAO devra intégrer les normes quantitatives pour les patrimoines des structures de soins aux différents niveaux de la pyramide sanitaire. En plus, elle devra permettre de définir des plans d'inspection et de maintenance préventive par défaut pour des infrastructures et équipements biomédicaux ciblés.
- Gestion des plans de maintenance préventive (priorité 1). L'élaboration de plans de maintenance, le cas échéant basés sur des normes définies par le niveau central, devra être intégrée dans la GMAO.
- Gestion de la maintenance corrective (priorité 1). La production de bons de demande d'intervention et la planification des réparations/remplacements en fonction des implications financières et de la criticité de chaque item pour le fonctionnement de la structure sanitaire, devront être offerts par la GMAO.
- Bibliothèque GMAO (priorité 2). Un module de bibliothèque numérique devra permettre d'intégrer dans la GMAO (i) de la documentation liée à des éléments individuels des nomenclatures des infrastructures, des équipements biomédicaux et des véhicules et (ii) des instructions sur l'application des procédures et règlements par rapport à la maintenance biomédicale au sein du Ministère de la Santé du Bénin.
- Gestion des plans d'inspection (priorité 2). La GMAO devra offrir un module pour la planification des inspections périodiques sur des éléments ciblés dans le patrimoine des structures du Ministère de la Santé.
- Gestion des pièces détachées (priorité 2). Une gestion des références fournisseur et des stocks des pièces détachés tenus par les services biomédicaux des structures sanitaires devra être accessible à partir des fiches d'inventaire et des écrans de gestion des plans et des opérations de maintenance.

4.5 Architecture de la GMAO

Vu la disponibilité encore réduite de connexions internet à haut débit dans une grande partie du territoire du Bénin, l'architecture proposée pour la GMAO est celle d'un système d'information distribué. Cela signifie que les différentes structures (centrales, départementales et périphériques) qui sont censées d'encoder les inventaires et les données des procédures de maintenance pour leur patrimoine, disposeront chacune d'une solution GMAO autonome et locale.

Les instances GMAO locales enverront périodiquement (il est proposé de le faire chaque nuit) des extraits structurés détaillés (en format XML) des dernières données ajoutées/modifiées vers un entrepôt de données central installé au Ministère de la Santé à Cotonou. La communication avec cet entrepôt de données se fera à travers internet via un API basé sur la technologie web RESTFul. Ainsi l'entrepôt de données contiendra à tout moment la dernière situation du patrimoine et des activités de maintenance de toutes les structures de soins avec un délai d'au maximum 24h (sauf dans le cas où une structure serait privée de connexion internet pendant plus de 24 heures). Comme la transmission des informations vers l'entrepôt de données ce réalisera en arrière-plan, en absence de toute interaction avec l'utilisateur, la bande passante internet disponible pour cette communication ne jouera pas de rôle significatif.

Au niveau de l'entrepôt de données, des procédures d'extraction de données agrégées pourront être installées pour échanger des informations de maintenance biomédicale avec d'autres systèmes d'information exploités par le Ministère de la Santé, comme le DHIS2 et OpenRBF.

Selon le type de structure dans laquelle la solution GMAO devra être mise à disposition, différentes interfaces utilisateurs sont proposées :

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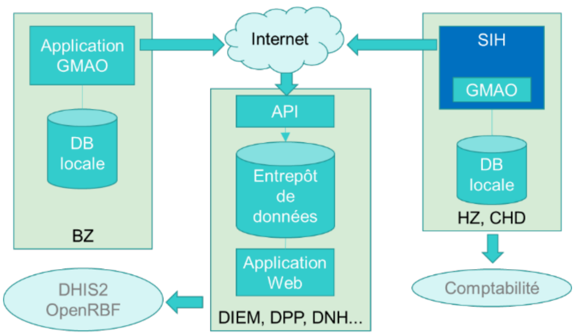
Au niveau central il est proposé d'installer une application web qui utilisera directement les informations stockées dans l'entrepôt de données. Cette application centrale n'utilisera les données des inventaires et des opérations de maintenance qu'en lecture seule, comme le niveau central n'est pas censé de les modifier directement. Les données des ressources humaines, les normes quantitatives, les plans de maintenance préventive par défaut, les données des inspections et le contenu de la bibliothèque numérique GMAO, pourront par contre être directement modifiées à travers l'interface web (ces données sont en principe seulement utilisées en lecture seule par le niveau périphérique)

Dans les bureaux de zone et les structures de soins qui ne disposent pas d'un système de gestion d'informations hospitalières, une application GMAO autonome et complète sera installée sur un serveur local. Dans la base de données locale, les utilisateurs des bureaux de zone pourront encoder les données des inventaires et des procédures de maintenance préventive et curative pour leur propre patrimoine. Ces données seront répliquées chaque nuit vers l'entrepôt de données central. Dans l'autre sens, les normes quantitatives et les plans de maintenance préventive par défaut (mise à jour par le niveau central) seront copiés chaque nuit de l'entrepôt de données central vers l'application GMAO locale. Les bureaux de zone auront en plus accès aux données des ressources humaines, les données des inspections et le contenu de la bibliothèque numérique GMAO à travers l'interface de l'application web du niveau central.

Le troisième cas de figure est celui des structures sanitaires qui disposent d'un système de gestion d'informations hospitalières (SIH). Dans ce cas, il est préférable qu'un module GMAO soit intégré dans le SIH, afin de limiter le nombre d'applications et d'interfaces différentes pour les utilisateurs. Ce module GMAO devra grosso modo offrir les mêmes fonctionnalités que l'application GMAO indépendante des bureaux de zone.

Le schéma de cette architecture se présente comme suit :



4.6 Formations

Le nombre de ressources humaines impliquées dans l'implémentation et l'utilisation d'une GMAO est assez important. Certaines personnes devront seulement être formées sur une partie de l'application, d'autres utilisateurs auront besoin d'une formation sur la totalité des fonctionnalités offertes par la GMAO. Nous distinguons 4 types de formations, c.à.d. (i) la formation fonctionnelle complète qui couvre toutes les fonctionnalités accessibles pour les utilisateurs, (ii) la formation fonctionnelle partielle, focalisée sur des fonctionnalités précises et limitées de l'application, (iii) la formation informatique qui traite les aspects d'installation et configuration des serveurs, les procédures de backups, les interfaces de synchronisation avec l'entrepôt de données etc. et finalement (iv) la formation maintenance qui traite les procédures de maintenance, les normes et les nomenclatures.

4.7 Préalables

L'analyse situationnelle au Bénin a permis d'identifier un nombre de préalables pour le déploiement correct d'une solution GMAO :

- Une nomenclature des structures sanitaires devra être établie pour le Bénin. Ceci comprend (i) la mise en place d'un code unique pour chaque structure du Ministère de la Santé et (ii) la normalisation des types de structures comme les centres de santé communaux, les centres de santé arrondissementaux, les maternités isolées etc. Cette nomenclature devrait idéalement être partagée avec d'autres applications nationales comme le DHIS2 et OpenRBF.

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- La GMAO ne devrait pas être conçue comme une solution pour un problème isolée, mais plutôt s'intégrer dans l'écosystème d'information sanitaire au Bénin. Ceci signifie qu'il serait par exemple intéressant d'utiliser la GMAO pour alimenter un volet équipements et maintenance dans le DHIS2 ou d'intégrer les indicateurs de performance de la maintenance ainsi que la complétude des inventaires dans l'évaluation PBF (interface avec OpenRBF)
- Le démarrage effectif de la GMAO nécessitera de disposer d'inventaires corrects et complets dans les structures de soins. Ceci constitue un travail préparatoire important (qui a déjà été fait dans les zones d'intervention de la CTB-PASS/Sourou).
- Sur base des visites de terrain, un renforcement des capacités des ressources humaines de maintenance ainsi qu'une mise à niveau de leur outillage semblent être nécessaires pour permettre d'optimaliser la rentabilité de l'investissement dans une GMAO.

Afin de permettre l'implémentation d'une solution GMAO pérenne dans un contexte technique parfois difficile, un nombre de choix techniques sont en plus proposés :

- L'utilisation de technologies modernes et répandues focalisées sur la stabilité de la solution
- L'utilisation de l'interface web pour raccourcir la courbe d'apprentissage
- L'utilisation de serveurs de base de données open source comme MySQL, MariaDB ou PostgreSQL
- L'utilisation de serveurs web open source come Apache, Apache Tomcat ou JBoss
- La sélection de standards internationaux partout où cela est possible. Ceci s'applique aux API, les protocoles de communications, les formats de messages et les nomenclatures des infrastructures ou équipements biomédicaux. La GMDN est avancée comme nomenclature des équipements biomédicaux.
- Absence de frais de licence récurrents et l'obtention d'un droit d'utilisation des applications sans frais supplémentaires sur tout le territoire du Bénin
- Une préférence pour les solutions open source ou au moins avec mise à disposition des codes source au Ministère de la Santé
- Sélection de fournisseurs avec une présence au Bénin disposant de préférence d'une capacité de développement locale

5 Conclusion

La gestion de la maintenance biomédicale au Bénin est aujourd'hui organisée de façon archaïque et peu efficiente. L'adoption de nomenclatures nationales et/ou internationales pour l'identification des infrastructures, des équipements biomédicaux et des structures de soins est un préalable important pour la mise en place d'une gestion harmonisée du patrimoine sanitaire à travers le pays. La mise en place d'une GMAO permettrait (i) l'application de normes quantitatives existantes pour les équipements dans les structures de soins aux différents niveaux de la pyramide sanitaire, (ii) l'utilisation de procédures standardisées au niveau national pour la maintenance préventive, (iii) l'organisation d'un suivi plus effectif des pannes en fonction de la criticité des équipements affectés et (iv) une planification des investissements futurs basée sur des besoins réels. Une gestion plus efficace de la maintenance biomédicale permettra de mieux rentabiliser les investissements du pays dans les équipements diagnostiques et thérapeutiques coûteux et ainsi d'améliorer l'offre de soins dans différentes parties du pays sur base de normes équitables.

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La numérisation en imagerie médicale : état des lieux au Sénégal

Abdoul A. BA[1*], Nadège G. PEYO [1,2], Frank Verbeke [3]

1 Centre d'imagerie médicale CIM Mermoz, Sénégal
2 Centre Hospitalier Universitaire National Fann, Sénégal
3 Vrije Universiteit Brussel (VUB), Belgique

1 Introduction

De la découverte des rayons X en 1895 à nos jours, l'imagerie médicale a connu de nombreuses évolutions. La révolution numérique a débuté dans les années 1950 avec l'invention de l'échographie médicale, suivie par celle de la Tomodensitométrie (TDM), dans les années 1970 et de l'Imagerie par Résonance Magnétique dans les années 1980 [3]. Si l'échographie, le scanner et l'IRM sont d'emblé numériques, la radiographie a d'abord été analogique avant d'évoluer progressivement vers la numérisation avec la radiographie computérisée puis la radiographie digitalisée à partir des années 1999 [3]. Cette transition vers le numérique ne peut être qu'applaudie pour plusieurs raisons. L'imagerie analogique nécessite un traitement chimique en vue du développement de l'image sur film analogique, qui représente alors le seul moyen de reprographie et d'archivage, en plus d'être l'unique support pour l'interprétation des images. Les bains chimiques utilisés sont sensibles aux variations climatiques et s'oxydent rapidement au contact de l'air ; mal conservés, ils donnent des images de mauvaise qualité qui vont rapidement être dégradées [4]. De plus, ils doivent être changés régulièrement et éliminés de façon adéquate afin de minimiser leur impact sur l'environnement. L'imagerie numérique présente l'avantage de pouvoir traiter l'image sur console avant la reprographie, ce qui permet d'éviter le gaspillage des films numériques ; ainsi on estime à environ 0.29 à 1.55 euros le prix de reviens d'une image radiographique numérique contre 2.4 à 3.4 euros pour une image radiographique conventionnelle [4].

La dématérialisation de l'image médicale a donné naissance à quelques nouvelles applications comme le télé-diagnostic et la télé-expertise. Cette dernière est définie comme l'envoi par réseau informatique des images produites par une structure médicalisée vers une autre équipe pour demander un avis complémentaire, en temps différé, tandis que le télé-diagnostic est l'envoi par réseau des informations produites par une structure médicalisée sans spécialiste vers une autre structure avec spécialiste pour établir le diagnostic primaire [8]. Les deux applications peuvent faire usage de solutions PACS (Picture Archiving and Communication Systems), qui sont des systèmes de gestion électronique des images médicales; ils permettent l'archivage, le stockage, le traitement et la mise en réseau des images numériques [6,1]. Leurs spécificités au sein des systèmes d'information hospitaliers sont d'ordre historique puisqu'ils ont été développés pour la radiologie et la médecine nucléaire, technique (capacité d'archivage, écrans haute définition, standards spécifiques,…) et médical puisqu'ils sont utilisés directement dans l'acte médical [9].

Depuis quelques années, la transition vers le numérique est devenu une réalité en Afrique subsaharienne, et en particulier au Sénégal. Cette étude a eu pour but de dresser l'état actuel de la numérisation du parc d'imagerie médicale dans les structures médicales de référence au Sénégal.

2 Matériels et méthode

Il s'agissait d'une étude prospective transversale à visée descriptive, sur une période de deux mois (d'octobre à novembre 2016). Elle a concerné les services d'imagerie médicale d'une part de 10 hôpitaux publics de référence des différentes régions du Sénégal (Centres Hospitaliers Universitaires et Centres

*Corresponding author.
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Hospitaliers Régionaux) , et d'autre part 2 centres privés considérés comme des centres de référence. Les données avaient été recueillies à l'aide d'un questionnaire pré-établi, et traitées à l'aide du logiciel SPSS 19.

3 Résultats

Les services d'imagerie médicale situés en milieu urbain représentaient 66,6%, contre 33,4% pour les services situés en milieu rural ; la moitié des services ruraux ne disposaient pas de radiologues sur place, soit 16,7% de l'ensemble des services étudiés (Tableau I).

Tableau 1. : Disponibilité des radiologues en fonction du milieu.

	Radiologue disponible dans le service		**Total**
	Non	Oui	
Milieu Rural	2 (16,7%)	2 (16,7%)	4 (33,4%)
Milieu Urbain	1 (8,3%)	7 (58,3%)	8 (66,6%)
Total	3 (25,0%)	9 (75,0%)	12 (100,0%)

Les appareils analogiques (tables os-poumons) étaient retrouvés dans les hôpitaux publics et représentaient 17,9% de l'ensemble des appareils. Les appareils numériques directs (échographie, TDM et IRM) représentaient 39,3% (Tableau II), contre 42,9% pour les appareils numériques indirects (tables os-poumons, mammographes numériques).

Tableau 2. : Profil des appareils disponibles.

	Type				
Appareils disponibles	**Milieu**	**Privé**	**Public**		**Total**
Appareils analogiques	Rural	0	2	2	5 (17,9%)
	Urbain	0	3	3	
Appareils numériques indirects	Rural	0	4	4	11(39,2%)
	Urbain	2	5	7	
Appareils numériques directs	Rural	0	4	4	12(42,9%)
	Urbain	2	6	8	
Total		4(14,2%)	24(85,8%)	28(100,0%)	28(100,0%)

La moitié des services ruraux ne disposaient pas de radiologues sur place, soit 16,7% ; les services ne disposant pas de radiologues sur place (25%) n'avaient pas de système de communication inter-hospitalier donc pas de possibilité de partage des examens (Tableau III). Parmi les services disposant de radiologue sur place 33,4% partageaient leurs examens pour télé-expertise, et 8,3% pour télé-diagnostic.

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Tableau 3. Partage d'images numériques.

	Services disposant de radiologues		
	Non	Oui	Total
Pas de partage	3	4	7 (58,3%)
Partage pour télé-expertise	0	4	4 (33,4%)
Partage pour télé-diagnostic	0	1	1 (8,3%)
Total	3 (25,0%)	9 (75,0%)	12 (100,0%)

Les examens numériques étaient archivés via le PACS Cloud dans un seul service, soit 8,3% (Tableau 4).

Table 4. : Archivage des examens numériques.

	Effectifs	Pourcentage
Temporaire sur disque dur	11	91,7 %
Via le PACS Cloud	1	8,3 %
Total	12	100,0 %

Dans 83,3 % des cas, la maintenance était effectuée à l'occasion d'une panne (Tableau V).

Table 5. : Fréquence de maintenance.

	Effectifs	Pourcentage
A l'occasion d'une panne	10	83,3%
Trimestrielle	2	16,7%
Total	12	100,0%

Le défaut de maintenance était la cause la plus fréquente de panne (45,8 %), suivi par la vétusté du matériel et la fluctuation du courant électrique (Tableau VI).

Table 6. Causes de panne.

	Effectifs	Pourcentage
Fluctuation du courant électrique	4	16,7%
Matériel vétuste	9	37,5%
Défaut de maintenance	11	45,8%
Total	24	100,0%

4 Discussion

Les services d'imagerie médicale situés en milieu urbain représentaient 66,6%, contre 33,4% pour les services situés en milieu rural. Les appareils analogiques (tables os-poumons) étaient retrouvés dans les hôpitaux publics et représentaient 17,9% de l'ensemble des appareils.

Les appareils numériques représentaient 82,1% dans notre étude, contre 58,3% pour l'étude de Guegang GE et al [2] au Cameroun, et 11,53% dans celle de Dansou Y. M. [1] au Togo. Les appareils numériques directs (échographie, TDM et IRM) représentaient 39,3% contre 42,9% pour les appareils numériques indirects (tables de radiographie, mammographes numériques).

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L'imagerie numérique nécessite comme consommables uniquement des films numériques, tandis que l'imagerie analogique nécessite également des bains chimiques pour le développement de l'image. Pour le format de film 35 x 43, une boîte de 100 films analogiques coûte environ 34 500 F CFA, contre 176 000 F CFA pour une boîte de 125 films numériques, soit 345 F CFA par film analogique et 1408 F CFA par film numérique. L'imagerie numérique présente l'avantage de pouvoir traiter et améliorer l'image avant impression, avec comme conséquence pas ou peu de rebuts de films. Malgré le faible coût des films analogiques, ils présentent l'inconvénient d'avoir une courte durée de conservation, qui peut être raccourcie par un stockage inadéquat [3]. En effet, ils vieillissent sous l'effet de la température et de l'humidité, ce qui va se traduire par une augmentation du voile de base de l'image et des pertes de sensibilité ou de contraste ; ils doivent idéalement être stockés verticalement, de façon chronologique et à une température n'excédant pas 22° pour éviter tout gaspillage [11]. Plusieurs facteurs peuvent conduire à un gaspillage des consommables analogiques: erreurs techniques (mauvais positionnement du patient, constantes d'irradiation inappropriées, défaut de développement de l'image), mauvais entreposage des films et bains, variation de température et d'humidité.

Au Mali, Keïta [9] avait retrouvé 11,2 % de rebut de films analogiques 35 x 43 en centre hospitalier urbain, contre 34,98 % en centre privé urbain pour Diallo [10]. Les facteurs techniques étaient en cause dans 84,7 % dans l'étude de Keïta [9]. Les principales causes de rebuts dans l'étude de Diallo [10] se situaient au niveau de la triade : erreurs de constantes (58,82%), erreurs de centrage (20,43%), et défaut de développement du film (12, 69%). La perte financière due aux rebuts de films analogiques était globalement estimée en centre hospitalier à 3.158.500 FCFA pendant une période de 24 mois dans l'étude de KEITA [9], contre 356.900 F CFA pendant 12 mois dans celle de ZHAO BING et SOUMARE [12] ; elle était estimée à 376.100 f CFA sur une période de 6 mois en clinique privée dans l'étude de Diallo [10]. Ainsi, malgré le faible coût des films analogiques, leur fragilité et la perte financière due aux rebuts les rendent moins compétitifs comparés aux films numériques.

Il y avait 25 % de services ne disposant pas de radiologues sur place, dont 16,7% de services ruraux. Cela pourrait s'expliquer d'une part par le déficit de radiologues au Sénégal, d'autre part par le désintérêt des médecins pour les postes en milieu rural. Parmi les services disposant de radiologue sur place 33,4% partageaient leurs examens via le PACS pour télé-expertise, et 8,3% pour télé-diagnostic. Les services ne disposant pas de radiologues sur place (25%) n'avaient pas de système de communication inter-hospitalier donc pas de possibilité de partage des examens. La généralisation du PACS à de tels services pourrait permettre de palier au déficit de radiologue par le biais du télédiagnostic. Dans 8,3% des centres, les examens numériques étaient archivés via le PACS Cloud ; cela permet d'avoir accès à l'historique des examens des patients et de pouvoir comparer des examens effectués à des dates différentes. L'archivage temporaire sur disque dur concernait 91,7% des centres ; les examens les plus anciens étaient effacés une fois la mémoire du disque saturée. Dans 83,3 % des cas, la maintenance était effectuée à l'occasion d'une panne, et le défaut de maintenance préventive était la cause la plus fréquente de pannes (45,8 %). A l'installation des appareils et des PACS, dans les services, le personnel médical et paramédical était formé à l'utilisation des appareils. Le déficit d'ingénieurs biomédicaux dans les services de maintenance hospitaliers est un frein au bon fonctionnement du numérique, car en cas de panne une intervention extérieure était indispensable, ce qui dans certains cas entrainait de longs délais d'attente.

5 Conclusion

Malgré le fait que les appareils analogiques soient encore retrouvés dans certains hôpitaux publics du Sénégal, ils sont largement supplantés par les appareils numériques. L'imagerie numérique présente de multiples avantages à savoir un moindre usage de consommables, une bonne qualité d'image et la possibilité d'archivage et de partage des images via les PACS. Cependant, ces derniers sont sous exploités dans notre contexte alors qu'ils pourraient permettre à la fois d'améliorer la prise en charge des patients et de palier au déficit de radiologues. Le principal défi à relever à l'heure actuelle semble être la mise en place de services de maintenance hospitaliers capables de mettre en œuvre une maintenance préventive des appareils et de les dépanner sans intervention extérieure.

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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.

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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.

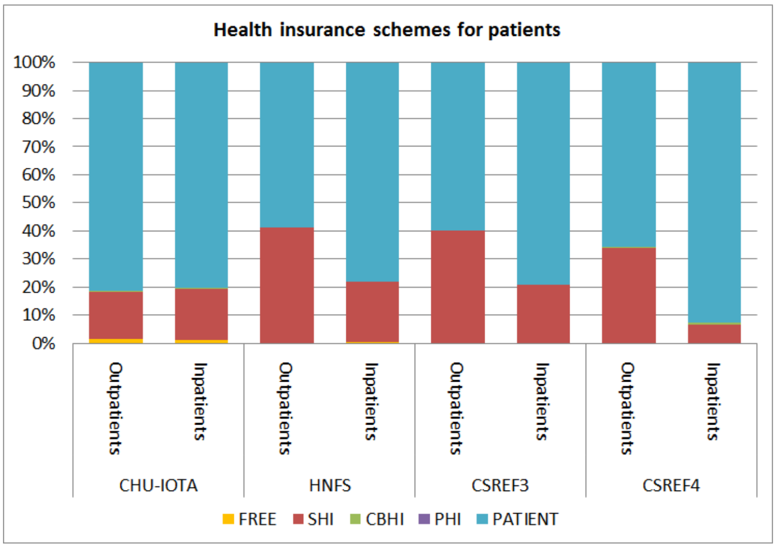

Figure 1: Health insurance schemes for out- and in-patient encounters

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

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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<=25%)*	**Un-insured** *(POOP>=75%)*	**Insured** *(POOP<=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 Chi² 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%.

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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.

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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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A Schematic View of the Application of Big Data Analytics in Healthcare Crime Investigation

Terungwa Simon Yange [a*], Hettie Abimbola Soriyan[b], Oluoha, O[c].

[a]Department of Mathematics/Statistics/Computer Science, Federal University of Agriculture, Makurdi, Nigeria
[b]Department of Computer Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria
[c]Department of Computer Science, University of Nigeria, Nsukka, Nigeria

Background and Purpose: One major challenge encountered during crime investigation via automated systems is the inability of conventional data analysis techniques to adequately handle the enormous data that are made available during the investigation. Existing crime investigation frameworks are built on orthodox data analysis techniques which cannot sufficiently manned the unprecedented size and variety of data available today, not to mention the significantly more anticipated data in the near future. This has affected the healthcare industry where data is predominantly multi-structured and is growing at a considerably faster rate.
Methods: To address this, a big data analytics model based on deep learning was designed in this research using enterprise application diagrams.
Results: This model is intended to be implemented using Apache Hadoop a big data implementation framework. When implemented, the model will create a platform that will handle a phenomenon that is affecting millions of people all over the world.
Conclusions: This is the first of its kind to use big data analytics techniques in healthcare crime investigation in Nigeria which provided security intelligence by shortening the time of correlating and deriving evidence from large volume of data for healthcare crime investigation purposes. Finally, this research also enabled the healthcare systems to systematically use big data analytics to identify inefficiencies and best practices that improve care delivery and reduce costs.

Keywords: Crime, Hadoop, Deep Learning, Investigation Data Analytics, Health Insurance

1 Introduction

Big data usually includes datasets whose sizes are beyond using conventional data analysis tools to manage. The analysis of big data commonly known as big data analytics is the process of collecting, organizing and analysing large, diverse dataset that involves different types such as structured and unstructured, and streaming and batch, with sizes from terabytes to zettabytes to discover patterns and other useful information [1]. Big data analytics can be applied in information security which involves the ability to gather massive amounts of digital information to analyse, visualize and draw insights that can make it possible to detect crime. This can transform security analytics by improving the maintenance, storage and analysis of security information. Big data analytics correlate the data drawn from multiple sources such as network traffic, log files, financial transactions, healthcare claims etc. into a coherent view so as to identify the anomalies and suspicious activities of the criminals. Big data is ideal for investigating information security issues; and detecting a crime is largely about uncovering data patterns that are not ordinary from log files. Applying big data techniques will ease such analysis to reveal anomalies that point to a data breach. With this powerful strength, big data analytics could lead to the discovery of big crime which invariably could culminate into 'big arrest'.

*Corresponding author address: Department of Mathematics/Statistics/Computer Science, University of Agriculture, Makurdi, Nigeria, Email: lordesty2k7@ymail.com, Tel: +2348064067803
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Crime encompasses a wide range of illicit practices and illegal acts involving intentional deception or misrepresentation. Crime is any illegal act characterized by deceit, concealment, or violation of trust [2]. These acts are not dependent upon the threat of violence or physical force. Crimes are perpetrated by parties and organizations to obtain money, property, or services; to avoid payment or loss of services; or to secure personal or business advantages." In other words, crime is a harmful act or omission against the public which the society wishes to prevent and which, upon conviction, is punishable by fine, imprisonment, and/or death. No conduct constitutes a crime unless it is declared criminal in the laws of the country [3][4]. Some crimes (such as theft or criminal damage) may also be civil wrongs (torts) for which the victim(s) may claim damages in compensation. Crime and fraud are synonymous, therefore in this research, the two words will be used interchangeably.

Crime impacts organizations negatively in several areas including financial, operational, and psychological. While the financial loss owing to crime is significant, the full impact of crime on an organization can be overwhelming. The losses to reputation, goodwill, and customer relations can be also devastating. The society is strongly affected by crime, both due to the cost of crime, as well as the decline in the quality of life that citizens suffer as a consequence of crime. As crime can be perpetrated by any employee within an organization or by those from the outside, it is important to have an effective crime management programme in place to safeguard the organization's assets and reputation. Crime and society are closely linked-for better and for worse and is as old as humanity, and occurs in different degrees of severity. However, society can also play a role in reducing and deterring crime. Many agencies and programmes in crime management are based on societal and community efforts. The magnitude of criminal activities can be perceived in all spheres of life [2].

For instance, the healthcare sector is among the most information intensive industries. Its information, knowledge and data keep growing on a daily basis and the ability to extract useful information that will improve the quality of healthcare services rendered is very crucial. Crime in this sector involve the intentional deception or misrepresentation for gaining some shabby benefits in the form of health expenditures [4]. This can be anything like providing false and intentionally misleading statements to patients, submitting false bills or claims for services, falsifying medical records or reports, lying about credentials or qualifications, unnecessary medical treatment or drug prescription; which seriously drain the finances in the healthcare system. This severely deters the healthcare industry from providing quality and safe care to legitimate patients; and it has called for an effective crime management system so as to reduce this illegal behaviour with the intention of improving the quality and reducing the cost of healthcare services. Owing to the large number of cases reported, investigated and prosecuted, it has been identified as a "high-risk" area in many regions such as the UK, the US, Romania, Nigeria etc. [4].

Healthcare crime exist in many forms: dishonest providers, organized criminals, collusion with patients, and patients who misrepresent their eligibility for health insurance coverage. It can be categorized into: health insurance crime, drug crime and medical crime. Due to the confidentiality of the medical records, data for healthcare crime comes mostly from health insurance crime; and it occurs when a company or an individual defrauds an insurer or government healthcare programme. In this paper, a survey of the existing healthcare investigation approaches is carried out and a new approach is designed.

1.1 Related Works

Crime in the healthcare insurance involve three parties [4][5]: healthcare service provider (i.e., the physician, pharmacist, laboratory scientist, healthcare centre, pharmacy, laboratory, and even ambulance companies) which render healthcare services; healthcare service consumer or beneficiary or insurance subscriber (i.e., patient) which receive healthcare service from the provider; and the healthcare insurance carrier which receive regular premiums from subscribers and make the commitment to pay healthcare cost on their behalves. These parties exchange information amongst them in the course of care delivery. This is basically in the form of service requested by the subscriber (patient visit) to the provider, explanation of benefits which contain the detail services rendered by the provider to the subscriber, claim/bill which is sent to carrier for the services rendered to the subscriber by the provider, and the payment to the provider based on the claim submitted to the carrier. As the number of beneficiaries (patients) of this scheme increases, high volume of data is generated by both the providers and the carriers; and consequently, some fraudulent activities (such as billing services that were never rendered, performing medically unnecessary services, misrepresenting non-covered treatments as medically

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necessary covered treatments, and misrepresenting applications for obtaining lower premium rate) are carried by these actors (beneficiary, provider and insurer) which give rise to the need to investigate such acts in an attempt to identify perpetrators, and this requires a proper analytics tool for the purpose [4][6].

Recent development of new technologies eased production, collection and storage of high dimensional and complex data. Healthcare has been no exception. Modern medicine generates a great deal of data which is stored in medical databases. Medical databases are increasing in size in three ways [6]: the number of records in the database, the number of fields or attributes associated with a record, and the complexity of the data itself. Extracting pertinent information from such complex databases for inferring potential fraudulent activities has become increasingly important for fraud detection. [4] gives an account of the amount of information involved in the reimbursement process for healthcare insurance scheme, which supports the cost of prescription medications to seniors and the disabled in the US. In such a complex process, involving many actors, the possibility of fraud cannot be overlooked. At the same time, quality of medical records should be ensured to avoid, for instance, fraudulent claims. Also, there is yet another type of healthcare crime called “conspiracy fraud” which involves more than one party [5]. An important characteristic of conspiracy fraud is the need to deal with dyadic data connecting the involved parties. The important feature of dyadic data is that it can be organized into a matrix where rows and columns represent a symmetric relationship. In healthcare fraud detection, the typical relationship of interest is the one between a provider and a beneficiary.

With this enormous amount of data that is generated in the healthcare industry, traditional methods of detecting healthcare crime are time-consuming and inefficient due to the complicated nature of medical processes and the complexity of the data have made crime to have a favourable niche in the healthcare systems as most crimes go undetected. Conventional analysis methods are not suitable due to their inner limitations to manage the volume, velocity, variety, veracity, value and complexity of the data in the healthcare [5][7][8][9][10][11].

Among these three types of fraud, the one committed by health service provider’s accounts for the greatest proportion of the total healthcare fraud. Although a vast majority of service providers are honest and ethical, but a few dishonest ones may have various possible ways to commit fraud on a very broad scale, thus posing great damage to the health care system. Some service providers’ fraud, such as that involving medical transportation, surgeries, invasive testing, and certain drug therapies, even places patients at a high physical risk.

1.2 Healthcare Crime Investigation Approaches

[11] proposed the use of cluster analysis for geographical analysis of potential fraud. The emphasis of this work was on types of fraud committed by a single party. But as pointed out by [5] some frauds in the health insurance involves more than one party: conspiracy or conspiratorial frauds. A typical conspiratorial fraud scenario is that patients collude with physicians, fabricating medical service and transition records to deceive the insurance company to whom they subscribed. This can be very rewarding owing to its complexity, increasing popularity, and severe consequences. An important characteristic of conspiratorial fraud is the need to deal with dyadic data connecting the involved parties. The important feature of dyadic data is that it can be organized into a matrix where rows and columns represent a symmetric relationship. In healthcare fraud detection, the typical relationship of interest is the one between a provider and a beneficiary. As also noted by [5], detection of conspiracy fraud has not gained much attention in the health care fraud literature. In what follows, [12] considered the use of co-clustering methods for detection of conspiracy fraud. In so doing, the proposed models were able to describe and capture the dyadic dynamics that connects providers and beneficiaries. Co-clustering allows the grouping of providers and beneficiaries simultaneously, that is, the clustering is interdependent.

[9] developed a data mining technique for fraud detection in health insurance scheme using knee-point k-means algorithm. They considered NHIS as the case study for the work. The work, focuses on the application of some computer-based techniques that could help to properly target investment in the healthcare sector and also drastically reduce fraud in health insurance by healthcare providers. To this effect, they applied the knee-point k-means clustering method, which was capable of detecting fraudulent claims by health service providers. Cluster-based outliers were examined. Health providers’ claims submitted to a HMO were grouped into clusters. Claims with similar characteristics were grouped together. The claims were grouped into two clusters: fraudulent and non-fraudulent. The results from the

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data collected from a particular HMO in Lagos, Nigeria show that the total number of claims identified as possible anomalies from cluster-based outliers was seven (7) in Nigeria health insurance using probability of 0.6 as the cut-off point. This research did not classify the fraud detected, whether it is provider, consumer or insurer frauds; it uses only the unsupervised technique (K-Means algorithm) for clustering; and the data was collected from only one HMO which cannot yield a perfect result.

In a survey on hybrid approaches for fraud detection in health insurance by [7], the act committed with the intent to obtain a fraudulent outcome from an insurance process was carefully examined. According to them, when a claimant attempts to obtain some benefits or advantages to which they are not entitled then that attempt is considered as insurance fraud and it has become a major concern for health insurance companies. They proposed a hybrid framework that applied some data mining techniques to detect frauds. This framework considered the analysis of the characteristics of healthcare insurance data, some preliminary knowledge of healthcare system and the fraudulent behaviours. The framework harnessed the advantages of both the supervised and unsupervised learning techniques to detect fraudulent claims. This framework did not consider the high volume, velocity, variety, veracity etc. of data and it was not implemented.

In the same vein, [13], investigated the benefits of big data technology and the main methods of analysis that can be applied to the cases of fraud detection in public health insurance system in Romania. They outlined the benefits of using big data technology in combating crime in the healthcare industry.

Consequently, methods for identifying and preventing fraud must always be adjusted and ready to rediscover the fraudulent actions [3][4]. To add to the lapses in legislation of the country, each country has unique economic, political, social, and institutional opportunities for and barriers which makes fraud examination different amongst countries. A crucial and peculiar issue in the Nigerian National Health Insurance Scheme is the high level of corruption in the sector, lack of accountability and clear sense of irresponsibility [14].

[15] proposed a model using big data in investigating real time crime in the health insurance in the cloud. This approach utilizes fraud management solution to detect potential frauds in the cloud. The solution was based on a high volume of historical data, predictive statistical models and social media analytics. It renders its services through client components like apps and web-services. Just like the [7][13][15] did not implement any working system for their research. Also, as opined by [13], healthcare crimes are country specific and Nigeria has not adopted the cloud services and there is no healthcare laws relating data on the cloud, and therefore, this model cannot be used to investigate crime in our healthcare system.

In [10], an approach of data mining implementation in medical fraud detection was carried out. They considered the increasing amount of data stored in files, databases, and other repositories which requires the development of a powerful means to analyse and extract interesting knowledge from them. The healthcare fraud detection requires compilation of potentially huge data, involving complex computation and sorting operations. Once such frauds have been detected and classified, data cleaning is applied to it which helps to remove the noise and inconsistencies in the data thereby enhancing its quality. This technique can be used to detect the sale of potentially dangerous medicine by pharmacists thereby preventing such medical fraud.

[4] in their bid to address these issues provides an approach to detect and predict potential frauds by applying big data, Hadoop environment and analytics methods which led to rapid detection of claim anomalies. The solution was based on a high volume of historical data from various insurance company data and hospital data of a specific geographical area. With the voluminous, diverse, and varying nature of the data used, the distributed and parallel computing tools collectively termed big data were employed. The work demonstrated the effectiveness and efficiency of the open-source predictive modelling framework used to describe the results from predictive model. The research was able to detect erroneous or suspicious records in submitted healthcare datasets and proved how the hospital and other healthcare data are helpful for the detecting healthcare insurance fraud. The research also used the decision tree algorithm.

In [16], a fraud detection approach in the health insurance using data mining techniques was developed. This approach used SVM (Support Vector Machine) and Evolving Clustering Method (ECM) in health insurance field for fraud detection. In the research, SVM algorithm was used for classification and ECM algorithm was used for clustering. The SVM was used to train the system to determine decision boundary between legitimate and fraudulent claims classes while the ECM identifies new data point that

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comes in, it clusters them by modifying the position and size of the cluster (i.e., used to cluster dynamic data hence it find out newly incoming fraudulent claims).

[17] developed a model for detecting healthcare fraud and abuse using the supervised and unsupervised data mining techniques. According to them, the supervised methods applied to healthcare fraud and abuse detection are decision tree, neural networks, genetic algorithms and Support Vector Machine (SVM); while the unsupervised methods that have been applied to health care fraud and abuse are clustering, outlier detection and association rules. They concluded that outlier detection is an unsupervised method and routine online processing task as supervised learning method.

In our research, we considered the further classification of fraud so as to report the actual fraud. We also considered deep learning which combined both supervised and unsupervised techniques, since hybrid methods are proven to yield better results [7][16][17][18]. We collected data from different stakeholders in the healthcare insurance relating to fraud. This research also used big data analytics techniques to carry out the investigation since the anticipated data is very large in size.

1.3 Nigerian National Health Insurance Scheme

A beneficiary got enrolled in the National Health Insurance Scheme (NHIS) programme after an eligibility screening is performed by the NHIS. The person's circumstances and income is verified and if the criteria are met, the person can enrol in the NHIS programme. When the beneficiary is ill, he/she will go to the hospital where he/she will get the necessary treatment. The provider of the services provided to the beneficiary would submit the bill to the Health Maintenance Organization (HMO) in the form of claims. It is generally assumed that all of the providers have an agreement with NHIS and that they participate in the programme. The providers send the claim to the HMO which is reviewed and processed for the payment of the services of participating providers to the beneficiaries.

An Explanation of Benefits (EOB) is sent to the beneficiary; an EOB contains an overview of the provided services. This is an automatically generated detailed overview of the provided services and the corresponding codes and amounts. The claim submission and processing is done manually which makes most frauds go undetected. Verification of the legitimacy of claims become more tasking creating the assumption that all claim submitted are true and genuine. If a claim is rejected, there is no follow up to investigate why the provider submitted this claim. The said provider receives the information with the explanation why the claim was rejected. The lesson how not to submit the claim can be mastered and in the next attempt taken into account. Because the perpetrators are not investigated, they get wiser by the note that is sent to them and learn about the billing rules.

To investigate this process, provider should submit additional documents to prove that the services were actually provided because if he/she provided the service it is not a lot of effort to submit additional documentation. However, a fraudulent provider has a good reason not to reply; the fraud attempt failed and there are no consequences when he/she does not reply since there is no investigation. However, if an honest provider made a mistake with the submitted claim he/she would send the additional documents to get his/her provided services reimbursed. Further investigation of rejected claims will reduce most of the frauds in this scheme and the NHIS can benefit of this information source.

2 Methodology

This paper employed the hierarchical structure of the deep learning (deep belief network) architecture will be employed to learn high level representations and complicated structure automatically from complex health insurance data collected from the various health facilities, and stored in the Hadoop Distributed File System; and also provide algorithms that will be implemented by the MapReduce Programming platform for the distributed processing of the data. It provides a framework that allows distributed processing of complex datasets using simple programming models. The multiple layers of this architecture continuously abstract features of the data undergoing processing from one layer to another, making the search for fraudulent claims simpler. The pictorial view of this model was designed by enterprise application diagram. It uses the Nigerian Health Insurance Scheme (NHIS) as a test bed.

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3 Results

This paper studies how the big data framework can be leveraged to extract, preprocess and analyse data from the NHIS with the aim of identifying fraud. Apache Hadoop is the Big Data framework considered. The Hadoop Distributed File System (HDFS) implementation of the Hadoop is used as an alternative to store data and the MapReduce to process extremely large data sets on commodity hardware. In addition, we will use Hive as an open-source data warehousing solution which is built on top of Hadoop. The design of the system is shown in figures 1 and 2. Hive supports queries expressed in a SQL like declarative language-HiveQL. RHadoop is a bridge between R, a language and environment to statistically explore data sets, and Hadoop, a framework that allows for the distributed processing of large data sets across clusters of computers. In this research, we will focus on using the ability of big data analytics to manage millions of events efficiently to develop a hybrid model for investigating health insurance fraud. The proposed model will be able to identify the erroneous or suspicious insurance claims during investigation. The conceptual view of the model is shown in figure 1 and figure 2. The model took into cognizance the high volume of data from this sector.

4 Discussion

The model designed in this paper when implemented will harness the big data's capability of crime investigation which will be of great value especially in the healthcare insurance scheme. This will be able to investigate breaches in security, determine compliance with established policies and operational procedures, and enable the reconstruction of sequences of events affecting the healthcare insurance domain to enable auditors do their work efficiently. It considered the volume and complexity of this data which made it impossible for humans and other traditional means to be sufficient enough to identify the crime perpetrated by the hoodlums in the healthcare insurance industry. The deep belief network algorithm of deep learning was used to "learn" normal activities so as to fish out any unwholesome activity in the healthcare insurance. The model created room to capture and process the data, help to visualize its flow and apply automatic learning techniques capable of discovering patterns and detecting anomalies from such patterns for proper investigation of the activities of fraudsters. With this, common repetitive errors that are "hidden" inside huge repositories of data which would go undetected in the absence of big data technologies because the orthodox techniques not being capable to correlate the huge quantities of data available in the medical sector will easily be identified and corrected. The deep learning architecture combined two machine learning theories: unsupervised and supervised theories, one is used in the pretraining while the other is used in fine-tuning the network. In the pretraining of a deep belief network, the unsupervised learning theory is used. This is aimed at finding clusters of similar inputs in data without being explicitly told that these data points belong to a different class. With the aid of this theory, unlabelled NHIS data will be used in to initialize the network in the pretraining phase. The supervised theory is aimed classifying inputs data with the aid of the target output. This theory implements the Back Propagation (BP) Algorithm which expressed the logic behind it. The idea behind BP algorithm is quite simple, output of the network is evaluated against desired output. If results are not satisfactory, connection (weights) between layers are modified and the process is repeated again and again until the error is small enough to be ignored. This theory aids the fine-tuning of all the weights and biases in the network pretrained by the unsupervised theory.

As opined by [4][7][17] and other researchers, this combined hybrid approach in the deep learning makes it easier to detect erroneous or suspicious records in submitted healthcare datasets and proved how the hospital and other healthcare data are helpful for the detecting healthcare insurance fraud. Components of the system are discussed below.

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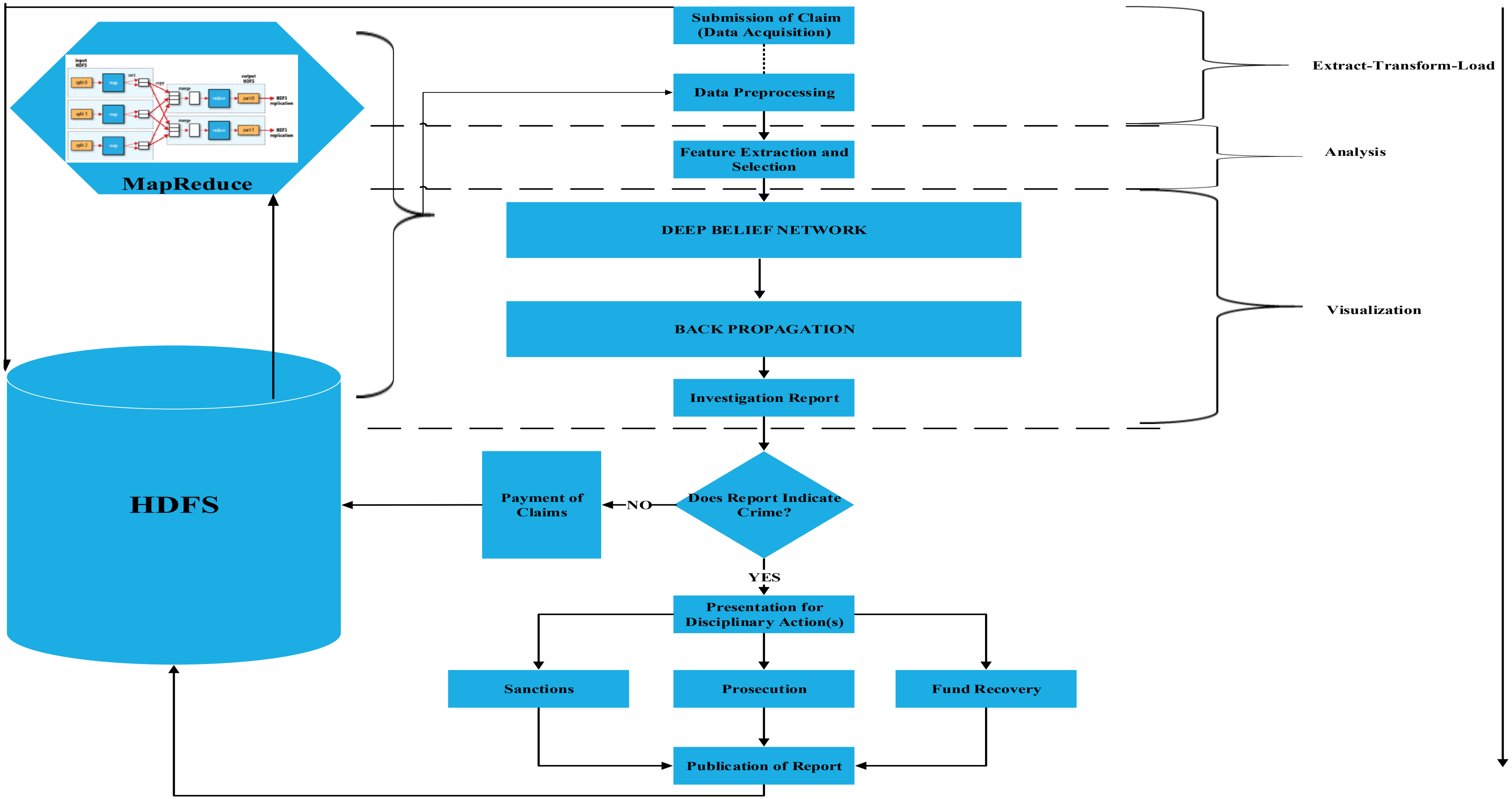

Figure 1. Schematic View of the Model

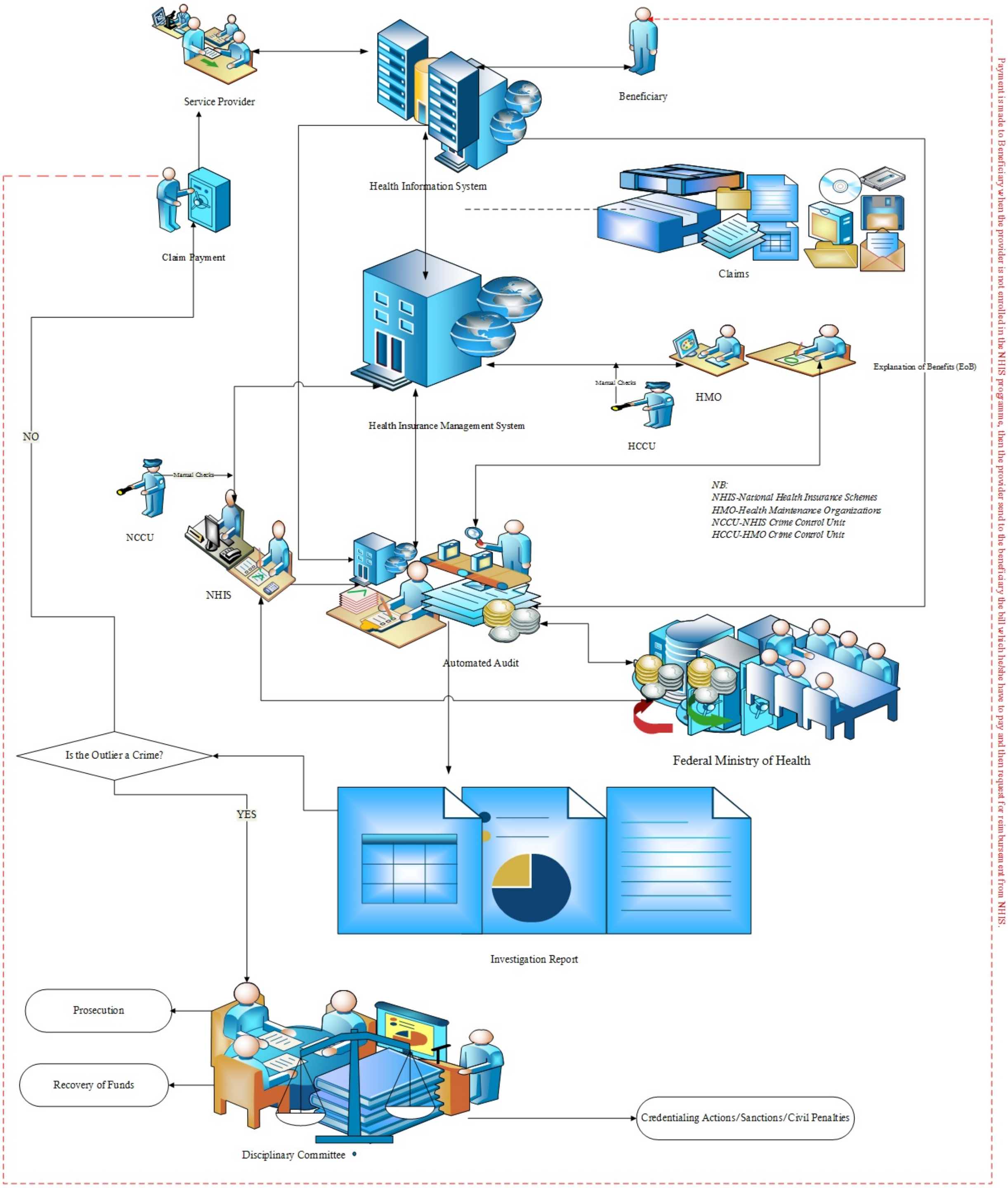

Figure 2. Model Flow

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Hadoop Framework: This is the combination of the MapReduce and the Hadoop Distributed File System (HDFS). This is the backbone of this model. It enables distributed parallel processing of huge amounts of data across inexpensive, industry-standard servers that both store and process the data, and can scale without limits. It can handle all types of data from disparate systems: structured, unstructured, log files, pictures, audio files, communications records, email - regardless of its native format. Even when different types of data have been stored in unrelated systems, it is possible to store it all into Hadoop cluster with no prior need for a schema.

Data Acquisition and Preprocessing: Real world data that is collected from different sources is noisy and heterogeneous (different format) in nature. The heterogeneity in the healthcare data is responsible for the prevalence of missing values and inconsistencies which poses a great challenge leading to an inaccurate result if not addressed at the beginning. Raw data must be processed (this task is associated with segmentation, normalization and noise removal algorithms) into a form that is acceptable. This helps in constructing the homogeneous data set.

Analysis: This step aims to define new features out of the original attributes, to maximize the discrimination power of the machine learning method in separating fraudulent and legitimate cases. The feature extraction and selection procedures aim at finding the minimum number of discriminative features that are considered. The term feature selection refers to algorithms that select the best subset of the input feature set, whereas methods that create new features based on transformations or combinations of the original feature set are called feature extraction algorithms. Feature extraction takes in a pattern and produces features values. Feature extraction may provide a better discriminative ability than the best subset of given features, but these new features (a linear or a nonlinear combination of given features) may not have a clear physical meaning. Health insurance is a complex phenomenon governed by multiple variables because there is no universal factor that can be used to predict the fraud.

Visualization: Visualization present large volumes of data, provide interactivity to explore the data, make visual patterns easy to see and make multivariate analysis simple and easy to comprehend.

Other Components: The investigation report is produced after this stage. If the report does not indicate any fraudulent act, payment is made, but if it is otherwise, the report is presented for disciplinary action (sanction, prosecution in the court of law and fund recovery) from the disciplinary committee. This stage marks the end of the investigation and everything is recorded in the database. Depending on the success of an investigation, further action may result in the form of civil cases, criminal prosecutions or both. Such actions can result in monetary penalties (fines), recoveries of funds (belonging to the public trust or to private payers) and industry sanctions (such as revocation of privileges or prohibition against administering services to NHIS patients) against offenders.

5 Conclusion

This research designed a model that will automatically identify the general patterns of suspicious behaviour of criminals in the healthcare insurance claims. It employed advance data analysis techniques of big data which aid auditors in investigating breaches in security, determine compliance with established policies and operational procedures, and enable the reconstruction of sequences of events affecting the healthcare insurance domain. This brought humans and computers to collaborate and work closely together in crime investigation. With this, it will reduce the time it takes to uncover fraudulent activity, and also shrink the negative impact of significant losses owing to fraud. It has created a platform that will handle a phenomenon that is affecting millions of people all over the world. This is the first of its kind to use big data analytics techniques in healthcare crime investigation in Nigeria which provided security intelligence by shortening the time of correlating and deriving evidence from large volume of data for healthcare crime investigation purposes. Finally, this research also enabled the healthcare systems to systematically use big data analytics to identify inefficiencies and best practices that improve care delivery and reduce costs.

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Design of a Data Analytics Model for National Health Insurance Scheme

Terungwa Simon Yange [a*], Hettie Abimbola Soriyan[b], Oluoha, O[c].

[a]Department of Mathematics/Statistics/Computer Science, Federal University of Agriculture, Makurdi, Nigeria
[b]Department of Computer Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria
[c]Department of Computer Science, University of Nigeria, Nsukka, Nigeria

Background and Purpose: The need for better and faster decision-making based on data is stronger than ever; and being able to use massive amounts of data is a necessary competitive advantage. This has necessitated the urgent need for a sophisticated data analytics model for the effective transformation of data into actionable information to enhance quality decision-making. For instance, the healthcare domain is faced with unnecessary delays in the processing of the data submitted to the National Health Insurance Scheme (NHIS).
Methods: To address this, a data analytics model based on deep learning was designed in this research using unified modelling language.
Results: This model is intended to be implemented using Apache Hadoop and MySQL. When implemented, the model will make it easier to consolidate, cleanse, analyse, and publish data, so that all stakeholders will get information that they can act on, in the format they need.
Conclusion: Thus, the stakeholders will access the information more easily, which will enable them to plan, evaluate, and collaborate more effectively.

Keywords: Hadoop, Deep Learning, Data Analytics, Health Insurance

1 Introduction

Data has become an increasingly important resource for organisations as it is the mother of information technology. Due to the improvement in information technologies and the growth of internet, organisations are able to collect and store huge amount of data. Data however is not the same as information as it need to be analysed and extracted before it is useful. This becomes more difficult as the amount of data, data type and analytical dimensions increased. In order to support decision making, data needs to be converted into information and knowledge [1]. The concept of applying a set of technologies to turn data into meaningful information is what is known as data analytics. Organisations are faced with a number of problems when attempting to analyse their data. There is generally no lack of data. In fact, many businesses are drowning in data; they are unable to turn it into actionable information as it is a big challenge to determine relationships, predict future events, spot bad data, and allow for its analysis.

The core methodology in data analytics is machine learning, which is the area of computer science that aims to build systems and algorithms that learn from data so as to aid the processing and modelling of large amounts of data to discover previously unknown relationships. A variant of this area is known as deep learning which applies machine learning techniques to both structured, semi-structured and unstructured data [2]. It is based on learning multiple levels of representation. The multiple levels of representation correspond to multiple levels of abstraction. A significant feature of deep learning which makes it more promising in data analytics, is the learning of high level representations and complicated structure automatically from huge amounts of data to obtain useful information. Also, deep learning provides high-accuracy results, avoids the expensive design of handcrafted features, and utilizes the

*Corresponding author address: Department of Mathematics/Statistics/Computer Science, University of Agriculture, Makurdi, Nigeria.
Email: lordesty2k7@ymail.com, Tel: +2348064067803
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massive unlabelled data for unsupervised feature extraction [3]. This makes it more suitable for analytics of huge data generated by information intensive industries; e.g., oil and gas sector, financial institutions, health insurance sector etc.

The healthcare insurance is among the most information intensive industries. Its data, information, knowledge and insights keep growing in every second and the ability to extract useful information that will improve the quality of healthcare services rendered is very crucial. The primary purpose of the analytics of health insurance data is to track payments done by beneficiaries to providers for healthcare services, beneficiaries' contributions (premium), the cost of health services and also to address fraud [4]. This is the major source of the cost associated with healthcare which is vital to addressing the economic challenges associated with modern healthcare system. It provides for the payments of benefits as a result of sickness or injury which includes insurance for losses from accident, medical expense, disability, or accidental death and dismemberment.

With the prised benefits of the scheme outlined above, results from past researches have demonstrated the dissatisfaction of beneficiaries with the scheme for reasons such as additional fees on the pretext of no-inclusion of particular services in their insurance plan and poor customer service. It has also been discovered that there is poor general knowledge of the scheme among those that have enrolled for it [6][7]. Most of these issues are due to the lack of proper data processing facilities to provide good insights from the data collected from various health service providers in varying formats in the course of administering the scheme. This data (i.e., data about the enrolment of beneficiaries and service providers, claims submitted, registration updates, complaints, enquiries, sanctions of service providers) ranges from the structured, semi-structured to unstructured data which are manually collected from varying data sources posed a great challenge due to the manner it is collected and presented. The processing of this data is done by an exhausting manual task carried out by a few personnel who have the responsibility of approving, modifying or rejecting these requests within a limited period from their reception. This has called for a sophisticated analytics tool for proper processing, but as stated by [7], there is no such tool available in NHIS hence the manual processing of the data available which caused unnecessary delay in the process.

These delays in processing the transactions of the scheme have been a discouraging factor in embracing the scheme. Those who have dared to register with the scheme complain of delay in having their documentations regularized to enable them reap the full benefits of the scheme. Therefore, many who are yet to register get discouraged by the experiences of those who have started the process of documentation as it takes ninety (90) to three hundred and sixty-five (365) days. The implication is that the number embracing the scheme tends to be reducing or not encouraging. Service providers complain of excessive delay in processing their claims leading to delay in payments of their bills and this could lead to total withdrawal of service or provision of substandard services. In fact, the general complain in Nigeria is that service providers are excessively owed and payment delayed for a period of six (6) to twelve (12) months [5]. It must be understood clearly that the sustainability of the scheme is largely dependent on the commitment of service providers; therefore, prompt payment of their bills is likely to raise their morale and guarantee some level of commitment.

1.1 Related Works

Data analytics had empowered businesses to make better decisions. With the amount of digital and analog data increasing at an enormous rate, rigorous research is carried out in an effort to extract value from these datasets, to convert them into a form that can be used to make smarter decisions for improving business results. Data analytics has integrated the state-of-the-art computational and statistical techniques to extract business value from a rapidly expanding volume of data. In the business world where the gap between winners and losers is narrowing down, companies are increasingly turning to data analytics to gain a competitive advantage in productivity, profitability and sustainable manufacturing processes for better products and better services. In order to exploit the potential value in data, it is of crucial importance that the data be processed and analysed so as to derive meaningful insights in order to achieve it set objectives.

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1.2 Implementation of Data Analytics

Large-scale data (big data) refers to data that exceed the capability of traditional data processing technologies. This is differentiated from small data which is process by traditional technologies in many ways: the amount of data (volume), the rate of data generation and transmission (velocity), the types of data: structured, semi-structured and unstructured (variety), the trustworthiness of the data (veracity), value and complexity [8][9]. The rate of data creation has increased so much that ninety (90) per cent of the data in the world today has been created in the last two years alone. This acceleration in the production of data has created a need for new technologies to analyse these massive data sets.

The framework for implementing big data is the Apache Hadoop. This is a fast-growing platform that enables the distributed processing of large data sets across clusters of commodity servers. It is designed to scale up from a single server to thousands of machines, with a very high degree of fault tolerance. Rather than relying on high-end hardware, the resiliency of these clusters comes from the software's ability to detect and handle failures at the application layer. Hadoop has capabilities to store and handle huge amounts of unstructured data within a smaller timeframe in an economically responsible way [9][10]. Two important parts of the Hadoop ecosystem are the Hadoop Distributed File System (HDFS) for making the partition of data and computing across many nodes possible; and the MapReduce which is the framework that understands and assigns work to the nodes in a cluster, and is able to distribute data workloads across thousands of nodes with machine learning as its core.

Traditional machine learning algorithms were designed to make machines recognize and understand the real world to learn a new knowledge and experience in limited dataset by some special customized methods. But this has become a challenging task for these algorithms to learn and analyse huge amount of data, complicated structure and wide range of varieties. The key limitation of traditional machine learning is that it can't efficiently generate complicated and non-linear patterns from raw input data [8][9][10]. Hence, deep learning (a variant of machine learning) is a very promising method to solve analytics problem in large-scale data.

Deep learning is based on learning multiple levels of representation of data features. The multiple levels of representation correspond to multiple levels of abstraction. A significant feature of deep learning, also the core of data analytics, is to learn high level representations and complicated structure automatically from massive amounts of data to obtain meaningful information [10]. This massive data provides training dataset for deep learning algorithms to learn more complicated features and to improve the state-of-the-art performance. Mining and extracting meaningful patterns from input data for decision-making, prediction, and other inferencing is at the core of data analytics [11].

1.3 Health Insurance Data Analytics

The major drive of the analytics of health insurance data is to track payments done by beneficiaries to providers for healthcare services, beneficiary contributions (premium), the cost of health services and address fraud as stated earlier [4]. Most works done in the analytics of healthcare insurance data has been in the area of combating fraud [12] and hence, there are serious issues with regards to delays in the processing of the data. In Nigeria, we have a peculiar situation; this is because the analytics in the NHIS is completely manual [7]. This has given rise to most of the issues we have in the scheme today. Fraud is one out of the many issues in NHIS and therefore a proper analytic tool should take into cognizance the other issues (delay in registration/update, payment, response to complaints, etc.) affecting the processing of data in addition to fraud.

As stated above, most researchers in this area focused on the detection of fraud in health insurance; for instance, [13] develop a data mining technique for fraud detection in health insurance scheme using knee-point k-means algorithm. They considered NHIS as the case study for the work. The research did not classify the fraud detected, whether it is provider, consumer or insurer frauds; it uses only the unsupervised technique (K-Means algorithm) for clustering; and the data was collected from only one HMO which cannot yield a perfect result. Consequently, in order to improve the health status of Nigerian via this scheme, the analytics tool should go beyond identifying and preventing fraud [14]. A crucial and peculiar issue in the Nigerian National Health Insurance Scheme is the high level of corruption in the sector, lack of accountability and clear sense of irresponsibility [5].

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2 Methods and Materials

To achieve the objective of this paper, an investigation of the system was carried out via the review of existing works on data analytics and NHIS, observation, and data collection from different HMOs. The data analytics model which employed deep learning was designed using unified modelling language (UML) tools. The implementation of this model designed is intended to be done using Apache Hadoop and MySQL. The Apache Hadoop which comprised of Hadoop Distributed File System (HDFS) and MapReduce will be used for storing and analysing the data (i.e., the HDFS will be used for storing the data that will be collected from the various sources; and the MapReduce which is the Programming Platform will use Java technology to implement the data analytics model for the analysis of complex data in the health insurance scheme). The MySQL will be used to store processed data which will subsequently be made available for visualisation/reports. The model implementation is outside the scope of this paper

2.1 Study Site

In this research, we considered ten (10) HMOs in Nigeria and they include: Hygeia HMO Ltd, Total Health Trust Ltd, Clearline International Ltd, Healthcare International Ltd, Medi Plan Health Care Ltd, Multi Shield Nigeria Ltd, United Healthcare International Ltd, Premium Private Health Trust Ltd and Ronsberger Nigeria Ltd. These are accredited by NHIS.

2.2 Data Collection

Data was collected from stakeholders in the HMOs and listed in section 3.2. The data captured five (5) different aspects of healthcare insurance. First is the claims data submitted by different providers; second is the provider enrolment data; third is beneficiary enrolment data; fourth is a list of blacklisted providers that have been sanctioned for various dishonest behaviours with the scheme; and fifth is complaint/inquiry data. The claims, beneficiary enrolment and the provider enrolment data were gotten from transactional data warehouses. Each claim, consists of several data elements with information about the beneficiary, provider, the health condition (or diagnosis), the service provided (procedure or drug), and the associated costs. Note that the providers typically are affiliated to each other through organizations such as hospitals. This information and additional data about the providers is present in the provider data.

2.3 Data Format

The formats of data collected include: comma-separated values (CSV), spreadsheet, portable document format (PDF), scanned images (.png, .jpeg, .gif, .bmp, etc.), emails and email attachments, web contents, structured data from relational databases (Oracle, MySQL, PostgreSQL, MSSQL, etc.), text files, etc.

3 Results

Data analytics is not an isolated set of activities but a continuum; hence the model described a cohesive set of solutions for data analytics: from acquiring the data and discovering new insights to making repeatable decisions and scaling the associated information systems for ongoing analysis. It also shows an integrated architecture for data analytics which makes it easier to perform various types of activities and to move data among these components. Implementing this model will improve data management and reduces cost incurred in the processing of data in the NHIS. Figures 1, 2 and 3 shows different views of the model.

4 Discussions

The structure of the analytics model comprised of the input, the Hadoop (HDFS and MapReduce), the Relational Database Management System-MySQL, and the output components. With this arrangement, raw data generated from the various health facilities with varying data formats - comma-separated CSV, spreadsheet, PDF, scanned images (.png, .jpeg, .gif, .bmp, etc.), emails and email attachments, web contents, structured data from relational databases (Oracle, MySQL, PostgreSQL, MSSQL, etc.), text files, etc. are loaded into HDFS which is a scalable fault-tolerant distributed system for data storage. It can store any type of data – structured, semi-structured and unstructured. This data is less dense and more information poor at this unrefined stage, and is not fit immediately into the predefined relational database or data warehouse; and if forced into a relational database, valuable information will be lost in the process. This data is placed in a non-relational database-HDFS which stores data in files that accept varying formats of data. This explains why loading data into Hadoop can be faster than loading data into a relational database.

Within Hadoop, the data would be interpreted using the MapReduce platform. It processes the data into a structured manageable form which would be evaluated as well. The MapReduce implement the deep belief network and back propagation algorithms which aid in the data processing and subsequently storing it in MySQL. The output is fetched from the relational database technologies for business intelligence, decision support, reporting etc. This is the final stage which visualized the insights uncovered and these visualizations are automatically updated.

The architectural flow of the model as shown in figure 3 depicts a high level view of the model and how it processes the data. In step 0, data is extracted from the HDFS; and at step 0.1, the MapReduce engine is responsible for splitting the data extracted from HDFS. The engine then caches the split data for the subsequent MapReduce invocations. Every algorithm has its own engine instance, and every MapReduce task will be delegated to its engine (step 1). Similar to the original MapReduce architecture, the engine will run a master (step 1.1) which coordinates the mappers and the reducers.

The master is responsible for assigning the split data to different mappers, and then collects the processed intermediate data from the mappers (step 1.1.1 and 1.1.2). After the intermediate data is collected, the master will in turn invoke the reducer to process it (step1.1.3) and return final results (step 1.1.4). Processed results are stored in MySQL (step 3) and reports are generated based on the user's request (step 4) is used for business intelligence, decision support, reporting etc. This could visualize the insights uncovered and these visualizations are automatically updated.

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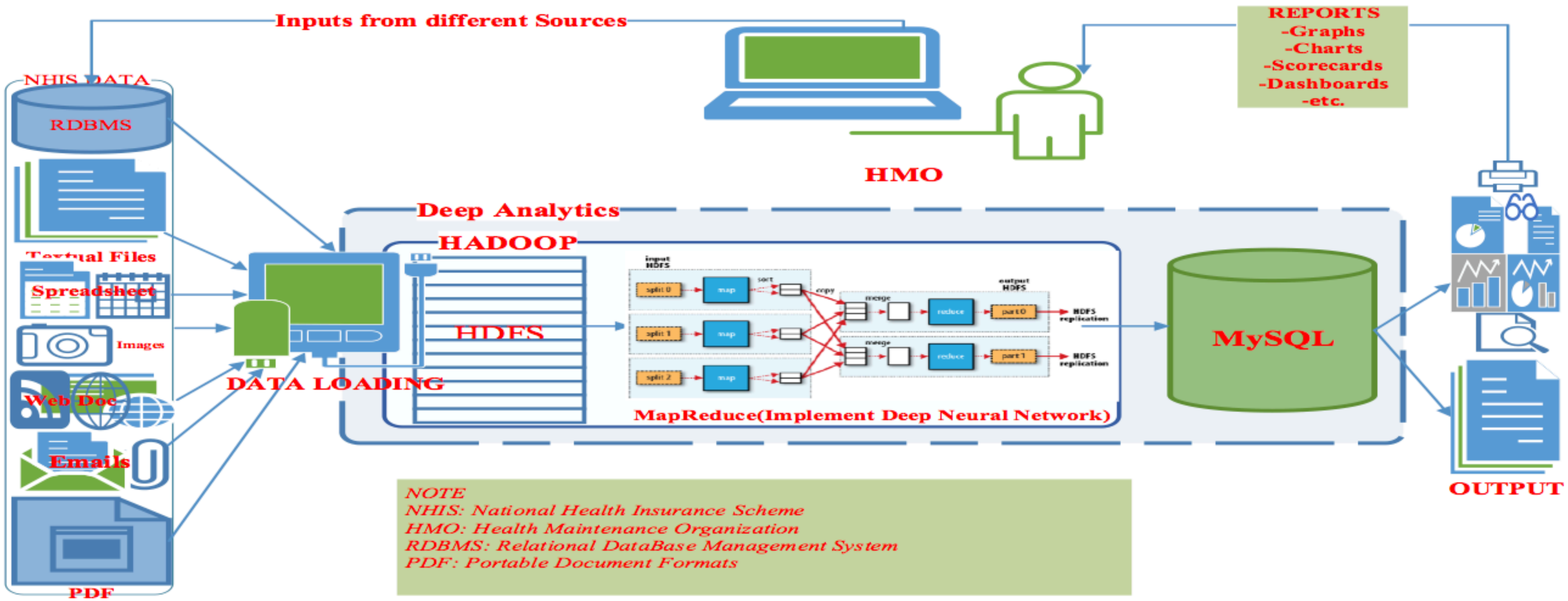

Figure 1. Conceptual View of the Model

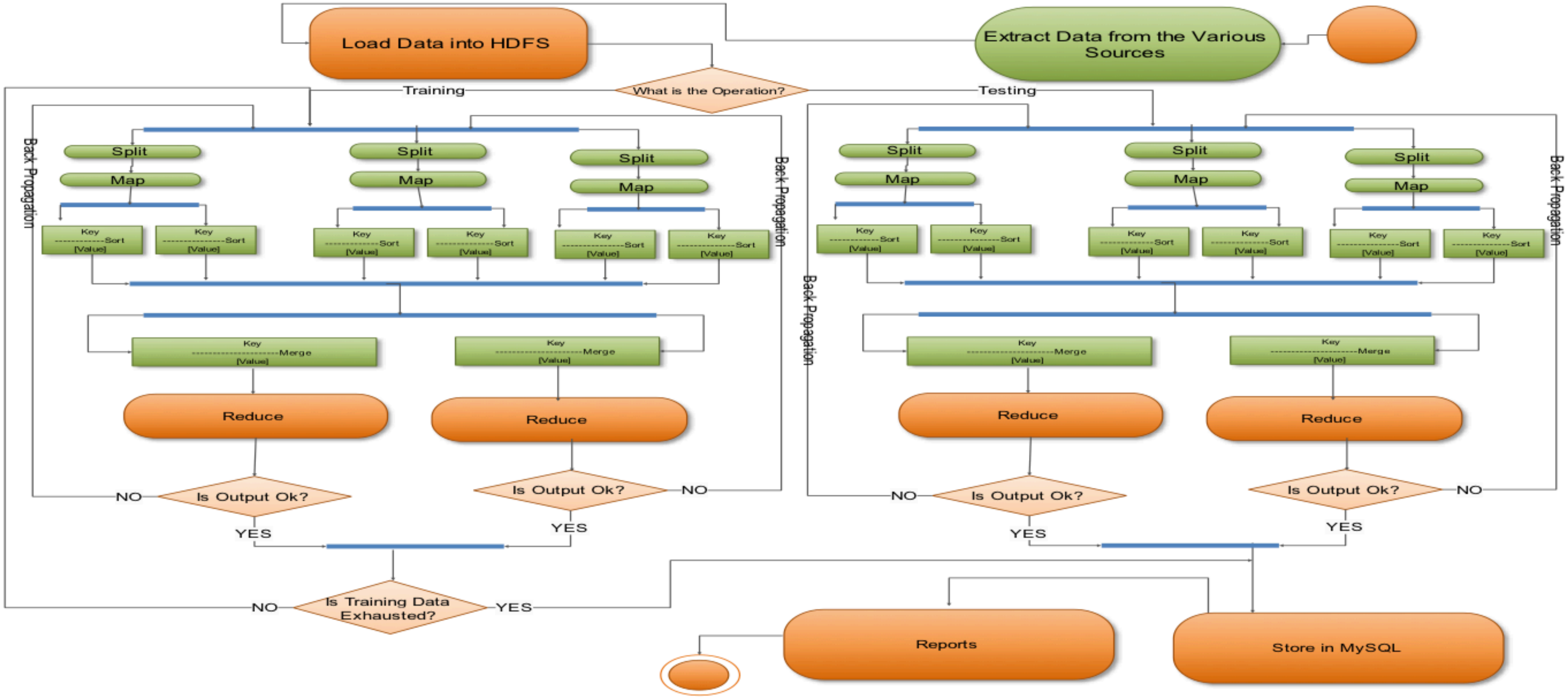

Figure 2. Activity Diagram of the Model

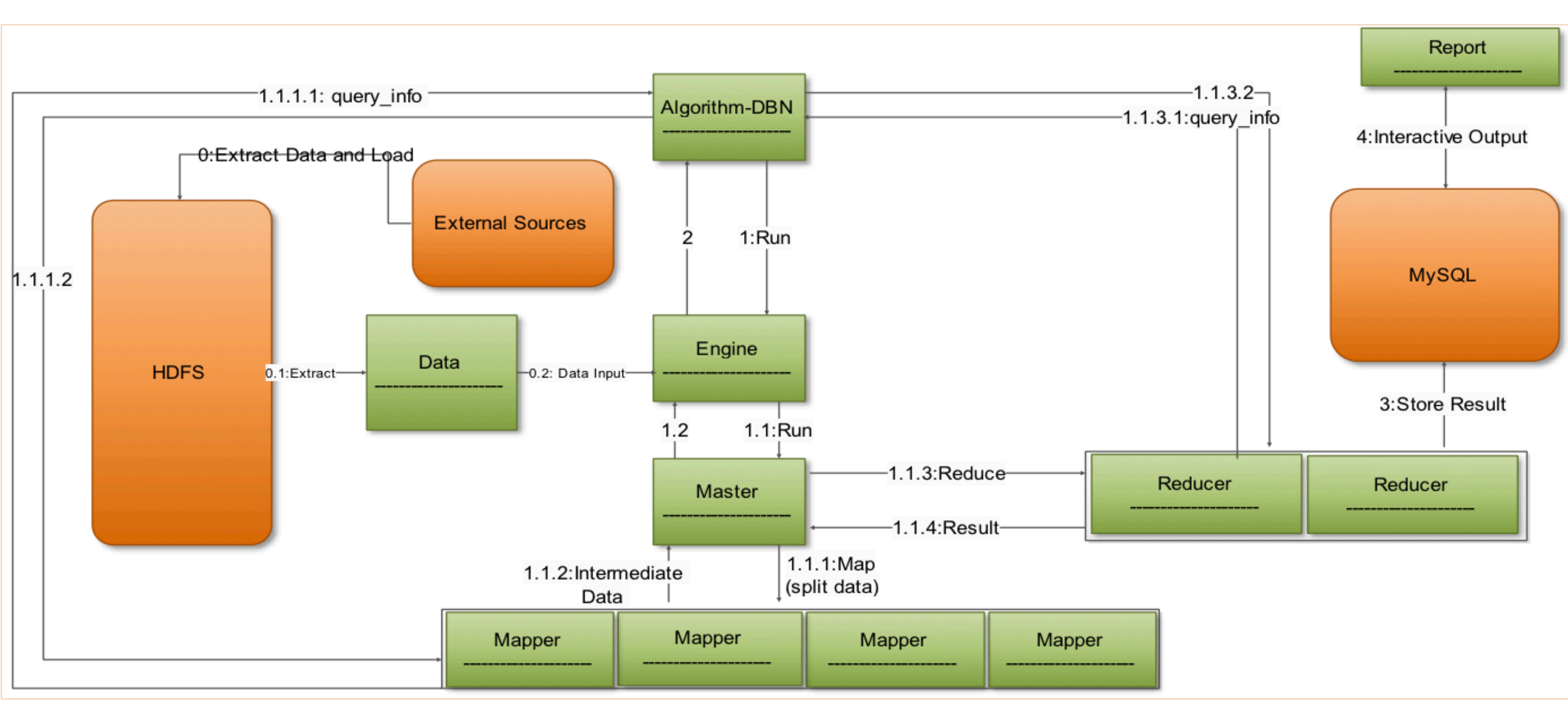

Figure 3. Architectural flow of the Model

5 Conclusion

This paper designed a data analytics model based on deep learning techniques. This model when implemented will aid in the processing of data for NHIS. This will significantly reduce the time required to manage, query, and process data in NHIS. That is, it will reduce the time it takes in processing document of registered beneficiaries, claims submitted by providers, payment of claims and the remission of contributions to NHIS, HMOs and HSPs, which will also shrink the negative impact of significant losses owing to the delay. Thus improving the health status of Nigerian

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Electronic health information systems for public health care in South Africa: a review of current operational systems

Graham Wright [a,*], Don O'Mahony [b], Liezel Cilliers [c]

[a] CHIRAD, University of Fort Hare, East London, South Africa
[b] Department of Family Medicine and Rural Health, Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa.
[c] Depart of Information Sciences, Faculty of Management and Commerce, University of Fort Hare, South Africa

Background and Purpose: The South African eHealth Strategy was published in 2012 and acknowledges that health information systems should be used to strengthen the public health care system in the country. While the benefit of electronic health information systems has been documented in the literature, the implementation of these systems in public health care in South Africa remains limited. Currently, patient data is still manually recorded in the patient's file, while data required for monitoring and evaluation purposes is hand written by the nurses in registers, aggregated and only the results entered into electronic health information systems for analysis.
Methods: The objective of the paper is to review existing electronic health information systems in public health care in South Africa in terms of their role and focus on health care. A qualitative approach was undertaken to identify the role of health information systems that are most prevalent in public health care in South Africa.
Results: The results indicate that the most common role of health information systems include support for clinical care, e.g. radiology and pathology, as well as monitoring, evaluation and administration purposes. While some systems do capture limited clinical information, there seems to be few systems that support patient centred clinical care.
Conclusions: The recommendation of the paper is that the role of health information systems should be expanded to support direct patient care and improve health outcomes for individuals.

Keywords: Health Information Systems, Primary Care, district health care, electronic patient record, South Africa

1 Introduction

In South Africa, the eHealth Strategy states that it needs to "implement patient-based information systems at all facilities where healthcare is delivered", and that all indicator data should be derived from data captured electronically at the point of care [1]. There is evidence that health information systems (HIS) can improve the quality of healthcare by increasing adherence to guidelines, enhancing disease surveillance, and decreasing medication errors [2]. Furthermore, electronic patient record systems (EPRs) can reduce the time spent by nurses on documentation in hospitals [3]. The evidence of improved quality and safety of patient care due to EPRs is limited to a few successful sites worldwide, while there is still a lack of evidence of their cost-effectiveness [4].

Literature suggests that HIS and EPRs may in fact cause primary clinical work to be conducted less efficiently if the health care worker is not computer literate or the system was not designed to fit with the task flow. In contrast, secondary work (audit, research and billing) may become more efficient as administrators have access to all the patient's information in one repository [5]. Despite these

*Corresponding author address: Email: profwright@gmail.com,Tel: 0735434677
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reservations, there is widespread support for HIS both in the developed and developing world, [6] including South Africa [1]. The district health system (DHS) is the institutional vehicle to deliver primary care services. While HIS for primary care comprises those at clinics and community health centres, it is also necessary to consider those at district hospitals. District hospitals form part of the DHS and the services they provide should be integrated with those in primary care [7]. The objective of the paper is to review existing electronic health information systems in the public health care sector in South Africa in terms of their role and focus in health care.

2 Materials and methods

The authors made use of a qualitative, inductive approach in the study. Firstly, a literature search for HIS in South Africa using the search engines PubMed and Google Scholar was conducted. A secondary search was conducted on Google, and the first hundred hits were reviewed. Keywords used included ‘electronic health records’, ‘health information systems’, ‘eHealth strategy’, ‘primary care’, ‘district health care’ and ‘South Africa’, which was used alone and in combination with the others. The references of articles retrieved were also examined. Secondly, where information on HIS was not found in the literature, experts in both the private and public health industry were requested to provide information as personal communications.

The rest of the paper is presented as follows: the next section will discuss the HIS that are currently found in South Africa after which the common challenges of HIS in the primary care sector are discussed. Critical success factors are provided as a possible solution to improve the uptake of HIS in the public health care sector of South Africa.

3 Results

3.1 Existing Public Sector Health Information Systems in South Africa

HIS can be divided into two categories depending on whether the user is focused on the ‘subject’ or ‘task’ that the system must perform. A subject based system relates to a particular subject, such as a doctor or nurse, in the health care system and will be used by the individual to perform their duties. In contrast, a task based system supports a particular task, regardless of who enters the data e.g. prescription system or a billing system [8]. In this paper, HIS will be categorised according to the tasks they perform.

Furthermore, Beaumont [8] provides an overview of the information systems pyramid and how it fits with HIS in the primary health care system (figure 1). The pyramid classification provides a tool for the Department of Health to determine how mature HIS implementation is. Operational HIS are normally the first to be developed and implemented, and the pyramid then highlights an uneven or inappropriate HIS development.

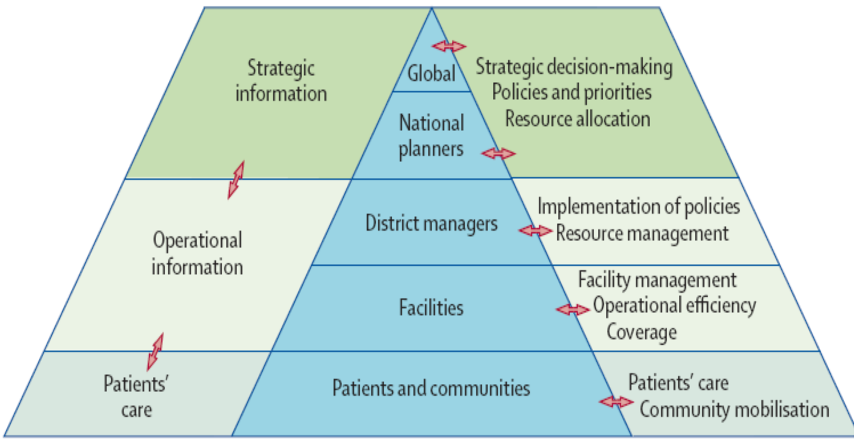

Figure 1: Health information System pyramid

The next section will discuss the current HIS that were found during the literature review and personal correspondence with experts in the field.

3.2 Health information systems

The CSIR and Department of Health [9] reported at least 42 different HIS, i.e. systems that recorded transactions specifically in support of patient administration and care, in operation in the public sector in 2013. Only seven (7) of these HIS were operational in five or more of the nine provinces; and of these, five were for surveillance and monitoring and only two concerned patient care.

The major systems that were identified during the current literature review have been divided into patient level systems e.g. clinical care and supporting services; operational level HIS e.g. monitoring and evaluation (M+E) and administration systems; and strategic level HIS. These are discussed below:

Patient Level HIS: Clinical care and supporting services systems.

eHealth@Joburg: A primary care EPR is being implemented by Med-e-Mass, a private vendor in 83 facilities in the City of Johannesburg, Clinical notes are entered into the system with templates for mother and child health and non- communicable diseases. There is as yet no pharmacy module [10].

Additional EPR Systems: In line with the National Health Insurance strategy, South Africa has started to implement EHR systems in the public health care sector. Currently, five out of the nine provinces in South Africa have some form of EPR system implemented in public hospitals. In KwaZulu-Natal province, some hospitals use the Medicom or Meditech EPR system, while a few hospitals in the Western Cape use the Unicare EHR systems. Hospitals in the Limpopo province also use the Unicare or Medicom EPR systems [11]. An EHR can be described as a comprehensive electronic collection of a patient's health history that is maintained and controlled by healthcare personnel [1]. The implementation of different EHR systems from various vendors presents a challenge as these systems are built with different underlying database architectures and therefore often fail to communicate and share information amongst each other. However, while these systems have been implemented in a few areas, the majority of the public health centres in South Africa still make use of a paper-based record system [12].

TrakCare Lab: From 2008, this proprietary laboratory management information system (InterSystems Corporation®) has been used by most laboratories in the National Health Laboratory Service that is responsible for all diagnostic pathology in the public sector [13]. Patient details are entered into the system either manually or scanned from barcodes, and results are printed or available electronically via the Internet on computers and smartphones.

Picture archiving and communication systems (PACS): Many South African public sector hospitals have implemented PACS systems but none seem to be operating optimally [14]. While current digital radiology imaging machines use the Digital Communications in Medicine Standard (DICOM) to communicate standard information on images [15], PACS vendors use different formats for non-image data (patient identifiers and clinical details), file registry and repository [14]. Thus, vendors' systems are not interoperable, and significant costs are involved in changing files if migrating to another vendor's system. Other problems identified included disruption to workflow, a lack of integration with existing patient information systems, an absence of government standards for PACS integration, and a lack of expertise in project management [16].

JAC Pharmacy System: This proprietary pharmacy dispensing and stock control system was launched in 1999 and is now installed in most hospitals in the Western Cape, [17] and in an increasing number of CHCs, totalling 70 facilities in 2015.

Patient and Operational level HIS: Administration systems.

CLINICOM Hospital Information System: This is used by nearly all hospitals in the Western Cape, providing patient demographic and hospital administration data. It supplies a unique patient identification number that is shared across other HIS for public-sector users throughout the Western Cape [18].

Delta 9™ Hospital Information System: Little detail is provided on the company website about the functionalities of its product Unicare™ that are used in 108 institutions (hospitals and clinics) in both the

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public and private sector [19]. It contains a master patient index that can provide demographic and administrative data about patient visits based on input from paper records. It does not provide a unique patient identification number and is not HL 7 compatible [19].

Patient Administration and Billing System (PAAB): A private company runs PAAB, which is owned by the Department of Health. While mainly used for administration, a clinical data-recording module has been added but lacks the functionality to enable the data to be used in an integrated manner. However, the system does not currently support electronic linkage to a pharmacy system, direct importing of laboratory or radiology results, and decision support [20].

RxSolution: This stock control programme was funded by the US Centres for Disease Control and Prevention (CDC), and implemented in clinics and hospitals in five provinces [18].

Primary Health Care Information System (PHCIS): PCHIS Basic was developed for public-sector community health sectors and clinics in the Western Cape. It provides demographic data and ICD 10 codes for patient visits. It uses a unique patient identification number (administered by CLINICOM) that is attached to a patient's paper record as a bar code. Data capturers enter data into the system [19]. A second system, EKAPA, was built on the same platform as PHCIS but was for HIV case management and cohort monitoring, and is now being merged with PHCIS (Boulle, A. Personal communication, 26 June 2015).

Patient Record and Health Management Information System (PREHMIS): This is a Linux-based system operated by the City of Cape Town (capital of the Western Cape) in primary care clinics. Data capturers read patient records, select an indicator from a printed menu, and then scan the barcode into a computer [18].

Operational and Strategic Level HIS: Monitoring and Evaluation systems.

Primary health care (PHC) in South Africa is provided mainly by nurses at community health centres (CHCs) and clinics in the public health sector [21, 22]. Data that is required for monitoring and evaluation (M & E) purposes by the Department of Health is hand written by nurses in multiple registers (mainly for vertical programmes) within each clinic and then aggregated for data capturers to enter in electronic HIS [9]. This process is associated with poor data quality, and the nurses perceive a high work burden [23-25]. In 2010, Odama et al. [14] found no evidence "that data analysis informs any policy or programme management in individual clinics" in the Eastern Cape Province.

National Health Patient Registration System: This system allows identity verification and records the reason for a visit and is installed in 650 public PHC facilities countrywide. The system is considered the most reliable source of national patient demographic data [26].

DHIS: South Africa has a District Health Management Information System (DHMIS) that is responsible for the collection and analysis of routine healthcare data from all primary care facilities and district hospitals in the public sector [27]. This function is achieved by use of the open source District Health Information System Software (DHIS). A National Indicator Data Set has been developed, consisting of about 200 indicators, of which 140 are relevant for PHC [28]. Data for calculation of these indicators is sent monthly from health facilities to the Department of Health (DoH). Provinces are asked to report 27 indicators quarterly to the National DOH [29]. Surveys, census data and registration of deaths and births supplement the routine monthly data.

Weaknesses identified in the DHMIS include limited alignment of the goals of the health sector and the present indicators; too many indicators, especially with requirements for donor-driven programmes; lack of Information and Communication Technology (ICT) infrastructure, and a lack of experienced health information personnel [27, 28]. Challenges with DHIS software include that it stores aggregated data which means patient-level data cannot be analysed, and there are no cut-off dates for data input resulting in inconsistent outputs [28]. Other HIS challenges include legislative, leadership, software and hardware resources, and data management. Data for vertical programmes are collected separately and later incorporated into the DHIS.

3.3 Challenges with current HIS

The eHealth strategy of South Africa states that "data quality will remain inferior where there are mainly paper-based systems or a mix of paper and computerised systems" [2, p21]. Challenges have been identified with the data quality of the health care system in South Africa. It is useful to classify these challenges according to the socio-technical theory as a starting point to understand and address the challenges. The socio-technical theory, first developed by Trist and Bramforth in the 1950s, describes the social and technical dimensions that affect the data quality in the PHC sector in South Africa [20]. The technical subsystem comprises the devices, tools and techniques needed to transform inputs into outputs in a way which enhances the economic performance of the organisation. The social system comprises the employees and the knowledge, skills, attitudes, values and needs they bring to the work environment as well as the reward system and authority structures that exist in the organisation.

Technical subsystem.
While there is an eHealth strategy in South Africa, there is no national master patient index and enterprise architecture that support the national public health system. The development of HIS is flawed as too many health indicators are included for reporting purposes with no clear delineation to the health outcomes that they support [30]. Other technology barriers that contribute to the failure to implement HIS systems include the high costs associated with these systems. The lack of ICT infrastructure needed to support these systems was also highlighted as a further challenge and includes the lack of computer equipment as well as reliable Internet connectivity. Additionally, there is insufficient capacity for data analysis in the health care department [30]. This has resulted in differing levels of eHealth maturity across and within provinces with a large number of different HIS from which little or no interoperability and communication is possible. As a result, information silos have developed which contribute to the duplication of effort and discrepancies in reporting [31].

The social subsystem.
The prevalent paradigm in South Africa is that data capturers undertake data entry from clinician paper records. Problems identified with the manual system include lack of continuity of care due to missing or duplicated files, time wastage as data have to be duplicated in multiple registers, and data entry errors. This statement is supported by the National Health Research Summit which identified poor information systems at facility level to provide information on the implementation of health interventions [4]. Venter [32] concurs that there is inaccurate reporting on the numbers and treatment and outcomes. Accurate M & E statistics are often only available at research sites. Therefore, this also means that clinicians are not engaged in information management and its use other than as the collector of the data [16].

There is an increased recognition that the failure to implement effective HIS cannot be attributed only to technology factors. The role that managerial, cultural and financial issues play in the success of information technology projects must be considered. There is thus an increased awareness of the interrelation between technology and the social environment in which it exists. This has necessitated a new research focus area with particular emphasis on the human and organisational factors involved [16, 33]. Factors that will contribute to the acceptance of HIS by health care workers include the attitude of the health care worker towards the HIS, the leadership style, the organisational structure, and change management when planning and implementing the technology. Individual barriers reported include the computer literacy skills of the healthcare workers and their awareness about the purpose and benefit of the system [25, 33]. Often healthcare workers are not consulted when new systems are designed, which could mean that the workload of the healthcare worker is increased as the technology does not fit into daily workflow processes [33]. While some EPR systems do capture limited clinical information, there seems to be no EPR that supports patient-centred clinical care in South Africa [34]. There is also limited evidence of the effectiveness of EPR systems in the PHC system at present, which has resulted in pilot projects not being sustainable [30].

4 Discussion

From the literature it is clear that the National Department of Health has prioritized HIS to improve the health care quality especially in the public health care sector, however there is no implementation plan as

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of yet. The development of HIS, despite the eHealth strategy, has been done in silos and on an ad hoc basis as the need arose for different task-based services to be completed. These legacy systems make it difficult to implement an overall HIS that will be able to serve the needs of the patient, health care worker, hospital manager and National Department of Health.

While there are clinical systems to record patient data, these are mostly support services e.g. radiology and pathology without EHRs that are able to integrate all the services. Patient-centered care is defined as "care that is respectful of and responsive to individual patient preferences, needs, and values" [35]. However, the most advanced HIS seem to support the upper level activities of the HIS pyramid such as monitoring and evaluation or administration needs of the Department of Health. The lack of patient-centered care could be one of the reasons health care workers are resisting the use of HIS as they perceive the systems as non-beneficial to their patients

In summary, existing HISs in South Africa are predominantly paper-based and geared toward M & E and administrative purposes of public health programmes. The lack of integration between the various systems that was identified makes it difficult to use the systems for patient-centric care. However, there is the beginning of integration of systems in the Western Cape which links a unique patient identifier module to a master patient index that can then be interfaced.

While some systems do capture limited clinical information, there seems to be no public sector EPR that supports patient-centred clinical care. A paradigm shift is needed in South Africa towards designing an EPR for patient care rather than for collecting epidemiological or management data. Information should support clinicians' decisions and actions; 'if it fails to do this, it is irrelevant noise'.

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Statement on conflicts of interest

There is no conflict of interest that the authors need to declare.

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Perceptions of EMR usage by health sciences students in Ghana

Frances Baaba da-Costa Vroom [a,*], Anthony Godi[a], Samuel Dery[a], Seth Afagbedzi[a]

[a]School of Public Health, University of Ghana, Legon, Ghana

Background and Purpose: Electronic Medical Records improve healthcare delivery, reduce medical errors and costs among many other benefits. A knowledgeable and willing workforce is an important antecedent to actual EMR use. Students in health training institutions should be educated about these tools in order to encourage adoption in their future workplaces. This study therefore set out to identify factors that could influence perceptions of EMR use among College of Health Science students.
Methods: This was a cross-sectional study of students of the College of Health Sciences, University of Ghana. EMR perception was measured on 5 domains using a 5-point Likert scale measured from 1 (Strongly disagree) to 5 (Strongly agree). Chi-square tests examined significant differences in the levels of agreement across the respondents' background characteristics, experience and knowledge in computing. Means were used to determine ranking of applications/tools thought to be most useful for respondents' work.
Results: The study identified age, school affiliation, type of study, health sector work experience, frequency of computer use and knowledge of eHealth communication techniques as factors influencing students' perception of autonomy and physician-patient relationship. Again, type of study, frequency of computer use and knowledge of eHealth communication techniques were the factors influencing students' perception of ease of use, usefulness and attitude of physicians.
Conclusions: Findings from this study bring to the fore, the need for inclusion of health informatics curricula in training health professionals. This will ensure easier adoption of EMR technology as the country journeys towards a paperless health care delivery system.

Keywords: User acceptance, medical education, electronic health records

1 Introduction

Electronic Medical Records (EMR) surfaced in the 1960's with the hope of transforming healthcare delivery [1]. They are known to improve healthcare quality, reduce medical errors and reduce costs, among others [2]. An important component that plays a crucial role in achieving these healthcare delivery improvements is the human resource for eHealth. Workforce, is a component in the eHealth framework proposed by the WHO and development of human resource to engage eHealth should be the focus of every country [3]. Similarly, Strategy 2 in Ghana's eHealth Strategy focuses on building capacity for eHealth, while Strategy 4 entails moving towards a paperless records and reporting system [4].

While these frameworks and strategies spell out what countries should do to maximize the potential in eHealth, there are possible bottlenecks that could slow this process down. A number of factors influence the adoption and use of EMRs in various settings both positively and negatively. EMR implementations are challenged by high initial costs, workflow reengineering, inadequate training, user resistance and many more [5, 6]. Among the many challenges, user resistance was found to be a primary hindrance to adoption in a pilot situation in Ethiopia [7]. This could be as a result of poor computer literacy or lack of knowledge of eHealth. Health professionals are major stakeholders in the use of EMR and their

*Corresponding author address: [a]School of Public Health, University of Ghana, Legon, Ghana, Email: fbvroom@ug.edu.gh, Tel: +233 267338320
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willingness to adopt this new technology is critical. The Ghana Ministry of Health (MOH) has indicated the inadequacy of eHealth skill sets in the country and the need to improve this situation by incorporating computer and eHealth literacy in health professionals training curriculum [4]. Students training as healthcare professionals ought to be trained on eHealth since their exposure or lack of it can influence their adoption behaviour for future use. Currently, few health facilities have implemented EMRs in Ghana, based on anecdotal evidence and few published literature reviews on the subject [8, 9]. Paper-based records are being used in the health facilities even though they are fraught with challenges such as inadequate space for storing paper-based records, missing and duplicate patient records [10]. Thus students being trained in health institutions lack or have inadequate exposure to EMRs during their training. Out of the four medical schools training medical doctors in Ghana, only one has a medical informatics course as part of the curricula [11]. Nursing training schools also, did not have informatics as part of their curricula until recently [12]. This could potentially hamper their acceptance and adoption of EMRs when they are eventually introduced in health facilities where they may practice. Based on these issues outlined with EMR adoption, this study set out to identify factors that influence perceptions of EMR use among College of Health Science students in Ghana. Knowing health students perceptions of EMR use could help in acceptance and identifying potentially negative attitudes [13]. It could also provide more justification for its mandatory inclusion in health professional training curricula in to minimize future change management challenges.

2 Materials and methods

This paper is part of a cross-sectional study to examine the knowledge, attitudes and use of ICT tools (computers, mobile phones/devices and Internet) and eHealth in general by students of the College of Health Sciences, University of Ghana. The College of Health Sciences has six schools with each having different levels of academic progression, from entry year undergraduates to postgraduates at the PhD level.

Sample size was estimated based on simple random selection with the expected proportion of the outcome(s) set at 0.5±0.03, 95% confidence level and adjusted for potential nonresponse by up to 10%. The 773 students who responded were randomly selected from all the levels of the six schools under the College proportionately according to the relative school and class sizes. In most instances, the questionnaires were self-administered with support from data collectors where further help was sought.

The dependent variables on agreement to the various domains on EMR perception were measured on a 5-point Likert scale where 1= Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree and 5= Strongly agree. Both categories under agreement and disagreements were merged as one, resulting in a 3-point Likert scale (Disagreement, Neutrality and Agreement) for analysis.

Chi-square tests were carried out to find out if there were significant differences in the levels of agreement across the respondents' background characteristics, experience and knowledge in computing. Where assumptions underlying the use of Chi-square failed, Fisher's exact tests were used. Alpha levels of significance for these tests were indicated at 5%, 1% and 0.1% and for nonsignificant relationships, exact p-values were stated. Means and standard deviations were also used to determine ranking of applications/tools thought to be most useful for respondents' work. Microsoft Excel 2010 was used for data management and Stata 13 for analysis.

3 Results

The total number of respondents was 773 students at a response rate of 95%. There were almost equal number of males and females with females making up 49.4% of total participants. Majority of respondents were between the ages of 20-24 years (51%). About 43% of participants were Medical School students with about 71% being Undergraduates. Sixty-five percent (65%) had no health sector working experience, majority (82.5%) owned a computer and about 55% of these used it 5-7 days a week. A good number were familiar with eHealth (62.4%) and had knowledge of more than three (3) communication techniques used in eHealth (63%). Details of socio-demographic characteristics can be found in Table 1.

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3.1 Perception of Autonomy

About 40% of all students agreed on the perception that EMR would negatively affect physician's attitude due to security, legal and ethical concerns. There wasn't a significant difference in the level of agreement among males and females. Most students who were 30 years and older (60%) disagreed that EMR would affect physician's attitude, while 51% of participants below 20 years agreed with this statement. Students in Public Health (63%) also largely disagreed with this perception, while Medical (48%), Dental (43%) and Allied Health (48%) students moderately agreed. There was also a significant difference between perceptions of those with health sector work experience (50%) and those who did not have such experience (44%). Participants owning computers disagreed with this perception as well (30%). Familiarity with eHealth and knowledge of eHealth communication techniques did not show significant differences to influence this perception. Details in Table 1.

3.2 Perception of EMR effect on physician - patient relationship

In all, 41% of all participants agreed that EMR would likely interfere with physician – patient interactions. Among males and females, there was higher level of agreement. Participants who were 30 years and more, mostly disagreed (64%) with this assertion while those less than 20 years agreed (60%) there would be interference in interactions. In terms of School affiliation, those in Allied Health (51%), Dental (53%) and Medical (50%) School mostly agreed there would be negative effect on doctor-patient interactions while students in Public Health (68%) mostly disagreed. The details are shown in Table 1. There were significant differences in the levels of disagreement for ever working in the health sector (50%), more than 5 years health sector work experience (69%) and high agreement due to familiarity with eHealth, mHealth and Telemedicine.

3.3 Perception of Ease of Use (PEOU) of EMR

There was a generally positive high level of agreement on participant's perceived ease of use among all participants (71.3%). There was a significantly high agreement among participants based on the type of study ($p < 0.05$), frequency of computer use ($p < 0.01$) and knowledge of communication techniques used in eHealth ($p < 0.05$) (Table 1).

3.4 Perception of Usefulness (PU) of EMR

Similar to the high level of agreement on the PEOU of EMR, there was also a high level of agreement of participants on the usefulness of EMR to clinical practice. Overall, 74% of participants agreed that EMR would be useful for clinical practice. School affiliation ($p < 0.05$), frequency of computer use ($p < 0.05$) and knowledge of communication techniques ($p<0.01$) all showed significant differences between the levels of agreement and disagreement within the categories of the independent variables. Details in Table 2.

3.5 Attitude about EMR Usage

Attitude towards EMR usage was generally positive with 74% of participants showing a positive attitude. Participant's type of study ($p < 0.01$), frequency of computer use ($p < 0.05$) and knowledge of eHealth communication techniques ($p<0.01$) all showed significantly high levels of agreement. Details can be found in Table 2.

3.6 Barriers to eHealth Knowledge

As shown in Figure 1, participants indicated some barriers that were a hindrance to them in improving their eHealth knowledge. A lack of exposure to technology was indicated to be the biggest barrier to participants (52%). This was followed by lack of education (49%), lack of guidance (45%) and lack of time (36%).

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Figure 1. Main barriers to improving eHealth Knowledge

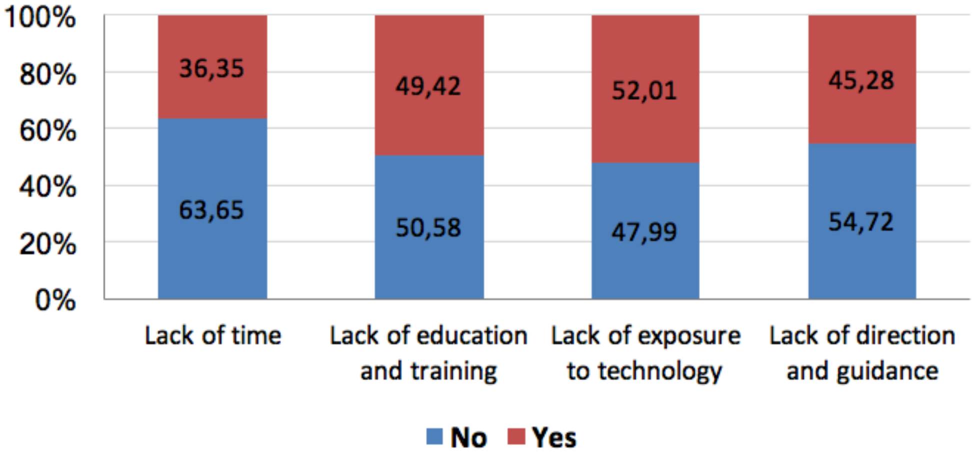

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Table 1: Relationships between respondents' characteristics and perceptions on EMR use

	Total	Autonomy (% of total)				Patient relationship (% of total)				Perceived ease of use (% of total)			
	N (%)	D	N	A	P-value	D	N	A	P-value	D	N	A	P-value
Sex					0.578				0.202				0.561
Female	382 (49.4)	28.3	19.4	39.0		30.1	18.9	38.2		2.6	13.1	72.5	
Male	383 (49.6)	25.6	21.2	41.8		26.9	16.7	44.9		3.9	13.8	70.2	
Age (years)					<0.001				<0.001				0.103
<20	144 (18.6)	13.9	21.5	50.7		12.5	15.3	59.7		1.4	10.4	75.7	
20 – 24	394 (51.0)	23.4	20.8	43.9		24.9	19.3	43.9		3.1	14.7	70.8	
25 – 29	111 (14.4)	30.6	22.5	34.2		32.4	20.7	33.3		8.1	10.8	66.7	
30+	89 (11.5)	59.6	12.4	20.2		64.0	13.5	15.7		2.3	14.6	76.4	
School					<0.001				<0.001				0.091
Allied Health	170 (22.0)	24.7	21.2	44.7		25.3	14.7	50.6		5.3	11.2	74.1	
Dental	51 (6.6)	9.8	31.4	43.1		11.8	19.6	52.9		2.0	21.6	62.8	
Medical	331 (42.8)	16.3	20.9	48.0		17.2	18.1	50.2		2.7	11.8	71.0	
Nursing	92 (11.9)	43.5	14.1	23.9		42.4	21.7	18.5		4.4	19.6	58.7	
Pharmacy	46 (6.0)	34.8	23.9	37.0		39.1	23.9	28.3		0.0	19.6	76.1	
Public Health	83 (10.7)	62.7	12.1	19.3		68.7	14.5	13.3		2.4	9.6	83.1	
Type of study					<0.001				0.002				0.028
Undergraduate	547 (70.8)	26.0	18.8	43.3		28.0	16.8	44.2		3.1	12.8	73.7	
Clinical/GEMP	179 (23.2)	22.9	26.8	33.0		24.0	23.5	33.5		4.5	17.3	59.2	
Postgraduate	47 (6.1)	55.3	8.5	34.0		51.1	8.5	38.3		0.0	6.4	89.4	
Ever worked in health sector					<0.001				<0.001				0.858
No	505 (65.3)	21.2	21.4	43.8		22.2	18.2	45.9		3.4	14.3	69.1	
Yes	168 (21.7)	50.0	17.3	22.6		50.0	19.1	22.0		4.2	13.7	72.6	
Health sector working experience (years)					0.050				<0.001				0.390
<5													
5+	86 (51.2)	41.9	22.1	23.3		34.9	24.4	29.1		5.8	15.1	67.4	
	74 (44.1)	62.2	10.8	21.6		68.9	13.5	13.5		2.7	12.2	79.7	
Frequency of computer use (days per week)					<0.001				<0.001				0.008
1-2													
3-4	56 (7.2)	21.4	26.8	28.6		35.7	23.2	23.2		5.4	23.2	51.8	
5-7	175 (22.6)	16.0	12.6	63.4		21.7	8.6	59.4		3.4	8.0	78.9	
	425 (55.0)	36.7	24.2	28.0		34.8	23.1	31.8		3.5	14.6	72.0	
Familiar with					0.202				0.003				0.919
e-health (electronic health)	482 (62.4)	28.6	22.0	42.1		29.7	19.3	44.2		3.9	14.1	75.3	
Telemedicine	450 (58.2)	26.2	22.7	44.2		26.4	20.0	47.3		3.8	14.2	76.2	
m-health (mobile health)	444 (57.4)	26.4	20.7	45.1		27.3	16.7	48.4		3.8	13.3	75.7	
Knowledge of communication techniques used in e-health					0.295				0.529				0.049
<3	285 (36.9)	27.0	15.8	37.2		27.7	14.7	36.5		3.5	15.8	60.7	
3+	488 (63.1)	27.1	22.5	42.2		28.9	19.7	44.3		3.1	12.1	77.5	
Total	773 (100.0)	27.0	20.1	40.4		28.5	17.9	41.4		3.2	13.5	71.3	

D=Disagree, N=Neutral, A=Agree. Missing value frequencies and percentages not shown.

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Table 2: Relationships between respondents' characteristics and perceptions on EMR use

	Total	Perceived usefulness (% of total)				Attitude about EMR usage (% of total)			
	N (%)	D	N	A	P-value	D	N	A	P-value
Sex					0.266				0.592
Female	382 (49.4)	1.6	9.2	75.1		2.4	9.2	71.7	
Male	383 (49.6)	3.4	10.2	73.9		3.4	8.1	76.2	
Age (years)					0.306				0.490
<20	144 (18.6)	4.9	6.3	75.0		2.8	6.3	75.0	
20 – 24	394 (51.0)	1.8	10.9	73.9		2.3	9.9	72.6	
25 – 29	111 (14.4)	1.8	10.8	73.0		3.6	10.8	71.2	
30+	89 (11.5)	2.3	7.9	82.0		4.5	5.6	82.0	
School					0.021				0.424
Allied Health	170 (22.0)	5.3	7.7	76.5		4.1	7.7	77.1	
Dental	51 (6.6)	0.0	9.8	70.6		0.0	7.8	72.6	
Medical	331 (42.8)	0.9	9.7	73.4		2.1	8.8	71.3	
Nursing	92 (11.9)	1.1	14.1	67.4		3.3	12.0	66.3	
Pharmacy	46 (6.0)	4.4	17.4	69.6		2.2	13.0	71.7	
Public Health	83 (10.7)	4.8	4.8	86.8		4.8	3.6	88.0	
Type of study					0.191				0.003
Undergraduate	547 (70.8)	2.7	8.6	77.0		2.9	7.9	76.1	
Clinical/GEMP	179 (23.2)	1.7	13.4	63.7		3.4	12.9	61.5	
Postgraduate	47 (6.1)	2.1	8.5	85.1		0.0	0.0	95.7	
Ever worked in health sector					0.715				0.449
No	505 (65.3)	2.6	10.7	71.9		2.6	9.5	71.1	
Yes	168 (21.7)	2.4	8.9	78.6		4.2	7.7	78.0	
Health sector working experience (years)					0.057				0.810
<5									
5+	86 (51.2)	0	11.6	74.4		3.5	8.1	74.4	
	74 (44.1)	5.4	6.8	83.8		5.4	6.8	83.8	
Frequency of computer use (days per week)					0.002				0.022
1-2									
3-4	56 (7.2)	7.1	16.1	57.1		5.4	14.3	58.9	
5-7	175 (22.6)	1.1	5.7	84.6		1.1	5.7	83.4	
	425 (55.0)	2.4	11.8	74.6		3.5	9.4	74.1	
Familiar with					0.872				0.318
e-health (electronic health)	482 (62.4)	3.5	10.0	79.5		3.9	9.1	78.8	
Telemedicine	450 (58.2)	3.6	11.3	78.7		3.8	9.8	80.0	
m-health (mobile health)	444 (57.4)	3.4	10.1	78.4		2.9	7.7	80.6	
Knowledge of communication techniques used in e-health					<0.001				<0.001
<3	285 (36.9)	4.9	9.1	63.9		5.6	10.2	60.4	
3+	488 (63.1)	1.0	10.0	80.5		1.2	7.6	81.8	
Total	773 (100.0)	2.5	9.7	74.4		2.9	8.5	73.9	

D=Disagree, N=Neutral, A=Agree. Missing value frequencies and percentages not shown.

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3.7 Important EMR Components for Participants Practice

In ranking the importance of various EMR applications or tools, Patient Registration was the most highly ranked tool among the various Schools. Participants in the Dental, Medical and Public Health Schools considered Patient Registration as the most important tool for their work. The Doctor's Clinical Documentation was also ranked 2nd most important tool by the Dental, Nursing and Public Health Schools. As would be expected, tools pertinent to specific job roles were ranked highest in their corresponding schools. For example, Pharmacy students ranked Pharmacy management highest followed by Drug registry and Drug/Allergy Alerts. Nursing students also ranked Nursing Documentation highest, followed by Doctor's Documentation and Patient Registration. Details can be found in Table 3.

Table 3. Ranking of applications/tools though to be most useful for respondents' work

	Ranking						
Application	Overall	Allied Health	Dental	Medical	Nursing	Pharmacy	Public Health
Patient registration	1	3	1	1	3	4	1
Doctor's clinical documentation	2	1	2	3	2	6	2
Appointment scheduling	3	2	4	2	6	11	4
Nursing documentation/charting	4	5	3	4	1	7	3
Pharmacy management	5	7	8	8	4	1	7
Drug/Allergy alerts	6	12	6	9	5	3	11
Drug registry	7	9	7	11	7	2	10
Medical imaging	8	6	11	5	9	13	8
Telemedicine	9	8	10	6	11	8	12
Laboratory documentation	10	4	9	10	10	10	6
Electronic billing and insurance e-claims	11	10	5	7	13	12	9
Physician order request	12	11	13	13	8	9	5
e-Prescribing	13	13	12	12	12	5	13

(1 = Most useful, 13 = Least useful)

4 Discussion

This study set out to determine factors influencing health trainee's perception of EMR use. Frequency of computer use, type of study, School affiliation, knowledge of eHealth communication techniques, age and working experience with the health sector generally were factors identified to influence student's perception of EMR use. Overall, sex of participants did not influence perception of autonomy, effect of physician-patient relationship, PEOU, PU and attitude.

Factors influencing perception of Autonomy and Physician-patient relationship were similar. Participants in the less than 20 age group were mostly undergraduates while the above 30 years group were mostly Post graduates students at the School of Public Health and had some health sector working experience [14]. The less than 20 age group are known to have better utilization and experience with ICT [15]. Their experience with ICT would feed into their perceptions of security challenges that could arise with the use of EMRs for patient care. These findings are however in line with a study of EHR use perceptions among 3rd year medical students who had been exposed to EHR documentation in their training [16]. Also, the above 30 age group and participants with health sector experience also largely disagreed to the lack of autonomy due to security challenges and negative impact on physician-patient relationship. This may be due to experience or exposure with EMRs in their various places of work. These varied perceptions may call for the students to be trained in using EMRs during their clinical

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clerkship. There may also be the need to engage them with demonstration versions of real EMRs being used in health facilities in the country. EMR demonstrations were found to improve physician's, staff and patients knowledge and attitude to EMRs [5].

Few of the influencing factors identified in this study were significant on perceived ease of use. Participants largely agreed that EMRs would be easy for physicians to use in clinical practice. Differences among the sexes could not be found unlike other studies [17].The Undergraduate and Postgraduate students agreed very much with this statement, more than the clinical year students. There was a significant difference in the levels of agreement on frequency of computer use and knowledge of eHealth communication techniques. Participants using computers more than three times a week can be said to have a high computer efficacy and this can generally translate to higher expectations of ease of use [17, 18].

Perceived usefulness describes how useful a piece of technology is to an individual for use in a specific setting. Almost all participants in the various Schools agreed on the usefulness of EMR for clinical practice. Again, using computers 3 to 4 times a week was a significant factor influencing one's perception of the usefulness of EMRs for clinical practice. This could invariably mean a high self-efficacy which is a good influencer of PU among health care trainees [18]. In addition, having more knowledge about eHealth communication techniques was a good influencer of the perception of the usefulness for clinical practice. This shows students may have some knowledge about eHealth and this can be furthered by introducing them to medical informatics in their various fields of training.

Having a positive attitude about technology encourages its use [19, 20]. A greater number of postgraduate students agreed with the perception of physician's having a positive attitude towards EMR use. Type of study, frequency of computer use and knowledge about eHealth communication techniques have an effect on an individual's perception of EMRs being received with a positive attitude. PEOU and PU have been theorized to influence attitude to use technology for a specific purpose and a positive response is expected to result in actual use of the technology [21]. This can be expected to show smoother EMR adoption among these participants when they begin real world clinical practice.

The perceptions investigated are commonly found under the technology acceptance model (TAM) theoretical framework. The constructs in TAM focus on the causal relationships between PEOU, PU, attitude and actual use of technology systems [21]. Respondents in this study had similar perceptions with regards to the three constructs. If this study had been conducted within the context of the TAM theoretical framework, it could have shown a positive prediction for actual use of EMR. These results show promise for policy makers as attempts are being made to implement eHealth in various aspects of health care delivery in the country.

This study found that participants generally had positive perceptions on the ease of use, usefulness of EMRs and attitude towards EMR use. These show great promise for Ghana's health workforce as the country journeys towards a paperless health care delivery system. It will be crucial for health training institutions and teaching hospitals to incorporate health informatics curricula and as well introduce students to live EMR demonstrations to help them build experience for future use in clinical settings. Nursing informatics training should be encouraged for nursing training institutions in the country. The Ministry of Health and Ghana Health Service could consider providing infrastructure and resources for these training institutions in order that eHealth training could be improved. This would reduce training time and the learning curve for these future professionals when they are finally employed by the Service in facilities where these tools are being used.

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Statement on conflicts of interest

The authors declare there are no competing interests.

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Data Dissemination and Use (DDU) Strategy Development: Design of the DDU Strategy Methodology

Mecky Isaac Matee [a]*, Geoffrey Somi [b], Desderi Wengaa [c], Niamh Darcy [c], Sriyanjit Perera [d]

[a] Muhimbili University of Health and Allied Sciences, Dar Es Salaam, Tanzania
[b] Ministry of Health. Community Development, Gender, Elderly and Children, Dar Es Salaam, Tanzania
[c] RTI International, Dar Es Salaam, Tanzania
[d] CTS Global, Assigned to U.S. Centers for Disease Control and Prevention, Dar es Salaam, Tanzania

Background and Purpose: The Tanzanian Ministry of Health, Community Development, Gender, Children and Elderly (MOHCDGEC), during the development of its Health Sector Strategic Plan III, identified the need for strengthened Monitoring and Evaluation (M&E) in the health sector and improved evidence based decision making. The MOHCDGEC developed a detailed M&E strengthening initiative (MESI) 5-year operational plan that included the development of a national data dissemination and use (DDU) strategy as response to the M&E and Health Management Information System (HMIS) situational analysis. The goal of the DDU strategy is to promote dissemination and better use of health information to drive effective and evidence-based decision-making in the health sector. MOHCDGEC, together with its M&E and DDU teams and other supporting partners, underwent a detailed process to develop the DDU strategy. This process included primary and secondary qualitative research. Within the methodologies employed in developing the DDU strategy, there are potential best practices, insights, and difficult lessons learned that may help inform the DDU strategy development in other countries or working groups in the region.

Methods: The development of the DDU strategy was done in three main phases. Phase 1 and Phase 2 follow a qualitative research methodology with qualitative data collection and analysis. Phase 3 used the Tanzania eHealth strategy development framework to take the results and develop the strategy. Phase 1: Planning and inception phase entailed rapidly assessing existing DDU tools, drafting a DDU strategy outline, creating a roadmap for DDU strategy development, developing 12 DDU monitoring indicators based on international best practices, and establishing research protocols and tools for data collection to inform DDU strategy development. Phase 2: Qualitative data collection and analysis, which involved in-depth desk review, orientation of data collectors, field data collection at the national level and district level in two regions, data analysis, and development of key preliminary findings. Phase 3: Drafting the strategy; review and finalization development included using the key findings from Phase 2 and inputs from the DDU Working Group to draft DDU strategy, presenting the draft strategy to the DDU Working Group, assigning the final strategy reviewers, circulating the draft strategy to stakeholders for review and feedback, and finalizing the draft strategy using feedback received from across Tanzania.

Results: During the development of the DDU strategy, in Phase 1, the initial MESI 5-year plan had proposed using some existing DDU tools for a rapid secondary data review, which was to be used to develop the DDU strategy, following the initial draft DDU strategy outline proposed in the 5-year plan. However, these secondary data were lacking details on certain key aspects of DDU, and had not included taking advantage of the experience gained through the rollout of the revised national HMIS and District Health Information Software (DHIS2) in some regions, compared to other regions with neither. MOHCDGEC decided to proceed with primary qualitative research, looking at broader stakeholder representation across all levels of the health system, including users with DHIS2 familiarity, those who were using the revised national HMIS tools, and those who were still using the older, paper-based HMIS and its associated reporting mechanism. This was combined with secondary data research to provide a more comprehensive view of DDU strengths, weaknesses, opportunities and threats in Tanzania. The results were used to develop the DDU strategy using the same strategy framework that Tanzania had developed and used for developing the Tanzania national eHealth Strategy.

*Corresponding author address: Muhimbili University of Health and Allied Sciences, Dar Es Salaam, Tanzania, Email: mateemecky@yahoo.com
Tel: +(255)-713-081-162
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Conclusions: The development process of the Tanzanian DDU strategy evolved as the MESI DDU team made amendments based on lessons learned during the first phase and on taking advantage of having users both with and without DHIS2 experience and also with the revised HMIS tools and the old HMIS tools. The lessons learned ensured that the DDU key objectives were more clearly identified and used to inform primary data collection and analysis, along with ensuring that a broader set of stakeholders were interviewed, thus representing all levels of the health system. This led to the development of a more comprehensive and usable final DDU strategy.

Keywords: Data dissemination and use, Health information, Decision-making, National health strategy, Information use

1 Introduction

Health Data Dissemination and Use (DDU) is fundamental for informed public health action and effective management of health resources [1]. In Tanzania, however, data collection and use do not always take place at all levels of the health system [2]. This is mainly due to inadequate systems, processes, knowledge, and skills [3]. Health data are not always readily available to be used by Tanzania's routine Health Management Information System (HMIS) for generating trustworthy, applicable, and up-to-date information [3].

Overall, the situation with regard to health information in Tanzania, up to the year 2012, is of a considerable amount of data that potentially are available from routine data collection and from population surveys and research, but access to reliable, timely, complete, and useful information has continued to be poor [3]. As a result, use of information for decision-making has been limited, and parallel but uncoordinated systems of data collection have been set up to meet specific health-sector needs. This situation has resulted in the identification of the need for further integration of programs and systems into a broader health-sector data warehouse as a central source of information. The development of a health-sector data warehouse also seeks to improve the collection, dissemination, and use of health data and also to ensure that data are collected only once but are used many times [4].

The data collected routinely through the HMIS (2008–2009) is widely regarded by stakeholders as unreliable and cannot be depended on for effective planning [1]. In most developing countries, particularly in sub-Saharan Africa, evidence shows that the continued use of paper-based systems contributes to poor data quality in terms of reliability, availability, timeliness and completeness of reporting and also compromises health service delivery [5-7]. In Malawi, for instance, Makombe et al. [6] found that the use of paper-based health facility reports to generate national summaries resulted in a 12% underreporting of persons on first-line antiretroviral treatment because many sites did not submit accurate data on the national level. In South Africa, Garrib et al. [7] found that 2.5% of the total data values that should have been collected at 10 primary health care clinics using a paper-based system were missing, while 25% of the data were outside the minimum and maximum values specified for the facilities. In Zanzibar, there was an improvement with data quality through the use of quarterly data-use workshops[8].

As a result of these challenges, the health sectors in most developing countries lack the culture of information use for evidence-based decision-making at different levels, especially at the level of facilities, which are the primary sources of data. Against this backdrop, the Government of the United Republic of Tanzania, with technical assistance from international development partners, launched a 5-year Monitoring and Evaluation (M&E) Strengthening Initiative (MESI) in 2011. MESI aims to enhance evidence-based decision-making in the Tanzanian health sector [3].

In 2011, MESI was divided into eight work streams, one of which focused on DDU to ensure that the Tanzanian health sector develops a data-use culture that demands quality information at all levels to facilitate evidence-based decision-making, transparency, and accountability to continuously improve quality of care and health services delivery. The DDU work stream included development of a DDU strategy for the country that is in line with the Health Sector Strategic Plan (HSSP III), 2009–2015, and the National Strategy for Growth and Reduction of Poverty (NSGRP) [9,10]. The goal of the DDU strategic initiative is to take advantage of current initiatives that aim to strengthen M&E (including

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HMIS) and eHealth [11], which is a cost-effective and secure use of Information and Communications Technology (ICT) in support of health and health-related fields.

The aim of the DDU strategy was to outline data-use procedures and provide feedback to lower levels and within levels, harnessing data analysis skills of program staff at all levels and encouraging use of HMIS data to strengthen teamwork at all health system levels and across vertical programs and enables stakeholders, including policymakers, to optimize health-care services and coverage and to improve quality and, ultimately, health status and outcomes. During 2013, MESI changed from managing by work packages to managing by the following three core objectives: (1) ensure regular detailed analysis and interpretation of existing data using best international practices, (2) improve data dissemination, and (3) institutionalize data use and evidence-based decision-making within routine work practices, processes, and work culture throughout the health sector. The DDU strategy addresses all three of these high-level MESI objectives.

During the period from 2011 to 2014, MOHCDGEC has strengthened the HMIS and introduced the District Health Information System Version 2 (DHIS2), used at the district level for entering HMIS summary information monthly. Since then, significant improvements have been achieved in data handling and reporting. MOHCDGEC reported an overall national form completeness rate of 95.66% and on-time submission rate of 90.3% for the period between July and September 2015 for the main HMIS reporting forms at the national level, which is a significant improvement compared with the completeness rate of 67.9% reported in the quarter from October to December 2013 [12].

This paper does not address if implementation of the DDU strategy will achieve the stated aims, and this additional research will need to be conducted post-implementation of the DDU strategy. This paper describes the methodology used by the MOHCDGEC in developing its DDU strategy for the health sector and lessons learned in using the proposed methods and revisions made to these methods. Other countries in similar circumstances may use Tanzania's experience to develop their own DDU strategy.

2 Materials and methods

The initial plan was to go from Phase 1 (mainly focused on secondary data review, with a small set of qualitative interviews) directly to the second phase of the DDU strategy development, without the more detailed interim phase of broad stakeholder primary research. Given the timing of when the DDU team assembled to work on the DDU strategy in earnest, there was the opportunity to gather primary research data from users who used the revised paper based HMIS tools and DHIS2, and those who had just worked with the old paper based HMIS tools and the older HMIS reporting system. This allowed the DDU team to broaden the base of stakeholders involved in primary research, to include all levels of the health system and map the DDU goal “to identify DD&U practices and gaps in the Tanzanian health sector to inform the DD&U Strategy” to the main research objective, “to establish the data dissemination and use strategy, including data collection procedures, and monitoring and feedback mechanisms to ensure data quality, which will be implemented at all levels of the health system.” The development of the DDU strategy was done in three main phases.

Phase 1: Planning and inception phase entailed rapidly assessing existing DDU tools, drafting a DDU strategy outline, creating a roadmap for DDU strategy development, developing 12 DDU monitoring indicators based on international best practices, and establishing research protocols and tools for data collection to inform DDU strategy development. Phase 2: Data collection and analysis involved in-depth desk review, orientation of field data collectors (qualitative interviews), field data collection (qualitative interviews) at the national level and district level in two regions, data analysis, and development of key preliminary findings. Phase 3: Using the research results and applying the eHealth Strategy development framework to develop the DDU strategy; review and finalization development included using the key findings from Phase 2 and inputs from the DDU Working Group to draft DDU strategy, presenting the draft strategy to the DDU Working Group, assigning the final strategy reviewers, circulating the draft strategy to stakeholders for review and feedback, and finalizing the draft strategy using feedback received from across Tanzania.

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Phase 1: Planning and Inception Phase

Identification of DDU Team

This process started in November 2011, with MOHCDGEC identifying a DDU core team composed of public health specialists, social scientists, M&E specialists, statisticians, and health systems managers. The DDU core group included MESI MOHCDGEC staff and MESI implementing partners' Technical Assistance (TA) team.

Background Information and Initial Plan

The first task of the MESI DDU core team was to conduct a brief DDU assessment (existing Tanzania DDU secondary data review) and then to review and discuss other country best practices in DDU and health profiles. This resulted in the DDU core team producing the following outputs:

1. draft overviews/templates for regional, district, and facility health profiles;
2. an inventory of existing health information products in Tanzania;
3. a summarized review of existing tools and methodologies used to measure/evaluate DDU;
4. draft DDU monitoring indicators; and
5. an initial draft DDU strategy outline.

This component stretched between November 2011 and June 2012.

Initial Draft of the DDU Strategy: Outline and Tools

The DDU core team brainstormed and reviewed best practices, including the MESI 5-year plan to define the DDU research objectives and developed a comparison matrix to review existing data use and M&E tools [13-15, 17-21]. The team used these to create DDU data collection tools, and draft the proposed DDU monitoring indicators. However, during the review, the DDU core team determined that it was too early to pilot the draft DDU monitoring indicators before the qualitative research results were available that described the monitoring priorities. Without understanding the monitoring priorities from the qualitative interviews, it would not be useful to test out monitoring indicators. The DDU core team decided to wait until the research was completed before revisiting these DDU monitoring indicators. The DDU core team realized that the initial DDU strategy outline, while useful for assisting with key research objectives, was too prescriptive ahead of conducting the research and did not include sufficient local Tanzanian DDU context that would be used to inform the DDU strategy content. The DDU core team discontinued the draft DDU strategy outline and instead focused on this detailed DDU research (desk review and qualitative interviews), allowing the DDU strategy outline and document to be shaped based on the research results.

Development of DDU Research Protocol

The overall objective of the DDU research was to "to establish the data dissemination and use strategy, including data collection procedures, and monitoring and feedback mechanisms to ensure data quality, which will be implemented at all levels of the health system," which would be used to develop the data dissemination and use strategy. The research was based on broad DDU multi-stakeholder interviews and on issues regarding data collection procedures, monitoring, and feedback mechanisms at all levels of the health system.

To achieve this high-level objective, specific sub-objectives were included in the research for the following themes:

- current legal and policy framework, including guidelines and protocols;
- main routine and non-routine health data generated within all levels of the health system;
- current practices for data dissemination within the health system at all levels;
- strengths, weaknesses, opportunities, and threats of the current data-use practices at all levels of the health system; and
- available human capacity for DDU at all levels.

The development of the DDU research protocol involved several steps, as outlined below:

- development of a draft DDU research protocol and the data collection instrument (focused on the listed research objectives and sub-objectives);
- several rounds of brainstorming and consultation with ministry officials;

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- submission of the protocol and tool to the National Institute of Medical Research (NIMR) Institutional Review Board (IRB) for technical input and to ensure activity follows country's ethics requirements;
- training of data collectors in a 4-day workshop on the data collection tools and informed consent procedures;
- pretesting of the data collection tools in a pilot facility;
- revision of the data collection tools and of the protocols for informed consent and DDU assessment; and
- presentation of the research protocol and data collection tools to the Tanzanian Medical Research Coordinating Committee for ethical clearance.

Following approval by the NIMR Ethics Committee, the process of data collection and desk review was conducted to obtain necessary information about DDU practices in Tanzania.

Phase 2: Data Collection and Analysis

Data Collection and Documentation

The DDU research team carried out a desk review of national health-related protocols, standard operating procedures (SOPs), and other relevant policy, planning, and budget documents related to DDU (Table 1). The aim of the review was to understand existing technical, human, and institutional resources for DDU and gather content of technical guidelines for data collection, data management, data analysis, and data dissemination and use.

Table 1: A summary data collection tools used in the desk review and in interviewing key informants

Activity	Data collections tools	Aim
Desk Review	National health-related protocols, standard operating procedures, and other relevant policy, planning, and budget documents related to data dissemination and use (DDU)	To understand the current technical, human, and institutional resources for DDU and the content of technical guidelines for data collection, data management, data analysis, and data dissemination and use.
Key Informant Interviews	National, regional, and district-level health officials; implementing partner staff (Appendix 1: Common Semi-Structured Interview Guide).	To understand norms and practices in DDU, including implementation of protocols and SOPs and human capacity in implementing DDU across a range of health officials and workers to examine the DDU in different contexts in the health-care system.

Data collection started with key informant interviews targeting national-, regional-, district-, and health facility–level decision-makers in public and private facilities and also staff from international nongovernment organizations (Table 2). Purposive sampling was used to recruit study participants at all levels, with a focus on the posts held and not individuals. At the central level, a range of government officials and M&E personnel were selected. Convenience sampling was used at the health centers, dispensaries and with regional and district health officials. The sample size (97) was based on the assessment objectives and the participants who were most likely to provide useful information to inform the DDU strategy. Pwani Region was selected as one region based on the extensive work that had been completed there under MESI during 2011-2013 including national rollout of MTUHA version 3. Kilimanjaro was selected since it is a more rural region and was not part of this first phase of national rollout of MTUHA Version 3, with both districts in Kilimanjaro expected to give a broad picture of current practices, barriers and needs for data dissemination and use. Interviewers used a semi structured interview guide during the interview that provided an understanding of norms and practices in DDU, including implementation of guidelines and standard operating procedures (SOPs) and human capacity for DDU and to examine DDU in different contexts of the health care system. The data collection team experienced no difficulties in having people participate in these interviews. All 97 selected candidates agreed to interview and made the time to participate and share their views.

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Table 2: Key informants interviewed at each administrative level and respective sample sizes

Level	Staff	Sample Size
Central Level	Ministry of Health, Community Development, Gender, Children and Elderly (MOHCDGEC) staff at the central MOHCDGEC office: Chief Medical Officer (CMO), Assistant Director of Monitoring and Evaluation (M&E) in the Department of Policy and Planning, Head of Health Management Information System (HMIS), Head of the Department of Curative Services, Head of the Department of Preventive Services, Chief Pharmacist, Reproductive and Child Health (RCH) unit, National Resource Centre for Prevention of Mother-to-Child HIV Transmission, Health Education Unit Assistant Director, Commissioner of Social Welfare.	10
Central Level	MOHCDGEC units, departments, and partners at the central level (program technical staff and M&E focal persons): President's Office of Regional and Local Government (PORALG), Tanzania Commission for AIDS (TACAIDS), Medical Stores Department (MSD), Tanzania Food and Drugs Authority (TFDA), National AIDS Control Programme (NACP), National Malaria Control Programme (NMCP), National Tuberculosis and Leprosy Programme (NTLP), National Institute of Medical Research (NIMR), National Bureau of Statistics (NBS), Muhimbili University of Health and Allied Sciences (MUHAS) Director of Research and Publications	10
Central Level	Staff of the Muhimbili National Hospital (MNH): Director of Hospital Services, Executive Director, Chief Pharmacist, OB/GYN Head, Paediatrics Head and HIV Care and Treatment Centre (CTC) in Charge	6
Central Level	Kilimanjaro Christian Medical Centre (KCMC) – Similar to MNH	4
Central Level	International and national nongovernmental organizations (NGO)s: 1 staff member for Jhpiego, Christian Social Services Commission, and Management and Development for Health	3
Central Level	Total Interviews	33
Each Region	Regional Medical Officer (RMO), HMIS Focal Person, Regional Coordinators for HIV/AIDS, Regional Tuberculosis and Leprosy (TB/L) Officer, Regional Malaria Officer, and Social Welfare Coordinator	6 (per region)
Each Region	Health facility in charge, HIV/AIDS Coordinator, TB/L Coordinator, and Malaria Coordinator	4 (per region)
Regional Level	Total Interviews	10/region

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Level	Staff	Sample Size
Each District	District Medical Officer (DMO), District HMIS Focal Person, District AIDS Coordinator (DAC) or District TB Officer, and Reproductive and Child Health Focal Person	4 (per district)
Each District	Staff of one district hospital in each of the 2 districts: Health facility in charge	1 (per district)
Each District	Staff of 1 health centre in each of the 2 districts: Health facility in charge	1 (per district)
Each District	Staff of 1 dispensary in each of the 2 districts: Health facility in charge	1 (per district)
Each District	Ward and/or Village Chair of the Health Committee (select 2 per district across all wards/villages)	2 (per district)
Each Level	Staff of 2 community based health outreach programs in each of the 2 districts	2 (per district)
District Level Totals	Total Interviews	11/district
Combined Total	Interviews	33 Central 20 Regional 44 District 97 Interviews Total

Data Management

Data for developing the DDU strategy were obtained through review of documents and key informant interviews. Desk review included summaries of each document reviewed, written notes, matrices, or other tools used to analyze the documents. Interviews were recorded after obtaining permission from the participants. Recordings were transcribed verbatim and translated into English for analysis. The interviewer or moderator who conducted the interview transcribed a first draft of each interview. A third party who did not participate in the interview then reviewed the first draft of each transcription. The DDU field team also transcribed notes from the interviews in a similar manner. All transcripts were translated into English and stored in Word files for analysis. Personally identifying information or references to any particular interview participant were deleted from the English transcripts to protect the confidentiality of study participants. The study participant informed consents were stored separately at the MOHCDGEC from the interview transcripts. The interview recordings were destroyed.

Data Analysis

The DDU assessment team developed themes that were based on the key topics from the eight areas of the structured interview guide and then reviewed these together to finalize the list for how data will be coded. The DDU assessment team then analyzed qualitative data and discussed findings during a 5-day meeting after the data collection was completed. Analysis of key informant transcripts was done manually. Codes were developed based on key themes covered in the data collection guides and the DDU strategy research objectives and subthemes emerged during the 5-day meeting. There was no intention to characterize site differences in the analysis. The findings from this 5-day meeting were synthesized and used to create the draft key informant qualitative report, organized by themes and subthemes, which included "quotes" from the key informant interviews, which provided more context for some specific subthemes. The DDU assessment team used the results from the desk review and the key informant interviews to inform the draft DDU strategy.

Phase 3: Drafting the Strategy; Review and Finalization Development

Development of the DDU strategic development took the following steps:

- The DDU core team met several times to discuss the results of the desk review and the key informant qualitative report and to review the themes and subthemes.
- The DDU core team met to review the matrix of existing DDU methodologies and tools. The DDU core team did not find a specific DDU strategy development framework that had been used by other countries that could be used for the Tanzania context. The review extended to include the Performance of Routine Information Systems Management (PRISM) framework and tools, MEASURE Evaluation Data Demand and Use Tools, Joint United Nations Programme on HIV/AIDS M&E Reference Group Guidance and Tools, Health Metrics Network National Health Information System assessment tool, the Health Policy Project performance monitoring plan, and the Tanzania eHealth strategy development framework [13-15, 17-21].
- From this review, the DDU core team, some members having worked on the Tanzania eHealth Strategy, realized that when developing a strategy, it was important to use a strategy development framework that had worked in the Tanzanian context. The DDU core team selected the Tanzania eHealth strategy development framework for the Tanzania DDU strategy development, given that the framework had been successfully used in the Tanzania context for developing a strategy from the core DDU objectives.

DDU Strategy Development

The strategy development framework includes four key steps. The first step is "Defining Vision and Goals (Ends)," where the vision describes what the health sector aspires to achieve with DDU in the health sector, and the goals describe health outcomes in qualitative terms that reflect a realistic focus and direction for achieving the DDU vision. The second step is "Conducting a Strengths, Weaknesses, Opportunities, and Threats (SWOT)" analysis and completing a gap analysis. The third step, "Defining the Strategy (Means)," focuses on defining the DDU mission and strategic principles and refining the DDU strategic objectives and related initiatives. The fourth step, "Defining the M&E Framework," focuses on measuring the progress of both the DDU strategy's implementation and the DDU itself within the health sector in Tanzania.

The final stage in the development of the Tanzania DDU strategy involved a number of steps:

- The DDU core team met six times to create a draft DDU strategy.
- The DDU core team then created a DDU strategy review, which involved five meetings over a period of 3 months. These meetings scrutinized the DDU vision, mission, strategic principles, and objectives, using the qualitative research report and the desk review, along with reviewing materials that were used in developing the Tanzania eHealth strategy.
- Thereafter, the DDU team organized a 3-day workshop with a broader set of MESI DDU stakeholders from the M&E Technical Working Group, which revised the DDU strategy [16]
- Finally, the feedback during the workshop was reviewed by the DDU core team and used to produce the final DDU strategy.
- The DDU strategy was integrated into the MESI 2015–2020 (II) strategy, and during review by a broader set of HSSP IV stakeholders, the strategy received further revisions.
- The final DDU strategy was approved at the M&E TWG, 28 June 2016 and is available to all M&E TWG members on the MESI project share. This has not been officially launched by the MoHCDGEC.

3 Results

This paper describes the methods used to develop the Tanzanian DDU strategy.

4 Discussion

The development of the DDU strategy was a long process, which took several years (2012-2015) and involved broad participation of key informants from multiple stakeholders at all levels of the health system. This was done to ensure longer-term ownership and support for the DDU strategy. The development process took multiple steps, without which the strategy document would not be achieved. Consequently, each step should be seen as an important milestone, and we describe the lessons learned during the process.

During the development process, we learned that focusing initially on the DDU strategy outline and the draft DDU monitoring framework before doing data collection was too early and thus not very useful. We needed to gather input from a broad representative group of stakeholders to inform the key strategies and M&E framework for the DDU strategy implementation. What was useful with the outline was focusing on the key objectives for developing the DDU strategy. Overall, this was an evolving methodology as we learned along the way to make some corrections.

The main differences here between the original outline and final document were as follows: (1) a lot of the lower-level detail included in the first outline was merged and included in the final strategic objectives; (2) the strategy research was formalized around specific research questions (as opposed to the initial outline, which started without clear research questions); and (3) from the research (interviews/desk review), the DDU core team was able to develop a clear vision statement, mission statement, strategic principles, and strategic objectives.

The development of 12 DDU indicators (coming from international best practices for DDU [13-15]), with the goal of piloting/testing this DDU monitoring tool while developing the strategy, was not continued once the strategy research questions were developed and the team realized that the indicator development would come after the DDU strategy was formalized.

The major strength in our approach to developing the DDU strategy was to take into account the local situation in DDU practices in Tanzania, including stakeholders who were using the old HMIS tools and not using DHIS2, and stakeholders that were using both the revised HMIS tools and DHIS2, and stakeholders at all levels of the health system including community organizations. This included combining the results of the desk review as well as qualitative research from the tools used in data collection to the knowledge of attitudes toward data to the practices of data stakeholders at all levels of data generation and usage. We also took into account the international experiences from other groups, adopting a few items that we thought could be of use to the DDU in Tanzania [17-21].

Expanding the DDU strategy development to include primary research added the requirements for additional funding to support these activities, along with managing personnel time needed for these activities with staff members' other workloads, which caused delays in the three phases. Lack of literature in this area meant the DDU core team took longer to agree on which strategy framework to adopt.

We noted that starting with a small set of central stakeholder discussions and completing a rapid assessment of available documents on data use and decision-making so as to develop a draft DDU strategy outline missed some key DDU concepts. Completing formal DDU research at multiple levels of the health system and with a range of stakeholders involved in health service delivery in Tanzania created a more complete picture of DDU in the health sector in Tanzania.

The results from the research are described in the second paper, Analysis of Data Dissemination and Use Practices in the Health Sector in Tanzania: Results of desk review and interviews with key stakeholders [22].

In Conclusion, the development process of the DDU strategy was evolving as we learned along the way to make some corrections, changing from the simpler 2 phase approach to a more comprehensive three-phase approach. What was useful with the outline was focusing on the key objectives for developing the DDU strategy. It is hoped that the MOHCDGEC and DDU stakeholders will use the DDU strategy to improve evidence-based decision-making across the health sector in Tanzania. The authors hope that the implementation of the DDU strategy will lead the relationship of improved information, demand for data, and continued data use, encouraging a culture of information use and creating a cycle that leads to improved health policies, programs, and, ultimately, health outcomes.

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The authors declare that they have no competing interests.
Authors Contributions: Geoffrey Somi, Neema Makyao, Desderi Wengaa, and Niamh Darcy made important contributions to the study design. They were responsible for assisting with the training of data collectors. Geoffrey Somi and Neema Makyao supervised data collection, data management, and data analysis, and they and Desderi Wengaa and Niamh Darcy supervised interpretation and the results write-up. Geoffrey Somi, Sriyanjit Perera, Neema Makyao, Desderi Wengaa, and Niamh Darcy jointly developed the first draft of the research protocol. Mecky Isaac Matee is a co-investigator. All authors provided editing, assisted in the finalization of the draft, and approved the final manuscript.

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Analysis of Data Dissemination and Use Practices in the Health Sector in Tanzania: Results of desk review and interviews with key stakeholders

Geoffrey Somi [a]*, Mecky Isaac Matee [b], Desderi Wengaa [c], Niamh Darcy [c], Sriyanjit Perera [d]

[a] Ministry of Health. Community Development, Gender, Elderly and Children, Dar Es Salaam, Tanzania
[b] Muhimbili University of Health and Allied Sciences, Dar Es Salaam, Tanzania
[c] RTI International, Dar Es Salaam, Tanzania
[d] CTS Global, Assigned to U.S. Centers for Disease Control and Prevention, Dar es Salaam, Tanzania

Background and Purpose: In this qualitative study, the Tanzanian Ministry of Health, Community Development, Gender, Children and Elderly (MoHCDGEC) used the Tanzania eHealth Strategy Framework to develop a draft of the national Data Dissemination and Use (DDU) strategy. The DDU strategy promotes dissemination and better use of health information to drive effective and evidence-based decision-making.

Methods: A desk review of national health-related protocols, standard operating procedures (SOPs), and other relevant policy, planning, and budget documents related to DDU and key informant interviews were conducted to develop the draft of the national DDU strategy. The aim was to gather information regarding guidelines for data collection, data management, data analysis, and data dissemination and use. Key informant interviews were conducted at the national, regional, district, health facility levels and in the community, targeting health decision-makers at those levels in the public and private sectors, and technical assistance experts and implementing partners. A semi structured interview guide was used during the interviews that provided an understanding of norms and practices in DDU, including implementation of protocols and SOPs and human capacity in implementing DDU across a range of health officials and workers to examine these DDU in different contexts in the health care system.

Results: The analysis was guided by the eight themes, which were identified during data collection and initial qualitative analysis and these eight themes were used in developing the DDU strategy strategic objectives. There is a large quantity of data being generated within the Tanzania health system from the public and private sectors. However, significant challenges exist regarding DDU in the health sector in Tanzania; human, technical, organizational, and behavioural factors affect data quality, which in turn limits DDU. There is also the lack of a national legal framework on health DDU. There is minimal use of data for decision-making, particularly at the level of the health facility. Dissemination of data is mainly used to support the upper levels of the health system, with minimal use in the primary facilities where it is generated.

Conclusions: The development of a draft of the national DDU strategy faces significant challenges. There is a need to engage data users and data producers to improve quality; increase availability (access, synthesis, and communication); build capacity in data use core competencies; and strengthen data demand and use infrastructure. The government of Tanzania needs to invest adequate resources in DDU and promote a culture of data use for decision-making.

Keywords: Data dissemination and use (DDU), data demand, data analysis, data use

*Corresponding author address: Ministry of Health, Community Development, Gender, Elderly and Children, Dar es Salaam, Tanzania
Email: geoffreysomi@gmail.com, Tel: +(255)-766-775-059
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1 Introduction

Availability, dissemination, and usage of accurate, reliable, timely, and relevant health information is fundamental for informed public health action and effective management of health resources [1]. In Tanzania, however, data collection and use do not always take place at all levels of the health system [2]. This is mainly due to inadequate systems, processes, knowledge, and skills [3]. Health data are not always readily available to be used by Tanzania's routine Health Management Information System (HMIS) [3].

Overall, the situation with regard to health information in Tanzania, as described in these and other reports, is of a considerable amount of data that potentially are available from routine data collection and from population surveys and research, but access to reliable, timely, complete, and useful information has continued to be poor [3]. As a result, use of information for decision-making has been limited, and parallel but uncoordinated systems of data collection have been set up to meet specific needs. This has resulted in the need for further integration of the programs and systems into a broader health-sector data warehouse as a central source of information. The development of a health-sector data warehouse seeks to improve the collection, dissemination, and use of health data and to ensure that data are collected only once but are used many times [4]. The data collected routinely through the HMIS are widely regarded by stakeholders as unreliable and cannot be depended on for effective planning [2]. As a result, the health sector lacks the culture of information use for evidence-based decision-making (EBDM) at different levels—especially at the level of facilities, which are the primary sources of data.

In 2011, the Monitoring and Evaluation (M&E) Strengthening Initiative (MESI) was divided into eight work streams, one of which focused on Data Dissemination and Use (DDU) to ensure that the Tanzanian health sector has a culture that demands quality information at all levels to facilitate EBDM, transparency, and accountability to improve continuously quality of care and health services delivery. The Ministry of Health, Community Development, Gender, Children and Elderly (MoHCDGEC) initiated the DDU strategy development process to contribute to the objectives within the Health Sector Strategic Plan (HSSP III) and the National Strategy for Growth and Reduction of Poverty (NSGRP) and align with MESI, the eHealth Strategy Framework, and other health-sector programs and plans [5,6,7]. The strategic goal of the DDU strategy initiative is improved, promoted, and sustained dissemination, analysis, interpretation, and use of data for EBDM across the health sector that enables stakeholders, including policymakers, to optimize health-care services and coverage and to improve quality and, ultimately, health status and outcomes.

In 2013, MESI published the three core DDU objectives: (1) ensure regular detailed analysis and interpretation of existing data using best international practices, (2) improve data dissemination, and (3) institutionalize data use and EBDM within routine work practices, processes, and work culture throughout the health sector. We undertook analysis of data generation, dissemination, and use to provide information to be used in the development of the DDU strategy in Tanzania. This information is needed to comprehensively improve data-informed decision-making in the health sector in Tanzania.

Table 1. Eight themes that were used in the interviews with key stakeholders

Theme 1: Data generated within the health system at all levels
Theme 2: Current status of data quality (data collection, review, aggregation, entry, management, analysis and reporting)
Theme 3: Data Use to inform planning/policy decision and health service improvement
Theme 4: Current practices for data dissemination
Theme 5: Gathering and using feedback
Theme 6: Available human capacity for Data Dissemination and Use at all levels
Theme 7: Monitoring and reporting on Data Dissemination and Use at all level
Theme 8: The current legal and policy framework including guidelines and protocols

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2 Materials and methods

This paper provides analysis of the results of key informant interviews and the desk review report, which will inform the development of the draft DDU strategy. The analysis was based on using eight themes (Table 1) and the subthemes that emerged from the structured interview guide. This was done along with identifying strengths, weaknesses, opportunities and threats (SWOTs) in Tanzania. This analysis and the results from the desk review were combined into an overall set of findings and recommendations to be used to inform the draft DDU strategy. The DDU methods are completely described in the DDU methods 'Design of an Assessment Methodology to inform the Strategy [8].

2.1 Desk review

A desk review was conducted to provide information regarding the current technical, human, and institutional resources for DDU, content of technical guidelines for data analysis and DDU of national health-related protocols, standard operating procedures (SOPs), and other relevant policy, planning, and budget documents related to DDU. Specific questions that needed to be answered included the following:

1. What are the current legal and policy provisions, as well as guidelines and standards for dissemination and use of health data in Tanzania, including paper and electronic data, at national and other levels?
2. What main data are currently being generated at all levels of the health system in Tanzania?
3. What are the current legal and policy provisions as well as guidelines for DDU?
4. What main Strengths, Weaknesses, Opportunities, and Threats (SWOT) do you note in disseminating and using health data at your level of the health system?
5. Is there a national framework for dissemination and receiving feedback on quality health data?

2.2 Study settings and key informant interviews

A qualitative set of stakeholder interviews was conducted in various parts of Tanzania to assess the current practices in DDU. Purposive sampling was used to recruit key informants to be interviewed at all health system levels, and a total of 97 interviews (of planned 97) were conducted in Swahili [8]. We have published details on the design and implementation of this study [8]. At the central level, the key informant interviews involved MoHCDGEC units and departments and national stakeholders, the Tanzania Commission for AIDS, the National Bureau of Statistics, and academic and research institutions. At the regional level, two regions were selected for the purpose: Kilimanjaro, and the Coast region. The Coast region was selected because MoHCDGEC had already trained and rolled out the District Health Information System 2 (DHIS2) to the councils within this region so they had more experience with the improved HMIS. The Kilimanjaro region was selected because DHIS2 had not been rolled out to the councils in this region. Within each region, two districts were selected: the Mkuranga and Bagamoyo districts in the Coast region, and the Hai and Rombo districts in Kilimanjaro. The two districts in the Coast region were chosen because of the experience and knowledge gained by stakeholders in these districts in working with MESI in the national rollout of the improved HIMS (better known by its Kiswahili acronym, MTUHA) Version 3.0. In Kilimanjaro, the Hai and Rombo districts were selected as typical of more rural areas of Tanzania, with current practices and challenges in data collection, management, and use.

2.3 Data analysis

Data analysis was guided by the eight themes (and their subthemes), which were identified during data collection and initial qualitative analysis. Analysis involved the process of identifying codes and assigning texts to specific codes in the transcripts. Analysis was performed by the DDU assessment team iteratively during a 5-day workshop, with manual coding of data. Coded data were matched with specific themes and used to create sub themes. There was no intention to characterize site differences in the analysis. A few quotations were selected to illustrate key messages conveyed in each of the main themes and subthemes. New subthemes emerged during the process of analysis. The desk review was used to

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provide additional context for the themes and subthemes. Findings presented here represent the eight main themes that guided this study.

3 Results

3.1 Data generated within the health system (data available and missing data)

Stakeholders associated with health data mentioned different types of data they generated. The data-generating sources in health in Tanzania consist of routine systems (HMIS, demographic and disease surveillance) and non-routine systems (household surveys, research). However, others admitted to not generating data but rather receiving and using data from other departments. From this study, we found out that at least every department deals with data at some point in time. As it emerges from interviewing with one key informant, Dispensary in the Rombo District:

We do collect data from other sources, mainly by nurses of different sections. The nurse officer collects data about prevention of mother-to-child transmission (PMTCT) of HIV infection; a nurse assistant collects data about MCH [maternal and child health], and a clinical officer collects data about OPD [outpatient department]. After collection, we sit together to review data and make corrections or changes, if needed, before sending it to the next level.

Another important part of the study was looking at the missing data. Respondents discussed, at length, the issue of data that were supposed to be collected and made available but that were missing. One key informant commented, from Kibaha District.

Data that I have on HIV presents the picture of the prevalence of the disease but it does not give information about ARV uptake

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The missing data mentioned included the following: Provider-Initiated Testing and Counseling for HIV infection, information on street children and those most at risk, data on HIV drug resistance, infant feeding, and antiretroviral uptake. For Vital Registration, the role of MoHCDGEC is not clearly stipulated, despite the fact that health facilities are involved in recording events like births and deaths. While some were able to mention data that are missing at the moment, most of the respondents alleged that the current system of data collection is sufficient and collects all the important data.

3.2 Data format

Respondents discussed in depth the format of the generated data and were able to mention the format that they prefer most. From the discussion, it was seen that most of the data generated on a daily basis were summarized and presented in tables and narratives. From the interviews conducted, it appeared that most of the respondents preferred tables (and, sometimes, graphs and short narrations) to make it easy for the reader to understand. Another participant insisted that it is not their preference that dictates the format of the data reporting but that sometimes it should suit the requirements of the consumers and nature of data to be reported. One key informant commented, from Muhimbili Hospital

Daily reports and data are normally generated in tables except the yearly report, which is prepared and presented in graphs and I prefer tables and graphs because they are all important

We found out that most data are presented as tables and graphs, but most health workers, especially at lower levels of the health system, face significant challenges in understanding and interpretation, thus limiting the data's use.

3.3 Inclusion of data from different sources

Generally, most of the respondents said they incorporated data from different sources mentioning different departments or sections within the same health facility. Others, especially those at the district and regional levels, include data from lower levels of the health system like health centers and

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dispensaries (both public and private). Other respondents said they normally receive data from all facilities and levels because they are at the national level. Those working at the lower levels of the health sector said they do not receive data from other sources rather than their department's data, as noted in this testimony from the Mawenzi District:

> *Yes, the data we collect we also get from private implementers for example on HIV/AIDS testing and counseling we have several NGOs working as partners. We include it on our data; it is easy because we give them the tools for data collection. This makes joining the data easy, they use standard tools. The data is reliable.*

3.4 Management of data generated

Another area that emerged was data management. Data Management includes data collection (paper and electronic), access, storage, archival and deletion. Specifically, who is actually responsible for data management? It was evident from the interviews conducted that, in most cases, the leader/person in-charge of the section or department is the one responsible for data management of that section or department. It was also noted that for research institutions, the principal investigator is responsible, while at the district and regional levels the health secretaries are responsible for data management. One key informant commented, from Mawenzi Hospital commented

> *In district and regional level health secretary is responsible for managing health data to make sure that all data are correctly filled and collected.*

We found significant variations. In some cases, it is the person in charge who usually is responsible for data management; in other cases, some sit and review data before circulating. In other cases, it was mentioned that everyone handling data should be responsible for proper data management. One key informant from a dispensary in Rombo District commented

> *As a clinical officer and in charge of the dispensary, I am the one who is responsible for managing health data and also responsible for data reporting. I store the data and submit to DMO on a quarterly basis.*

3.5 Challenges on health data accessibility

We found significant challenges with regard to accessing data. The most commonly mentioned challenges include lack of communication between centers and departments; high frequency of changing data collection tools; submission of incorrect data; incorrect copying and pasting of data from previous reports; lack of enough skilled personnel to deal with data collection, analysis, and report writing; HMIS/MTUHA books do not have some columns to fill in some data; lack of enough MTUHA books for data collection; lack of funds for quality data collection; and, last but not least, the lack of a special organ that controls data in the country. A frequently mentioned challenge was to do with quality and reliability of the data generated as well as financial difficulties hampering data collection and dissemination. Following are some of the quotes from respondents on access to data:

- *The process of collecting data is expensive—it needs a lot of money and resources. (Mawenzi District)*
- *Insufficient working tools; for instance, the government has stopped providing the guidebooks, hence making other centers to work in difficult environments. Lack of experience from the new staff hence are affecting quality of the data. (Rombo District)*
- *Still technologically is a big challenge because for data to reach [the] required destination on time, the assumption we use is that such [a] person in the office has a computer, he is computer literate and has internet access and is skilled in internet use. These are assumption[s] that we use, but you may call someone and find he has to find a third party to help him before he can reach you. (Pwani Region)*
- *There is need of transport to the remote areas to enable health providers [to] submit [the] report in time as it is supposed to be. (Kibaha District)*

Recommendations for improvement were mentioned, and these included the need to improve communication to allow easy data and report transfer from remote areas, provision of adequate tools by MoHCDGEC, and training of additional staff to increase skills on data handling. It was further suggested

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that whenever the MoHCDGEC plans to introduce a new system, it should involve data users from initial planning stages in order to incorporate views from different stakeholders.

3.6 The current status on data quality

We found the quality of data to be a very big challenge for most respondents. There are significant variations in understanding of importance of quality data and what this means. In some facilities, data are double checked before they are disseminated to the next level. In many cases, however, this is not the case. Some facilities hold meetings to review data and implement data cleaning, while others do not. In most cases, there is no identification of who is responsible for data collection, thus making it difficult to identify the person who can verify or make clarification in case of questions. As summed up by one health worker,

> *You cannot even think that we have quality data or [that] we produce quality data because the issue of data is facing a lot of challenges, and nobody seems to take care about that. (Hai District)*

Another important area that emerged was the qualifications of data managers in the health facilities or departments. Participants revealed that, in most cases, those who are given this important task possess qualifications other than those required (e.g., doctors, nurses, fourth form graduates, head of departments, information technology personnel). Some respondents said their data managers had the requisite qualifications. Two key informants commented

> *People who are involved in data collection are the least trained and sometimes we don't use skilled people because it is expensive (Medical Stores Department)*
> *No one here is employed specifically for data. The RH incharge is responsible for data although she has other responsibilities. Her education level is first digree in nursing (Hai District)*

Respondents said that nothing much was being done to ensure data quality and that this was one of the reasons for such poor-quality data. It is important to note that most of the respondents said they double-checked the data before disseminating. Some even reported going back to the sources to verify the data's authenticity. Another quality-improvement strategy involved is writing the name and contact information of data collectors so that whenever there was a problem or an inconsistency, staff could quickly contact the person to verify the data. In other instances, quality checks were done through meetings to verify the correctness of the data at hand, and other staff does data cleaning and sorting to eliminate discrepancies. Many respondents said that additional training is needed and that there should be more incentives for staff.

3.7 Data usage including policy and decision-making

In addition to using data to improve health services offered, data were also used for decision-making purposes, preparing work plans, policies and SOPs, and guidelines. In addition, data can be used in developing strategic plans and ordering of medical equipment and supplies at the right times and in the right amounts. Some reported that they did not use data collected at their facilities because of the lack of knowledge on data interpretations.

The use of data for policy and decision-making is very limited, especially in the lower level health facilities, due to limited knowledge on interpretation and use. In some cases, health workers indicated that reports are written in scientific language, so they cannot easily understand the reports. We also found out that donor funds specific data collection, and reporting and the government do not use these reports. Further, we noted that there is no forum for policymakers and researchers to share and discuss data issues. It was reported that the major conference for data dissemination is normally done once per year and that it involves policymakers, journalists, and researchers, but there is very little focus on policymakers. Regarding the benefits of sharing reports and the reasons as to why they do share reports, participants maintained that it improves their working environment because they can get feedback from others, that sometimes they get solutions of their problems from the experiences of others, that it helps learn new things, and that it is just because it is their responsibility to share or disseminate the report. We further

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noted that private hospitals do not share their learning in DDU practices with the district and that there is no policy on data dissemination available:

- *I don't use any data that are collected at the dispensary. I don't have the knowledge on data interpretation and use. What I know is to request the kind of medicine needed at the dispensary in case there is a shortage or in case of an outbreak such [as] cholera. (Kilimanjaro District)*
- *Policymakers are saying they cannot use our data because they are prepared in the scientific language not understandable to them. (National Institute for Medical Research)*

When responding on how to improve data usage, most of the staff recommended an increase in training for the health care providers on the data collection, analysis, and decision-making. They also recommended that health facilities like the Muhimbili Hospital should not work in isolation because they can share a lot of their health data practices with other facilities.

Data dissemination poses many challenges. In the interviews that were conducted in various places of the Tanzania mainland, this was another important area, and respondents stipulated a number of challenges that exist, including the lack of enough funds for data dissemination; poor feedback from upper-level staff, which demoralizes staff engaged in the data collection process; a smaller number of staff members to handle the workload; unqualified staff; and not having specific policy guidelines on data dissemination.

Regarding recommendations on report dissemination, stakeholders gave different views, which included use of an electronic data dissemination system, an increase in the number of trained personnel on data management, the development of an organ that will deal with data management, making the tools necessary for data collection available at all times, increasing funds in the departments responsible for data, and developing a stronger system of feedback.

3.8 Feedback

Most of the participants said they do not receive feedback; some, however, said they do receive feedback. Those participants who do receive feedback are mostly those who are working in the nongovernmental organizations (NGOs), but those from the government institutions say they either receive very minimal feedback or no feedback at all. While many confirmed that they did not receive any feedback, some of them alleged that they have received feedback and some gave examples on how they used that feedback.

Regarding the format in which the feedback is given, most of the respondents indicated it is through letters and reports. Nevertheless, these letters or reports were normally transferred using e-mails, meetings with stakeholders, workshops, or through telephone conversations.

Most respondents reported that feedback is often delayed, so it is difficult to follow up on their mistakes, and there are not enough funds to facilitate a workable feedback mechanism because sometimes people have to travel from one place to another to provide feedback, so without means of transport it is difficult to do so. Also, there are issues of ways in which to give feedback; it seems most people do not know how to give feedback in a constructive manner. Finally, there often is not enough time for those at the upper level to read and understand the report so as to give feedback in a timely fashion.

Several respondents commented on the issue of providing more training to health care providers on the importance of giving and receiving feedback and the ways of giving and receiving feedback. Others pointed out the issue of developing a constructive feedback system, which will facilitate feedback giving, mentorship of people who give and receive feedback, and supportive supervision after giving feedback; with the creation of such a system, most people would take feedback positively. As one staff member noted,

> *When we disseminate our data, we need feedback on time so that we can know where we did [make a] mistake and make changes before the next report; when we don't get feedback seriously, we get very demoralized. (Hai District)*

3.9 Availability of human resources for data dissemination and use

Most of the government health facilities do not have qualified personnel for dealing with data; health care providers without any qualifications always handle data. In some institutions, people who deal with data

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have only been trained for the short term but are not qualified for DDU; furthermore, institutions are often understaffed. Most of the respondents in private institutions, semi-autonomous government agencies, or NGOs, however, have qualified personnel to deal with data. The following comments reflect workers' views on these issues:

- *The department doesn't have any professional worker or trained person for data management. The work is being done by doctors and nurses in the departments who also have other responsibilities. (Muhimbili Hospital)*
- *Inadequate personnel in data collection centers make the data collection process inefficient and inaccurate as data tend to easily get mixed up or lost. (Rombo District)*

Most participants mentioned that more funding is needed to motivate people, provide training, and assist in the transportation of data. Others said there must be special personnel who deal with data alone, and training more people in the health facilities was mentioned as another strategy that could improve human capacity.

3.10 Legal and policy provisions for dissemination and use of health data in Tanzania

There is currently no national policy on data flow and information use, making it easy for parallel subsystems to be established, depending on the interests of involved parties. This apparent lack of guiding policies necessitates the need for MoHCDGEC to develop such a policy and a corresponding national strategy for the Health Information System through the development of the DDU strategy.

3.11 Combining Desk Review and Qualitative Results

Using the information gathered in the desk review and the qualitative interviews, we found several key SWOTs of the current Tanzanian use and availability of health information, as summarized in Table 2.

Table 2. Strength, weaknesses, opportunities and threats (SWOTs) of the use and availability of health information in Tanzania

	STRENGTHS	WEAKNESSES
INTERNAL FACTORS	△ The government recognizes the value of sound health information system and is backing this up with appropriate financial and staff investment. △ Existence of an established structure that allows for the efficient flow of data from service delivery sites through the districts and regions to the national level. △ MoHCDGEC and PMORALG collaborate with multiple development partners under the SWAp structure and the M&E TWG △ MESI focus on data dissemination and use at every level of health services delivery △ Improved availability, and completeness of data	△ There is no national policy on data ownership, flow, dissemination and information use, making it easy for parallel subsystems to be established. △ Lack of coordination and sharing of data among electronic systems. △ Fragmentation in the collection and reporting of health information caused by strong vertical programs running their own reporting systems. △ Health research is often funded by donors and may not be a national priority. △ Lack of integrated framework, such as a data warehouse/repository, whereby data across data sources and types can be analyzed and correlated. △ Inconsistency between the data collected and the information required to support decision-making processes. △ The Supportive Supervision procedures are not formalized and feedback of supervision

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		visits are either done or not available for easy access ∆ Lack of mechanism to ensure that communities have access to data/reports ∆ No motivation scheme for staff involved in ensuring the quality and timeliness of data collection and reporting. ∆ Insufficient number of staff and inadequate skills for HMIS at all levels. ∆ Data are not analyzed, organized or presented in a user-friendly way. ∆ Recording and reporting tools (HMIS tools) do not have sufficient space to record data correctly and have challenges for hospitals to use ∆ Frequent shortage of data collection and reporting tools at facilities
EXTERNAL FACTORS	**OPPORTUNITIES**	**THREATS**
	∆ Presence of partners who are willing to fund and collaborate with the MoHCDGEC in strengthening M&E ∆ Integration of health information systems ∆ Access to best practices and tools internationally (eHealth Strategy 2013-2018)	∆ Sustainability of funding ∆ Conflicting donor DDU requirements

4 Discussion

This is the first study, in Tanzania, to interview a broad group of stakeholders about DDU after the national HMIS has been revised and DHIS rolled out in some regions. We gathered information covering regions using DHIS and regions that were not yet trained on DHIS. The in-depth analysis of data generation, analysis, dissemination, and use in the health sector in Tanzania provides valuable information to be used in the development of the health-sector DDU strategy, which is under review. This analysis was conducted based on data collected during the period from 2012 and 2013, before DHIS2 had been rolled out nationally. During the period from 2011 to 2014, MoHCDGEC strengthened the HMIS and introduced DHIS2, used at the district level for entering HMIS summary information monthly. MoHCDGEC reported an overall national form completeness rate of 95.7% and on-time rate of 90.3% [11] for July–September 2015 for the main HMIS reporting forms, which has improved from the October–December 2013 reporting rate of 67.9% (first quarter, with all 25 regions reporting) [12]. With the improvements in HMIS routine data collection and reporting, there is still a need to develop the culture of information use more broadly for EBDM at all levels of the health sector.

At the time we conducted this study, we found out that there is a large quantity of data being generated within the health system, both from the public and private sectors. However, there were a number of challenges associated with analysis, dissemination, and use of the data for EBDM in Tanzania. These included data quality, data transmission, and lack of feedback, limited resources, lack of national policy and a culture that does not support information sharing.

The quality of data is highly variable due to the lack of trained data handlers, the complexity of the data collection tools, and the inability to aggregate and appropriately transform data into usable reports and guidance. We found variations in the ways in which data are transmitted to the next level of the health sector, which may cause delays. In rural facilities that are difficult to reach, data often reach the district level beyond the set deadlines. Many facilities lack computers and reports are paper based,

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hindering electronic transmission to the next level. Furthermore, specific and comprehensive guidance to improve data demand and use is lacking.

We found low motivation among staff, not only due to low pay but also due to limited feedback and lack of recognition of their efforts. In addition, a lack of trust between health care personnel was mentioned as one of the big challenges in data supervision and monitoring. The unwillingness among some office bearers to share reports with other facilities limits the scope of peer learning. There is no national policy on data flow and information use, making it easy for parallel subsystems to be established. It is anticipated that this work will assist in developing such a policy during the development of the DDU strategy.

We found human resources to be inadequate both in numbers and skills. Frequently, many health care workers have other multiple tasks, and data are given very low priority. We recommend recruitment and training of staff to give them necessary competencies and skills in data analysis, interpretation, synthesis, and presentation.

What we learned during our research is that the assessment of organizational, technical, and behavioral factors that affect decision-making is necessary to diagnose where to intervene with activities to improve demand for and use of data. Any successful DDU strategy needs to take local factors into full consideration.

Accordingly, the outputs from this research were used to guide the development of the draft DDU strategy, which takes into account these issues and addresses them. The broader M&E SI II (2015-2020) team used the draft DDU strategy to identify priority DDU activities that were included in M&E SI II and the Health Sector Strategic Plan IV (2015-2020). In the HSSP IV period, major developments are expected using Information and Communication Technology (ICT), including web-based and mobile data transmission, that address the high- priority needs of the health sector to improve efficiency and effectiveness (e.g. DHIS-2, LMIS, HRIS, PlanRep). The linked health information systems will constitute the National Health Information System.

A key finding is that for consistent data use to occur, data need to be of high quality so that data users are confident that the data they are consulting are accurate, complete, and timely. Without quality data, demand for data drops, data-informed decision-making cannot occur, and program efficiency and effectiveness will suffer [9,10]. Data quality protocols need to be developed, communicated, and implemented, and training and retraining of health professionals on data quality techniques and approaches need to be instituted.

Finally, following the review of the current DDU practices, the development of a health-sector strategy for DDU in Tanzania has occurred and this will guide DDU activities in the country for at least the coming 5 years, and is integrated into the HSSP IV. One activity included in the MESI 2009–2015 strategy was the development of profiles at the regional, district, and facility levels. During MESI, MoHCDGEC supported the development of the District Health Profile (DHP) and worked with 36 districts to create their DHP. Upgrading of the DHP template to regional-level health profile template so that each region has data from all its districts for use in its planning should follow this. Finally, a national-level health profile template should be developed, which will assist national-level organizations with developing their annual health reports for dissemination in the Joint Annual Health Sector Review. The national-level template should include more details than the district-level template so as to address issues of data quality and the help plan the way forward. Fortunately, DDU activities have been included in HSSP IV to be used at a high level to inform activities in the broader health sector.

In conclusion, the DDU in the health sector in Tanzania faces significant challenges. In order to maximize the use of data, there is a need to engage data users and data producers to improve quality; widen availability (access, synthesis, and communication); build capacity in data use core competencies; and strengthen data demand and use infrastructure. The government of Tanzania should consider continuing to invest adequate resources in data management and use and to inculcate the culture of data use for decision-making at all levels in the health sector.

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Statement on conflicts of interest

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Implementing Burundi's national e-health enterprise architecture: past, present and future

Frank Verbeke [a,b,*], Sandrine Kaze [a], Larissa Ajeneza [d], Lambert Nkurunziza [d], Gervais Sindatuma [d], Hassan Asmini [d], Stefaan Van Bastelaere [c], Etienne Mugisho [c]

[a] Burundi Health Informatics Association, Bujumbura, Burundi
[b] Department of Biostatistics and Medical Informatics, Vrije Universiteit Brussel, Brussels, Belgium
[c] Belgian Technical Cooperation, Bujumbura, Burundi
[d] Ministry of Public Health and Fight against Aids, Burundi

Background and purpose: The Ministry of Health (MoH) of Burundi initiated in 2014 the development of a national e-health enterprise architecture aiming to reclaim its leadership in this field and to better align existing and future ICT implementations in the health domain with the strategic options defined by the National Plan for Health Development (PNDS). **Methods**: The Open Group Architecture Framework (TOGAF) was used as a method for developing Burundi's e-health enterprise architecture. A first part of the study consisted of a detailed analysis of regulatory documents and strategic plans related to the Burundian health system and health informatics development. In a second part, field visits and semi-structured interviews were organized with a representative sample of relevant health structures throughout the country. Thorough analysis of human resources, business processes, hardware, software, communication and networking infrastructure provided both a baseline and a target e-health situation. Finally, a strategic document was developed for planning the way forward for filling the functional and technical gaps that had been identified.
Results: the preliminary study demonstrated the donor driven unequal distribution of hardware equipment over health administration components and health facilities. Internet connectivity was problematic and few health oriented business applications had found their way to the Burundian health system. Paper based instruments remained predominant in Burundi's health administration. The study also identified a series of problems introduced by the uncoordinated development of health ICT in Burundi such as the lack of standardization, data security risks, varying data quality, inadequate ICT infrastructures, an unregulated e-health sector and insufficient human capacity. The later architecture development effort resulted in the production and validation of a national e-health strategy for Burundi for the period 2015-2019 (PNDIS). This strategy has been put into implementation by the Ministry of Public Health and Fight against Aids since 2015 with the help of the country's development partners.
Conclusions: the results demonstrated the challenging situation of the Burundian health information system but also revealed a series of important opportunities for the future: a political will to reclaim MoH leadership in the health information management domain based on the PNDIS, the readiness to develop e-health education and training programs and the opportunity to capitalize the experiences with DHIS2 deployment, results based financing monitoring and evaluation with OpenRBF and hospital information management systems implementation based on OpenClinic GA.

Keywords: e-Health enterprise architecture, TOGAF, Health information systems, Burundi

*Corresponding author address

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1 Introduction

In 2005, the Ministry of Public Health and Fight against Aids (MoH) of Burundi has developed a National Health Policy covering the period 2005 to 2015 [3]. This policy was later translated by the MoH and its technical and financial partners into a series of objectives and resulted in the National Plan for Health Development 2011-2015 [1]. Amongst the objectives were the reinforcement of the National Health Information System and the restoration of MoH's leadership in the field of health information management. Therefore, a number of priority actions have been identified:

- The development of an e-health strategic plan for strengthening the national health information system
- The development of an integrated and competitive health information management system
- The development of effective tools for planning, monitoring and evaluation
- Increasing the availability of ICT tools (hardware, networks and software) at all levels of the Burundian health system
- The promotion of data driven research activities in the health sector

Integrating e-health in the national health policy yielded from the beginning enthusiasm from the donor community and in the course of the past decade, a growing number of ICT tools have found their way to the Burundian health sector. But most often, these tools have been introduced for supporting specific projects lead by NGOs and foreign technical and financial development partners. The majority of the chosen hardware and software solutions almost systematically served very well the individual project objectives, but inter-project coordination and interfacing remained almost inexistent. Doing so, sometimes successful e-health tools remained isolated in silo-projects where they only yielded a fraction of their potential benefits. Without corrective action, the Burundian health sector threatened to evolve towards a cacophony of divergent health informatics implementations that did not integrate with a coherent national health information system development strategy.

In order to cope with this threat, in 2014, the MoH initiated the development of a national e-health enterprise architecture with financial support of the Belgian Technical Cooperation. The Open Group Architecture Framework (TOGAF) [2] was chosen as the reference methodology for developing this architecture. During the first phases of the architecture development cycle, an initial analysis of human resources, business processes, hardware, software, communication and networking infrastructure related to health information management, had to be established. This paper describes the objectives, methods and findings of this preliminary analysis, leading to the development of Burundi's national e-health strategy [14].

2 Materials and Methods

The main objective of the preliminary analysis was to provide a reliable estimation of the existing human and material resources and the issues related to health information management in Burundi. This study was part of a complete e-health enterprise architecture development cycle according to the TOGAF methodology, and therefore its output had to address a number of expectations defined by TOGAF. In summary, the analysis focused on providing answers to the following questions:

- What are the MoH's business needs in terms of health information management?
- Which health information management applications have already been implemented in the field and to what extent do they address specific business needs?
- What data is being collected today by the MoH and what is the quality of it?
- Which technologies (software, hardware, and networking) are used today in the health domain in Burundi?
- What are the important health information management problems in Burundi today?

A first part of the study consisted of a detailed analysis of a number of regulatory documents and strategic plans related to the Burundian health system implementation and health informatics development [1,3,4,5,6].

In a second part, field visits and semi-structured interviews were organized with a representative sample of relevant structures of the MoH throughout the country. For the sake of completeness and

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standardization, a study-specific interview guide has been developed and was systematically used by the interviewers. After an introduction on the purpose of the interview, representatives of each structure have first been questioned about the mission, the mandate and the vision of their organization, the objectives, the functions and the roles fulfilled and the way their work is organized. After that, a detailed analysis was made of health information management related human resources, ICT solutions and non-ICT (paper based) instruments at their disposal and finaly an inventory was made of existing procedures for exchanging health information with other (MoH or non-MoH) organizations. Finally, an analysis was performed of health information management problems, expected benefits, potential threats and the perceived importance of health ICT for each component of the organization.

The preliminary study was then used as a starting point for the development of a national e-health enterprise architecture for Burundi. Using the TOGAF toolkit, the architecture team developed therefore the future target (i) business- , (ii) application- , (iii) data- and (iv) technology architectures for the MoH and consolidated these in a national e-health strategy for the period 2015 to 2019. This document was submitted to the MoH for final validation in 2015.

3 Results

3.1 Field visits and interviews

The study of regulatory documents and strategic plans took place in October and November 2014. After that, a series of field visits and interviews have been organized with 39 relevant MoH and -related structures in the Bujumbura region:

- The permanent secretary and all MoH directorates
- Major health programs (malnutrition, HIV, malaria, vaccinations, tuberculosis)
- Donor agencies and technical partners (Belgian Technical Cooperation, European Union, German Cooperation, Unicef, Japanese Cooperation, Gavi fund)
- Health facilities (third level reference hospitals, public and private clinics, health centers)
- Educational institutions

In the period from November-December 2014, the e-health architecture development staff also visited 5 other provinces (Muramvya, Gitega, Ruyigi, Kirundo and Ngozi). In total a sample of 5 provincial health offices (29%), 5 health district administrations (11%) and 12 hospitals (18%) have been analyzed by the study, representing an overall coverage of more than 15% of all MoH structures.

3.2 Hardware

The study showed that computer hardware has most often been supplied to the MoH within the scope of donor-driven intervention programs. There was no organization-wide management of computer equipment and therefore distribution of hardware over the different MoH directorates, provincial or district administrations and hospitals was very heterogeneous: some structures which were supported by several donors were very well equipped; others remained without any computer hardware at all. Under impetus of national and provincial policies, a growing number of health centers in Burundi had also started buying computer hardware with their own funds, unfortunately without having a clear idea of how to integrate these new tools into their existing business processes.

Generally speaking, hardware specifications were quite standard: desktop PCs with Windows XP and Windows 7 operating systems, of which a large number had limited functionality due to computer virus infections (there is no budget available for keeping antivirus software databases up to date and many of the PCs have no access to Internet for performing updates anyway). PCs were almost systematically accompanied by uninterruptible power supplies (UPS), but due to the lack of battery maintenance, the protection offered by these UPSs was minimal.

Many of the executive staff made use of laptop computers which in about half of the cases were their personal privately-owned equipment.

Most of the MoH structures owned one or more printers and many of them were individual printers that were not shared in a network. Toner and ink cartridge supply was often problematic due to

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unavailability of toner cartridges on the Burundian market or absence of a budget for this kind of operational costs.

Files and documents were commonly transferred from one computer to another using USB memory sticks, which constitute an infamous source of virus infections.

3.3 Networks

At the central level (Bujumbura region), most of the MoH structures had a local network (wired or Wi-Fi) at their disposal. Often, these networks were connected to the Internet thanks to donor funding, which unfortunately is always limited in time (and sometimes also in data volume). Few large structures (central MoH site, Military Hospital) had been connected to the national optical fiber network that offered reasonable Internet connectivity, but for most of the medium-sized and small health facilities prices for this kind of service remain prohibitive. Internet bandwidth offered by local ISPs in Bujumbura on the other hand, was poor and unstable although considerable improvement had been seen in the past few years. Installation of Internet connections was also uncoordinated, resulting in some structures accumulating several (poorly performing) parallel connections on the same site: 4 different wired Internet connections have been identified at the national blood transfusion site, without taking into account the numerous individual 3G-USB modems offered by donor programs. Remarkably, in spite of the generally poorly performing Internet connectivity, most MoH structures at the central level stated that an Internet connection had become indispensable for their activities.

Outside Bujumbura and the provincial capitals, the situation was completely different. Wired Internet connections were almost systematically unavailable and performance of 2G and 3G wireless data networks was poor. Some donor agencies (such as EU) had equipped MoH structures with VSAT connections, which have the advantage of providing stable and reliable bandwidth. Unfortunately, they come at rather high operational costs and therefore their use is subject to data volume limitations, causing the Internet connection being unavailable part of the time due to inappropriate use (downloading of movies or audio) which can consume all of the monthly foreseen VSAT credit in only a few days.

3.4 Software

Almost all of the end user computers ran on Microsoft Windows operating systems (XP, version 7 and 8) accompanied by Microsoft Office applications, with the exception of a number of desktop and server computers at the directorate of the national health information system, which ran on Linux Mint or Ubuntu.

Although health specific software implementations remained rare, a clear tendency towards web-based business applications was noted, often based on Linux/Apache, MySQL databases and PHP or Java developments:

- In 2014, the MOH started pilot implementations of the DHIS2 data warehouse in Bujumbura, Ngozi and Muramvya as a replacement for the outdated MS Access based GESIS health data collection solution. Further extension of DHIS2 to the other provinces were scheduled after a detailed evaluation of this pilot experience.
- iHRIS human resource information system deployment also started end 2014 with the first implementation pilots scheduled for early 2015.
- Hospital information system (HIS) implementations remained exceptional (less than 10% of the hospitals), with all of the health facilities in our study sample running OpenClinic GA [13]. The majority of the HIS solutions were concentrated in third level reference health facilities.
- OpenRBF has been implemented for monitoring results based financing (RBF) programs at the central and provincial levels.
- Joomla and Drupal seemed to be the most popular solutions for dynamic website content development

Additionally, some successful m-Health applications (the RapidSMS based KIRA Mama project [11] and SIDA-info [12]) also provided promising results.

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Epi-Info and SPSS were the leading statistics software solutions. General and analytical accounting systems are not uncommon in the health sector structures of Burundi: Asyst and QuickSoft (local development), SAGE Saari, Popsy, and Banana were used by half of the health facilities while Tompro had been recently introduced for project-oriented accounting at the central MoH level.

3.5 Paper based instruments

The vast majority of the provincial and health district administrations were using ICT-tools for reporting health data to the central level (GESIS), but a number of hospitals and almost all health centers still relied on paper based instruments for routine data collection. Information was written down in registers by peripheral health center- or hospital staff and sent on a monthly basis to the health district administration (emergency surveillance information was sometimes reported more quickly using SMS). Health districts then forwarded compiled health facility data to the provincial level, where eventually provincial reports were sent to the central level in Bujumbura.

A minimum of 25 registers must be permanently kept up to date by each health center and an amazing average number of 75 registers are in use in an average district hospital. Additionally, donors and health intervention programs sometimes claim parallel and redundant reporting from the health facilities and district administrations they support, which represents an impressive administrative overhead.

Paper based instruments were also predominant for health record keeping in the vast majority (90%) of the hospitals, which all faced health information quality issues.

3.6 Health information management problems detected

Over the past 10 years, the existing health sector ICT landscape of Burundi has been growing organically, with the majority of the project-oriented solutions being brought in by donors and health programs. This happened in an uncoordinated way, leading to:

- **Lack of standardization**: health information representation is hardly standardized and very few international classifications or coding systems are taken into account (with the exception of some of the DHIS2 and OpenClinic GA modules).
- **Data availability risks**: many databases are hosted in donor countries outside Burundi, with real data accessibility risks for the MoH. Also, many MoH agents use personal computer equipment without appropriate backup procedures or anti-virus protection.
- **Data protection risks**: data access rights are not formally organized according to the role that individual agents fulfill in the health administration; usually people have full access or no access at all to the information.
- **Varying data quality**: multiple reasons explain the poor quality of some data collected in the field. There is (1) the lack of intrinsic motivation with MoH staff members who don't produce data for their own purpose; (2) the important administrative burden caused by redundant health data collection processes; (3) the fact that many MoH agents don't have the necessary qualifications for producing reliable data; (4) the absence of personal consequences linked to the production of erroneous information; (5) donors focusing on project health data which compromises the global and systemic collection of data that is not linked to financial benefits (RBF) and finally (6) the frequent staff turnover at all levels of the health system (on average key personnel doesn't stay longer than 1 year in the same position).
- **Varying data promptness**: the lack of reliable (electronic) communication instruments delays the transmission of health information between different levels of the health system.
- **Lack of data completeness**: data is sometimes being considered a factor of power and the lack of perceived personal interest in information sharing interferes with effective and systematic communication of data in the health sector of Burundi.
- **Defective and insufficient computer equipment**: a number of MoH structures have no access to appropriate ICT hardware and due to the lack of maintenance procedures, many of the existing equipment has become defective. Computer virus infections also constitute a major problem for the MoH administration.
- **Inadequate ICT infrastructure**: today, access to stable electric power is out of reach for many MoH structures, even in the larger cities. UPSs have been provided with most of the computers, but their batteries are often defective and don't provide any protection against power failures

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(sometimes power failures can last for several days, which heavily compromises the reliability of electronics in every day's work). Affordable high bandwidth Internet is unavailable for most of the MoH components. Donor project-funded Internet connectivity is always limited in time and does rarely bring a sustainable solution.
- **Unregulated e-health market**: although e-health solutions are considered "medical devices" by WHO, neither standards nor regulations have been put in place for introducing ICT-tools into Burundi's health system. E-Health solutions deployment therefore escapes from any health authority control.
- **Lack of health applications**: most of the software solutions deployed in the health sector are generic office applications, statistical analysis applications or aggregate data reporting instruments. Too few health specific application implementations such as hospital-, laboratory-, radiology- or pharmacy information systems have found their way into Burundi's health system.
- **Insufficient human capacity**: human resources constitute a major problem for introducing e-health solutions in Burundi: on one hand, qualified staff who are capable of effectively using ICT-tools in their work environment are missing in many of the MoH structures. On the other hand, there is a plethora of unmotivated and underqualified staff occupying positions in the MoH administration preventing young and better qualified workers from being recruited. Additionally, health-ICT related training and education opportunities are not aligned to the needs expressed by the different directorates and health facilities.
- **Organizational problems**: the organizational structure of the MoH reflects in no way the important transversal role of ICT in today's healthcare. The statute of ICT professionals of MoH is far from attractive, demonstrating the fact that they are considered an administrative burden rather than a valuable asset of the organization.
- **Ineffective dissemination of information**: the absence of a reliable communication network limits the dissemination of regulations, good practice guidelines and policies from the central MoH level to the peripheral structures.

3.7 Towards a national e-health strategy

The TOGAF methodology, after applying some simplifications, enabled us to quantitatively and qualitatively estimate the status of health ICT tools deployment in Burundi's health sector, based on a representative sample of administrative structures, health facilities, education- and research institutions. The preliminary study results more or less confirmed the challenging situation of the Burundian health information system [4,5,7,8], but they also revealed a number of opportunities for the future [9,10]:
- There seemed to be a political will to reclaim MoH leadership in the health information management domain by enforcing compliance with international consensus and standards for all future e-health initiatives, with the MoH in a regulator/gatekeeper position.
- The human resources deficit in health informatics was huge and many of the country's education institutions should collaborate on national and international levels to provide necessary and appropriate ICT training, undergraduate and postgraduate health informatics programs. The readiness to do so seems to exist on the side of the Burundian academic institutions and the donor community.
- DHIS2 implementation got substantial support from the government and donor agencies. Extensive training programs have started in December 2014 and a lot of enthusiasm exists to make the implementation of a flexible national health information data warehouse happen.
- Hospital information management system implementations have been successful in several hospitals (University Teaching Hospital of Bujumbura, Military Hospital of Kamenge, Prince Louis Rwagasore Clinic, CMCK, CNAR), This provided clear evidence for the feasibility of HIS implementation in Burundi.

The challenge remained to capitalize the experiences from the success stories and to integrate them into a new coordinated, well adapted and appropriately funded e-health strategy for the country in the next 5 to 10 years. Therefore, the output of the preparatory study was used as a starting point for the further development of an e-Health Enterprise Architecture for Burundi's MoH (PNDIS), of which a first draft was presented in a stakeholder workshop in Bujumbura on December 10th 2014. A first part of the PNDIS defines a business architecture, an application architecture, a data architecture and a technology

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architecture for Burundi's future e-health developments in the public sector. A second part identifies opportunities of capitalizing existing strategic solutions. A third part provides an implementation plan and a budget. Based on this architecture exercise, a number of high priority recommendations have been forwarded by the architecture development team to the Burundian stakeholder community:

- The creation of a national MoH datacenter in Bujumbura that centralizes shared databases and applications and provides a professional infrastructure with stable electricity, access control, data backup and redundancy. *This recommendation was put into practice early 2017 with the collaboration of Lumitel, a national telecom provider*.
- The development of a multi-technology (optical fiber, 3G and VSAT) VPN-based health care intranet connecting central, provincial and district level structures. *Here also, Lumitel has engaged in provisioning of internet and VPN connectivity to public health administration and care structures based on a priority list established by the MoH*.
- The implementation of a number of shared generic applications for the public health sector: accounting software, workflow management, a unique central website, a virtual library, a geographic information system and an MoH owned mail server (preventing the loss of valuable information when staff using gmail.com of yahoo.fr accounts leave the organization). *These applications have been scheduled for progressive implementation in the MoH datacenter, starting with a national MoH collaboration server.*
- The implementation/strengthening of a series of health specific business applications such as DHIS2, iHRIS, OpenRBF, OpenClinic GA HIS, LMIS and a series of health resource registries (including a facility registry). *With the help of the Belgian development agency and guided by the national e-health strategy, the MoH has made substantial progress in this domain. From end 2014 till today, the DHIS2 data warehouse has been progressively deployed to all health districts, replacing the former GESIS national health information system. Since 2014, Burundi remains one of the most successful implementation of results based financing and the OpenRBF information system has played an important role in the management and monitoring of RBF activities in the country. Finally, in the period from 2014-2016, four new OpenClinic GA implementations of a standardized national hospital information management system have been piloted in 4 hospitals in Bujumbura, Ngozi, Muramvya and Kirundo. Since end 2016, after successful evaluation of the pilot phase, the MoH has started rolling out OpenClinic GA to other public health facilities in Bujumbura, Bubanza, Mukenke, Karusi, Gitega, Cankuzo and Bururi. Several private hospitals in Bujumbura, Ruyigi and Kigutu have joined the MoH in this implementation.*
- The implementation of tablet- and smartphone-based patient oriented health data collection tools in health centers and at the community level (KIRA Mama and SIDA-Info). *This recommendation is yet to be implemented.*
- The implementation of an SMS-to-IP gateway enabling health facilities that have only access to plain GSM and SMS connectivity to participate in the country's electronic data collection mechanisms. *The first pilot implementations for this solution will be implemented in 2017 and piloted in 5 health centers.*
- The development of 3 health informatics teaching programs to cope with the important human capacity building needs: (1) a Master in Health Informatics program in collaboration with neighboring universities from Kigali, Bukavu and Lubumbashi, (2) a specialization program in applied health informatics for health professionals and (3) the creation of a biomedical technician bachelor program. *These educational plans have been further elaborated in collaboration with Université Lumière and the National Institute for Public Health in Bujumbura and the first cohorts of students will be enrolled in 2017.*
- The creation of an autonomous health informatics directorate at the MoH with 4 departments in charge of (1) standardization and regulation, (2) health informatics infrastructure management (datacenter and intranet), (3) health informatics education and promotion and (4) helpdesk and support functions. *This recommendation shall have to wait to be integrated in a larger reorganization plan of the MoH, which is a difficult administrative and political exercise. Meanwhile, the bulk of the proposed functions of this new directorate are filled in by the actual Directorate of the National Health Information System (DSNIS).*

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4 Conclusions

After a first successful application for the development of a national e-health strategy in DRC in 2014 [15], the TOGAF toolkit also confirmed its status of a comprehensive and practical instrument for capturing and describing status, needs, opportunities and solutions in complex systems such as the e-health domain in Burundi. A preliminary e-health status assessment demonstrated the challenging situation of the Burundian health information system but also revealed a series of important opportunities for the future: a political will to reclaim MoH leadership in the health information management domain based on the PNDIS, the readiness to develop e-health education and training programs and the opportunity to capitalize the experiences with DHIS2 deployment, results based financing monitoring and evaluation with OpenRBF and the fast extension of hospital information management systems implementation based on OpenClinic GA. Burundi's national e-health strategic plan has proven to be a useful enabler for the MoH in coordinating its numerous e-health activities and for making impressive progress with nationwide deployment of a number of core e-health applications. Beyond initial expectations, the national e-health strategic choices have also been adopted by a growing number of private sector stakeholders.

The focus for future PNDIS implementation in Burundi is on improving systems interoperability (OpenRBF, DHIS2, OpenClinic GA), extending the implementation of the hospital information systems to new public hospitals, introduction of new applications for diagnostic and therapeutic support (quality of care improvement) and the introduction of a limited number of new applications such as a national asset inventory and maintenance management system and electronic health registries for health centers.

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Extracting clinically relevant information from pulse oximetry traces.

José Luis Hernández Cáceres[a], Graham Wright[b]

[a]Diez de Octubre Medical Faculty, Havana University of Medical Sciences, Havana, Cuba
bFaculty of Health Sciences, University of Fort Hare, South Africa

Cardiovascular assessment is necessary obtained from standard oximeters can provide reliable estimates for transit time, a measure associated to vascular stiffness, yet unafordable for large population groups worlwide. Here we illustrate how signals, as well as complexity measures derived from Recursive plot analysis. The salient features of our research were: 1) The possibility to use of photoplethysmographic (PPG) signals as a surrogate for transit time estimation; 2)The use of PPG signals for HRV analysis; 3)The possibility to use 2-min PPG recordings for cardiovascular estimation; 4)The proposal of a new vascular age estimator. An automated algorithm for estimating transit time from the PPG waveform yielded a strong association with age (r=0.80). All indices obtained from Recurrent Plot analysis of tachograms with PPG signals exhibited a high correlation with subject´s age. On the basis of the estimated indices a new estimator for cardiovascular age has been introduced, which exhibited a high correlation with age (r=0.97). Thus we concluded that PPG signals do retain information about cardiovascular age. This is evidenced from changes with age of different indices obtained from 2-min duration PPG traces. These results might be relevant for boosting cardiovascular diagnosis in settings with limited resources.

Keywords: Pulse Oximetry, Heart Rate Variability, Transit Time Estimation, Recurrent Plot Analysis, Cardio Vascular Age.

1 Introduction

One of the strategies in present-day medicine is to increase the diagnostic capacity of available methods and devices [1].

This is in line with the goal of reducing health care expenses, increase health care delivery efficiency and offer the best care possible without threatening the wellbeing of the patient.

Among markers of arterial disease, arterial stiffness has proven to be an important aspect in the assessment of cardiovascular risk [2]. From the different options to evaluate arterial stiffness, carotid to femoral pulse wave velocity (PWV) has emerged as the gold standard method because of growing evidence demonstrating its association with cardiovascular disease in various populations [3].

Arterial stiffness measures and PWV in particular, are being increasingly recommended for routine clinical assessment of patients as well as part of large-scale clinical studies. Thus PWV has been included in the 2007 guidelines from the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) for the management of hypertension [4].

On the other hand, togetherwith specific indices that measure a specific process (e. g. expression level for a living gene or visual acuity), we need indices for the state of the organism as a whole. In this sense, heart rhythm reflects the state of cardiac rhythm intrinsic mechanisms as well as its regulation by feedback from vasculature, autonomic function, respiration, as well as central nervous system. This explains the importance of heart rate variability (HRV) as a tool for accessing human body´s complexity.

*Corresponding author address: cacerjlh@infomed.sld.cu

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Thus far, PWV and heart rate variability studies are performed almost exclusively in advanced laboratories in developed countries.

Here we illustrate how it is possible to perform high quality studies about cardivascular system using afordable techniques for recordings and processing them with freely available software.

Our analysis will be based on the use of the photoplethysmographic (PPG) signal, which can be obtained through standard oximeters.

In particular wewill show that a reliable estimate of PWV can be obtained from the study of PPG signals.

At the same time, the PPG signal has been proven as an excellent surrogate for electrocardiogram in heart rate variability studies. In this research we are estimating cardiovascular age on the basis of recurrent plot analysis of HRV signals obtained from photoplethysmograms.

As a matter of comparison, a commercially available SphygmoCor system for PWV analysis costs more than 10 000 US dollars, compared to less than 40 US dollars for a portable oximeter.

Attempts to obtain surrogates for PWV from PPG signals are not new [5]. This possibility arises from assuming that the PPG signal can be the result of a superposition of at least two waves: a direct pressure wave coming from the heart and a second, reflected wave coming from abdominal aorta bifurcation [6-7]. However, the diversity in PPG waveforms suggest that special algorithms are required for PWV estimation from PPG signals. Here we are introducing an automatic algorithm based on first derivative analysis.

The use of HRV for estimating cardiovascular age has been proposed by Giuliani et al in 1998 [8]. For that, these authors used 7 minutes of ECG recording both in supine and tilt positions.

Here we are showing that good estimates for cardiovascular age can be obtained from 2'minutes PPG signals recorded on supine position only.

Overall, our results point to a high potentiality of the PPG signal for cardiovascular assessment of individuals in rural communities worldwide.

2 Methods

2.1 Subjects

We studied 230 recordings from healthy subjects with their ages ranging from 8 to 89 years (34 subjects were male). The demographic data of the subjects are as summarized in Table I. Recordings were obtained in Orense, Spain, and more than 95% of subjects were original from Galicia.

The inclusion criteria were: no clinically apparent arterial disease or physical abnormality and not observantly obese or on any medication. Approval was obtained from the local research ethics committee, and each subject's verbal consent was taken before the recordings were made. Peripheral (pointer finger of the right arm) pulse measurements were recorded for 5 min, using a validated oximeter (Nellcor 395, USA), with the subject sitting on a chair and the arm positioned at heart level with the forearm resting on a table in a temperature controlled room (24±1.5°C).

Table I. Demographic data of the subjects included in present study

Age range (years)	Female	Male	Total
6 to 20	7	11	18
21 to 30	17	23	40
31 to 40	24	25	49
41 to 50	12	30	42
51 to 60	11	18	29
61 to 70	12	12	24
71 to 80	10	14	24
81 to 89	3	1	4
	96	134	230

Care was taken to see that the effect of motion artifact was the lowest possible. The subjects were also asked not to undergo strenuous exercise, avoid consuming hot drinks or those containing caffeine, and

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refrain from smoking for 2 hours prior to recording. It was also ensured that the subjects were relaxed and breathing regularly and gently. Signals were digitized at 1000 Hz and saved as ASCII files.

2.2 Transit Time estimation.

Two-min PPG recordings were used for this analysis. PPG peaks were automatically detected and an average trace of all waves present in a two-min PPG trace was obtained. The average signal was differentiated via obtaining the differences between successive peaks in the time series. A special algorithm was implemented in SciLab for detecting the position of local minima and inflexion points at the derivative signal. A Transmission Time estimator (TTW) was introduced as the difference between the first local minimum and the subsequent local maximum (or inflexion point) of the averaged signal´s first derivative (see figure 1).

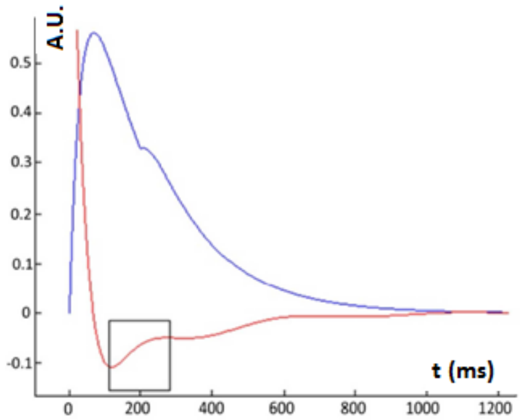

Figure 1. PPG averaged signal (blue) and its derivative (red). Here, TTW appears as the width of the black rectangle (170 ms).

2.3 Recurrent Plot Analysis

Cardiac tachograms were obtained as the differences between maxima positions in the PPG time series. Recurrent plot analysis [9] was performed using the Kubios 2.2 platform for HRV analysis [10].

The RQA is based on the computation of a distance matrix between the rows (epoch) of an embedding matrix of the tachogram. This distance matrix is computed making use of Euclidean metrics; after this first step, the distance matrix, having as rows and columns the subsequent epochs of the series of length equal to the chosen embedding dimension, is transformed into binarian data with values of zero for distances below a pre-established threshold. Here we used default data as proposed in the Kubios HRV package [10]. The following indices were studied:

- Recurrent Rate (Rec)
- Maximal Line length (Maxline)
- Percent of determinism (Det)
- Shannon entropy (Ent)

2.4 Statistical processing.

Procedures included regression and correlation analysis.

2.5 Limitations of Present Study

Studied subjects belong to a relatively large sample and are presumably healthy; however there are no clinical confirming data for cardiovascular health (e. g. ECG, blood pressure, lipid profile, etc.).

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Another limitation is related to sample size. This study uses a much smaller sample than published PWV reports. However, it is larger compared to most PPG transit time publications thus far. Our data set is comparable to that of Giuliani et al, who applied recurrent plot analysis to HRV data.

3 Results

3.1 Estimation of transit time from PPG signals.

The relationship between TTW and age is presented in figure 2.

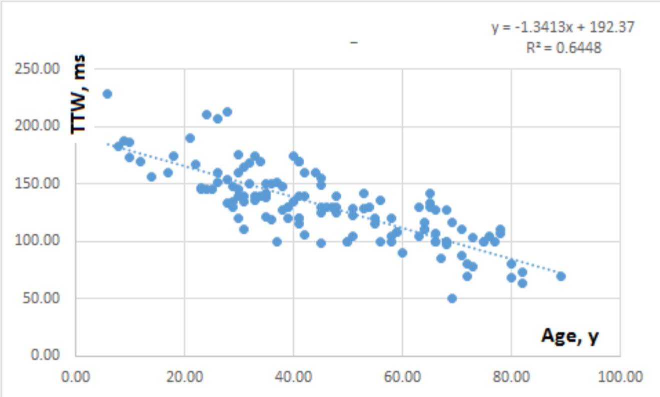

***Figure** 2. TTW age dependence for the whole sample.*

The obtained correlation coefficient is r=0.80, similar to the value obtained by Hernandez Cáceres and Syed using a manual version of TTW [11].

3.2 Recurrent Plot Analysis

All studied RPA exhibited significant correlations with age (Table II). The strongest correlation corresponded to percentage of determinism (´Det´; Figure 3).

Table II. Correlation of Recurrent plot analysis variables respect to age.

Rec	Det	Ent	Maxline
-0.63	-0.71	-0.63	-0.54

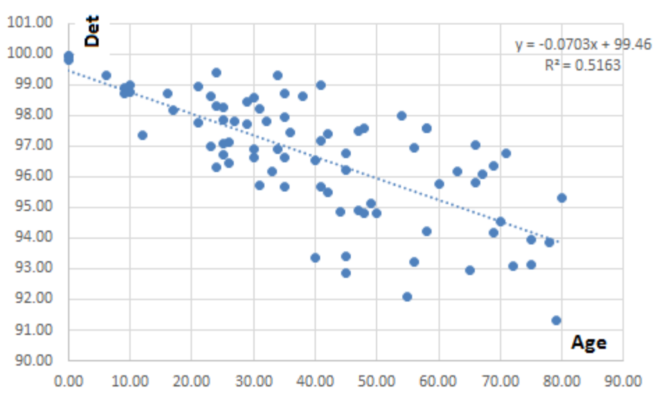

***Figure** 3. TTW age dependence for the whole sample. Points corresponding to age "Zero" represent three fetal tachograms downloaded from physionet.org*

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3.3 Towards a cardiovascular age estimator.

Based on our results, we introduced a cardiovascular age estimator. The proposed index is defined as the best candidate, for a given subject, among individual regression with age for each of the five variables obtained. As expected, the obtained correlation coefficient is very high, with a regression function very close to the identity line (CVAge=0.98*ChronologicalAge; r=0.97; figure 4)

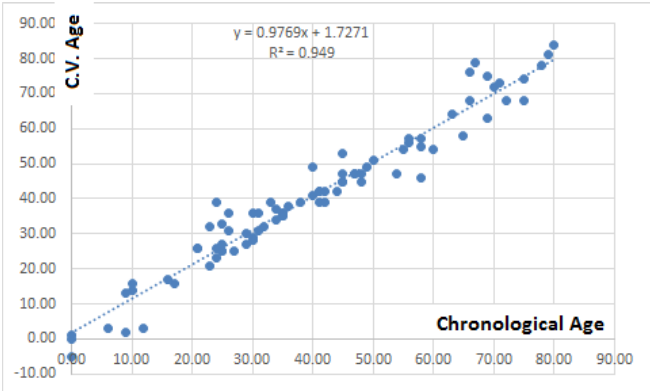

***Figure** 4. Estimated cardiovascular age as a function of observed chronological age*

4 Discussion

The salient features of present research are

- The use of PPG signals as a surrogate for transit time estimation.
- The use of PPG signals for HRV analysis
- The possibility to use 2-min PPG recordings for cardiovascular estimation
- The proposal of a new vascular age estimator.

Theoretical research supports the idea of a PPG signal as a surrogate for pulse pressure recordings [11]. Here, we showed that it is possible to obtain a high correlation with age using an automatic algorithm for transit time estimation. This can avoid any bias related to subjective appreciation.

ECG-based tachograms can be a problem in certain settings. A pulse oximeter is much cheaper and easier to handle than an ECG-machine. This potentiates the value of the pulse oximeter as a means for assessing cardiovascular function.

The optimal duration of HRV recordings have been discussed in literature. Giuliani et al used traces with 7-min duration recorded both in supine and tilt position. The possibility to use traces with 2 min duration in supine position only increases the potential of PPG studies.

Finally, given the fact that 5 variables are exhibiting high correlation with age allowed us to propose a Cardio Vascular Age estimator based on the information provided by each of these variables. We do realize that this estimate does not take into consideration the structure of the covariance matrix, and further studies are required to determine the behavior of the estimated Cardio Vascular Age under different conditions.

Taken overall, our results illustrate that data obtained with a pulse oximeter do retain important information about cardiovascular function. This can contribute to both prevention and treatment of population at risk in remote settings.

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5 Conclusion

PPG signals do retain information about cardiovascular age. This is evidenced from changes with age of different indices obtained from 2-min duration PPG traces. These results might be relevant for boosting cardiovascular diagnosis in settings with limited resources.

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A Dynamic Capability Perspective to Understanding the Typology of Big Data Capabilities. Evidence from a Ghanaian Health Insurance Firm

John Serbe Marfo

Department of Operations and Managment Information Systems, University of Ghana, Ghana

Big data has become a key competitive advantage tool for firms. Big data is disrupting several markets by causing firm to rethink and change their traditional way of handling and using data within and outside. This makes big data possess dynamic capabilities. Given that only few predominantly big technology firms have been able to fully adopt big data to obtain benefits. This research grounded in the theoretical lens of dynamic capabilities examines the constituents or typology of big data capabilities that are needed by firms to adopt big data. The research proposes a hierarchical model for the typology of big data capabilities which is made up technological capabilities, human skills capabilities and organisational capabilities as the core capabilities of big data capabilities. Beyond the second order capabilities, first-order capabilities and resource base or zero-order capabilities are proposed. An investigation of a health insurance firm implementing big data in Ghana is used to evaluate the suggested model and identify challenges in the development of the big data capabilities as experienced by the health insurance firm.

Keywords: big data capabilities, dynamic capabilities

1 Introduction

According to IBM, we create about 2.5 quintillion (2.5×10^{18}) bytes of data every day, so much that 90 percent of the data in the world today has been created in the last two years (IBM, 2011). This data comes from everywhere: climate sensors, social media, hospitals, digital pictures and online videos, online purchases, mobile data, chips embedded in gadgets, corporate information systems and GPS signals, to name just a few. These very large amounts of data which comes in structured, semi-structured and unstructured forms along with the intrinsic value that can be extrapolated from them using analytics, algorithms, and other techniques is called "big data" (Kwon, Lee & Shin, 2014).

Analysing such big data is becoming a keystone of competitive advantage, new waves of productivity growth, agility, innovation and an answer to questions that were previously considered beyond the reach of businesses and government (Zhang & Yue, 2013). Characterized by volume, variety, velocity, veracity and value (Chen et al., 2012), industry practitioners believe that big data is the next 'blue ocean' in nurturing business opportunities. There is a growing academic and practitioner literature on the opportunities to generate benefits through big data-driven decision making (Rousseau, 2012).

Kwon et al. (2014) indicate that unlike technology firms (e.g., Google, IBM, and Apple) who are at the forefront of big data and thus highly confident about its business potentials, a lot of firms are still un-decisive in adopting big data. This may be due to a lack of relevant understanding and experience which points to the need for more research to comprehend issues pertaining to big data adoption including the big data capabilities that are needed along the adoption path (Kwon et al., 2014).

Big data is seen as a disruptive technology (Needham, 2013) which is affecting several markets in several industries by causing firms in those industries to rethink and change their traditional way of

*Corresponding author address: cacerjlh@infomed.sld.cu

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handling and using data within and outside the firm (Sathi, 2012). This disruptive, turbulent or dynamic changing nature of big data suggest that, the big data possess dynamic capabilities (Wamba et al., 2016; Akter et al., 2016).

Grounded in the theoretical lens of dynamic capabilities this research intends to examine in the constituents or typology of big data capabilities that are needed by firms to adopt big data.

2 Towards a Typology of Big Data Capabilities

The nature of big data capabilities have been variously discussed through the literature (Kwon et al., 2014; Janssen, Estevez & Janowski, 2014; Wamba et al., 2016 ; Akter et al., 2016; Gupta & George, 2016; Wang, Kung & Byrd, 2016; Wang & Hajli, 2016). The studies have depicted big data as having a multidimensional perspective to big data capabilities. The different dimensions give rise to big data capabilities having a typology of several capabilities. Table 1 shows the

Study	Theory Used	Type of Analysis	Big Data Capability (Dimensions)
Kwon et al. (2014)	Resource Based View, Isomorphism		Data Management Capability
Wang & Hajli (2016)	Resource Based Theory, Capability Building View		Analytical Capability, Speed to Insights Capability, Predictive Analytic Capability, Interoperability, Traceability
Wamba et al. (2016)	Resource Based View, Sociomaterialism	Hierarchical Model	Infrastructure Flexibility, Management Capability, Personnel Expertise Capability
Akter et al. (2016)	Resource Based View, Sociomaterialism	Hierarchical Model	Management Capability, Talent Capability, Technology Capability
Gupta & George (2016)	Resource Based Theory	Hierarchical Model	Tangible, Human Skill, Intangible
Janssen, Estevez & Janowski (2014)			Data Management Capability
Wang, Kung & Byrd (2016)			Analytical Capability, Data Management Capability, Decision Support Capability, Predictive Capability, Traceability
Kiron, Prentice & Ferguson (2014)			Organizational Culture Capability, Analytical Capability
Davenport et al. (2012)			Management, People, Technology
Barton & Court (2012)			Management Capability, Technology Capability, Data Science Capability

From the literature, big data capability is seen by some authors as a having a hierarchical order of sub capabilities which culminate into other capabilities as they combine or are configured into other higher order capabilities (Wamba et al., 2016; Akter et al., 2016; Gupta & George, 2016).

Using resource based view (RBV) and sociomaterialism (Wamba et al., 2016; Akter et al., 2016), big data capabilities is perceived as a third order capability construct consisting of the second order capabilities - Infrastructure Flexibility, Management Capability and Personnel Expertise Capability (Wamba et al., 2016). Akter et al. (2016) also suggest that big data capabilities is a higher-order capability and a multi-dimensional construct consisting of Management Capability, Talent Capability,

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Technology Capability as a second order capability. Whereas Wamba et al. (2016) sees connectivity, modularity and compatibility as first order capabilities that make up the Infrastructure Flexibility, Akter et al. (2016) sees them as Technology Capability. Similarly, Wamba et al. (2016) sees technical knowledge, technology management knowledge, business knowledge and relational knowledge as the first order capabilities to Personnel Expertise Capability whiles Akter et al. (2016) sees them as Talent Capabilities. Both studies agree that big data capabilities are dynamic capabilities.

The studies (Wamba et al., 2016; Akter et al., 2016) fail to look at the zero-order capabilities (i.e. the resources) (Winter, 2003; Wang & Ahmed, 2007) that come together to form the first-order capabilities which subsequently leads to the second order capabilities and finally big data capabilities as a third-order capabilities. This flaw may be due to the positivist approach used in the study by Wamba et al. (2016) and Akter et al. (2016). The positivist approach is quite objective in its approach compared to a critical realism philosophical stance which looks underneath the layers of the reality to ascertain causal mechanisms and nature of the reality that is observed (Mingers, Mutch & Willcocks, 2013). Thus from a critical realist viewpoint, a review of the literature to clearly establish and understand the typology of big data capabilities from the zero-order constructs (i.e. the resources), to the first-order, then the second-order and finally the third-order at which big data capabilities occur as a dynamic capability is key. This will help firms that want to adopt big data to have a clear understanding of the resources and capabilities needed to develop big data capabilities.

Furthermore using resourced-theory, big data capabilities is also proposed in the literature as having a hierarchical model in its formation from its resources (Gupta & George, 2016). The resources are grouped as Tangible Resources, Human Skills and Intangible Resources. The Tangible Resources refers to the internal data, external data, big data technologies such as Hadoop and NoSQL as well as other basic resources such as time and investments that firm need to adopt big data. The Human Skill refers to the managerial skills in the form of analytic acumen as well as the technical skills such as big data specific training and education that a firm needs to adopt big data. The Intangible resources on the other hand refers to the data-driven culture as well as the intensity of organizational learning that a firm possess in its quest to adopt big data. A critical look at Gupta & George (2016) hierarchical model in comparison to other authors (Wamba et al., 2016; Akter et al., 2016) shows that managerial and personnel capabilities have been lumped into one as human skills. In addition, Gupta & George (2016) only looks at the zero-order constructs (i.e. the resources) and subsequently moves to second-order capabilities as being Tangible, Human Skills and Intangible without showing the other hierarchical levels suggested by (Wamba et al., 2016; Akter et al., 2016).

This suggest a lack of clarity in typology of big data capabilities as being proposed by advocates of the hierarchical model approach to big data capabilities. Perhaps this lack of clarity in looking at big data capabilities might be that, Gupta & George (2016) looks at the resources in their static form from an RBV perspective whereas the other authors (Wamba et al., 2016; Akter et al., 2016) looks at the changing nature of the resources to form other capabilities in the hierarchical model. Probably a new typology which looks at big data capabilities starting from the resource level or zero-order construct to first-order capabilities, second order capabilities and finally the third order capabilities where Wamba et al. (2016) sees as being a dynamic capability might be necessary.

3 The Hierarchical Order of Capabilities to Obtain Dynamic Capabilities

Dynamic capabilities are responses to the need for change or new opportunities, and the changes can take many forms. The change may involve the transformation of organizational processes, allocations of resources, and operations. The changing allocation and utilization of resources is a critical part of dynamic capabilities. These resources-which are assets and capabilities- can include human capital, including managers and employees, technological capital, knowledge-based capital, and tangible-asset-based capital, among others. Dynamic capabilities can be improved over time or can decay. But ironically, they can also remain at an unchanged level even as they continue to induce change. They can take on multiple roles in organizations, such as changing resource allocations, organizational processes, knowledge development and transfer, and decision making. Based on this changing nature of dynamic capabilities, several authors in trying to identify dynamic capabilities have suggested that dynamic capabilities result out of a hierarchical order of capabilities (Collis, 1994; Winter, 2003; Zahra et al., 2006; Wang & Ahmed, 2007; Ambrosini, Bowman & Collier, 2009).

Collis (1994) proposed four categories of capabilities. These are the resource base, the ability to improve firm activities, the ability use other resources to develop novel strategies before competitors and

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learning-to-learn capabilities. Winter (2003) in advancing the idea of a capability hierarchy suggest three levels of capabilities. The hierarchy begins with the "zero-level" capabilities or the resource base. First–order capabilities that allow for a change in zero-order capabilities to occur then follows. Finally, dynamic capabilities follow based on the outcome of organizational learning. Zahra et al, (2006) proposes two levels of capabilities namely substantive capabilities -which gives a firm the ability to solve a problem- and dynamic capabilities – which allows a firm to manipulate its substantive capabilities. Wang and Ahmed (2007), also identifies four hierarchical levels of capabilities in relation to competitive advantage. The first is the "zero-order" which refers to the resources which are the foundation of a firm and the basis for firm capabilities. The next level is the 'first-order' capabilities which are likely to result in improved performance, when firms demonstrate the ability to deploy resources to attain a desired goal. Core capabilities or second-order capabilities are the next level which are a bundle of a firm's resources and capabilities that are strategically important to its competitive advantage at a certain point. The final level is dynamic capabilities which emphasize a firm's constant pursuit of the renewal, reconfiguration and re-creation of resources, capabilities and core capabilities to address the changes in their environment. Ambrosini, Bowman and Collier (2009) build on previous hierarchies and suggest that aside the resource base there are three levels of dynamic capabilities: incremental, renewing, and regenerative capabilities.

Dynamic capabilities hence result out of a progression of capabilities along a hierarchical order as demonstrated by the various authors (Collis, 1994; Winter, 2003; Zahra et al., 2006; Wang & Ahmed, 2007; Ambrosini, Bowman & Collier, 2009) on dynamic capabilities. Combining the capability hierarchical orders as proposed by the various authors suggest that the most exhaustive hierarchical order that can be built based on the resources and a combination of the resources to form higher order capabilities is a four level hierarchical order. The hierarchical order starts off with the zero-order level (Wang & Ahmed, 2007; Collis, 1994; Winter, 2003) where the resources form the foundation of the firm; followed by the first-order level (Wang & Ahmed, 2007; Collis, 1994; Winter, 2003) where a combination of the zero- order level resources results in improved performance when the firm demonstrates the ability to deploy the combined resources to achieve a desired goal; then the second-order level (Wang & Ahmed, 2007; Collis, 1994; Zahra et al, 2006) which is referred to as core capabilities in where the first-order level capabilities are bundled together as a new form of capability when directed towards the firms strategic direction; then finally the third-order level (Collis, 1994; Winter, 2003; Zahra et al., 2006; Wang & Ahmed, 2007; Ambrosini, Bowman & Collier, 2009) where dynamic capabilities is achieved by firm constantly pursuing the renewal, reconfiguration and re-creation of resources, capabilities and core capabilities to address the changes in their environment.

Thus to develop a typology for big data capabilities which is considered a dynamic capabilities by several authors (Wamba et al, 2016, Akter et al, 2016), the four level hierarchical order suggested will be used. Fig 1 shows the typology of big data capabilities based on a review of big data literature.

This research suggest that big data capabilities is a dynamic capability which consist of three sub core capability dimensions namely technological capabilities, human skills capabilities and organisational capabilities. The technological capabilities consist of infrastructural capabilities, data management capabilities and analytical capabilities as first order capabilities. The human skills capabilities consist IT skills capabilities, data science capabilities and business analytic capabilities as first order capabilities. The organisation capabilities consist of management capabilities, organisational cultural capabilities and data ethical capabilities as first order capabilities. The resources -assets and capabilities- which make up the various first order capabilities are shown in Fig. 1.

Based on the typology of big data capabilities as proposed in Fig. 1, this research investigates the various sub dimensions of big data capabilities in a Ghanaian health insurance firm which is currently implementing a big data system.

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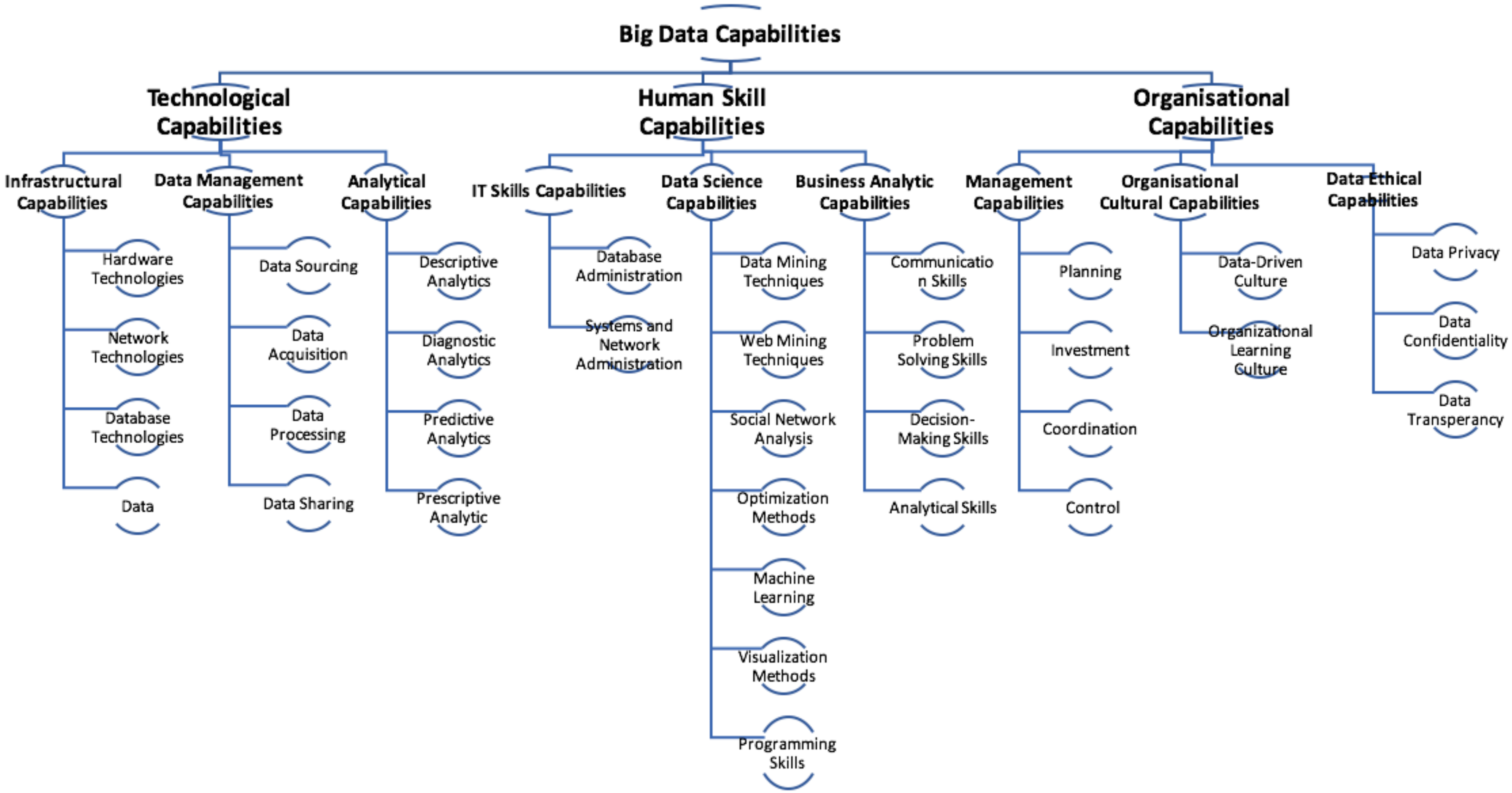

Figure 1. Typology of Big Data Capabilities from Firm Resource Base to Dynamic capabilities

4 Research Methodology

To carry out this research, the study proposes to employ a critical realism (CR) philosophical stance and qualitative methods to unearth structures and mechanisms of big data capabilities and their attending benefits (Mingers et al., 2013). The choice of CR will enable an IS researcher to unearth the big data capability constituents needed for a firms adoption of big data. Bhaskar (2010) argues that these constituents are not apparent in the observable pattern of events, and can only be identified through the practical and theoretical work of the social sciences. As a result, CR gives way for the complex and detailed unearthing of structures of a social reality like the capabilities needed for the adoption of big data. To unearth the big data capabilities constituent, critical realism adopts a retroduction research methodology (Bhaskar, 2010). Retroduction enables the CR researcher to establish the basic conditions for a phenomenon, such as for big data capability to exist. Hence, without these conditions big data capability will not exist.

CR is supportive of methodological pluralism - quantitative or qualitative data collection methods- as it acknowledges that a variety of objects of knowledge exist and each of these objects requires different research methods to unearth them (Carter & New, 2004). For the purpose of this research a qualitative research methodology is adopted. Qualitative methods within CR have a more profound role, as they are more capable of describing a phenomenon, constructing propositions, and identifying structured interactions between complex mechanisms. Thus for a deeper understanding of the typology big data capabilities are formed and developed a qualitative research methodology will be much suited.

Several CR researchers have identified the case study method as the best approach to explore the interaction of structure, events, actions, and context to identify and explicate causal mechanisms (Ackroyd, 2010; Easton, 2010; Miles, Huberman & Saldaña, 2013). Thus the study will employ a case study research design with a qualitative research methodology.

5 Research Design and Methods

The purpose of a research design is to make sure that as unambiguously as possible the research problem is effectively addressed by the evidence found. A qualitative research design was used to assess the big data capabilities from a dynamic capabilities perspective of the top Ghanaian private health insurance firm -Nationwide Medical Insurance- which is currently implementing a big data system.

Case study explores a case through in-depth data collection. The study employed the use of interviews, focus group discussions and observations as data collection tools to give a greater understanding of the big data capabilities phenomenon being studied. The interviews and focus group discussions consisted of open-ended questions that focused on the various dimensions in the typology of big data capabilities in the health insurance firms. Populations for the interview and focus group discussions consisted of a purposive sample of various groups that interact with the big data system that is being implemented by the health insurance firm.

The exact sample units were determined after a pilot study of another health insurance firm which is at the early stages of implementing a similar big data system. The units of analysis were made up of the staff in the IT, Claims, Business Development Unit (BDU), Actuarial, Membership, Health Service Providers (HSP) Unit in the health insurance firm. Other units of analysis were the Chief Executive Officers and technology suppliers of the health insurance firms.

The interviews and focus group discussions were supplemented with documentary evidence. The documents include those publicly available and those provided by the interview and focus group participants.

6 Evidence from Nationwide Medical Insurance

Nationwide has over the years being managing the data of health insurance claims from its service providers through its intranet based software called NatMed. The claims that are inputted into the intranet software of the company takes almost 90 days to convert from manual papers into digitized form for a given batch of claims before finally adjudicating them to detect fraud and process for payment. This voluminous task is a as a result of large volumes of varied types of claims data that Nationwide receives

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from their 521 health service provider network. This has made analytics performed on the digitized data mostly a bit outdated and not reflective of the real case on the ground. This late analysed data does not help Nationwide to know its real state of affairs at any time. For example in 2013, the firm's late analysed data prevented it from being able to forecast the changing trend in the Ghanaian economy when it comes to health care service cost, as it astronomically increased due to dollarization and inflation. This led to the firm making huge losses. Besides the varied nature of data from the different service providers, the large volumes of the data compounds the difficulty in fully handling the analytics associated with the digitized data. This has made it difficult for the company to expand its services to the general public for fear of not being able to control the services they offer to such customers.

Monitoring the claims utilization, plans and benefits of that nationwide seeks to the general public will be difficult to handle due to the lack of control and monitoring systems on the ground. In addition, the shear volumes of data to be collected in varied forms from varied service providers with different conditions to enforce further aggravates the problem Nationwide needs to overcome. The IT head comments that

"*Our processes are causing us to change because our members are increasing and we can't go on entering claims manually that means we have to increase our overhead costs at the claims unit. We realize that the cost of health care keeps on increasing so that is the external pressure. People are not able to renew their insurance. There is a need for us to check attendance or cost and industry wise we are now becoming choked. We are going after the same people and so we need to change our portfolio a bit. In changing that portfolio we need to put in systems in place. First we use to go to corporate bodies to insure their staff, now we are going after the ordinary person who is not formally employed and before you can do that you need to have a system that can check the person's attendance and adjudicate claims in real-time*"

To overcome this problem Nationwide in 2014 adopted a big data approach to identify, collect, store, manage and analyse data from its varied service providers. To do this, Nationwide went in for a big data insurance claim system called Rx Claim which integrates with the NatMed system that is used on the intranet of Nationwide. The solution involves the setup or integration of the Rx Claim system at the health service providers end through relevant APIs as well as a web based platform. The Rx Claim system works both online and offline (O2O) due to the developing country context or environment that Nationwide finds itself in.

Data from the Rx Claim system based on certain protocols are exchanged in real-time between Nationwide's NatMed system and the service providers using APIs and web services. The data collected comes as structured, semi-structured and unstructured. The structured data include membership data, corporate, family and individual data, health plans and benefits data, disease diagnosis related data, drug prescription data, HSP payment and claims data, WHO generic, therapeutic, ICD 10 and ATC coding data. The semi-structured data mainly comes in the form of XML and JSON. It includes disease adjudication rules, multiple diagnosis data, dental related data from HSPs, log files from HSPs, GPS data from mobile application, SMS data, member feedback data and mobile clicks data by members. The unstructured data includes diagnostic document data, laboratory document data and medical notes document data. The data uses both RDBMS and NoSQL databases to handle the data. The RDBMS consist of MySQL and Microsoft SQL. The NoSQL databases are mainly hosted in cloud due the high cost of setting up data centers at Nationwide as well as the need for Nationwide to focus on its core business instead of focusing on technology.

The system does real-time validation checks, fraud detection, benefit limit enforcement as well as real-time analytics at the service providers end and at Nationwide's end. This has led to great improvement in the data analytics that Nationwide carries out. Furthermore, Nationwide through the Rx Claim system introduced a mobile app and a web-based internet version of the system which is used by members on nationwide health plans to check their health and insurance records in real-time throughout the entire country. The mobile apps also gives members, the ability to interact with service providers and the insurance company in real-time. The mobile app predictively suggests the nearest service providers to members as well as give them value added services such as descriptive, diagnostic, predictive and prescriptive analytics to members on their health in real-time. The big data system has greatly increased the payment plan of insurance claims to health service providers as well the collection of premiums from corporate institutions and general public as a whole.

This big data approach has greatly given Nationwide the much needed competitive advantage it requires to dominate the dynamic market space in the health insurance industry it finds itself. Nationwide based on the big data system is now confident and is expanding its business to the general public since it

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can control and interact with the general public in real-time and still process and analyse the large volumes of varied data it encounters.

Nationwide as a result of the big data system and its integration with the internal NatMed system has being going through the process of developing big data capabilities by acquiring certain big data technologies and as well as its technical processes. Some of the technologies have involved using and reconfiguring existing infrastructure owned by Nationwide to handle the big data system. In other cases, Nationwide has had to acquire new infrastructure such as cloud computing systems to deal with the big data.

The development of the big data capabilities has also led Nationwide to acquire new human skills by upgrading the skills of its existing staff as well as employ the skills set of other people. The development of data science capabilities and business analytic capabilities has been very challenging for Nationwide. There is an acute shortage of data science skills on the Ghanaian market. Though business analytic skills exist within Nationwide, they are embedded in different departments namely IT, Actuarial and BDU. A participant of one of the focus group discussions comments on this as saying;

"…NoSQL has been around for long but a lot schools in Ghana do not even know it or let alone teach it. We need data scientist who can manipulate NoSQL databases. May be it is high time the schools change their curriculum to teach NoSQL. NoSQL is the future of databases. The earlier the better for the schools…"

Nationwide has undergone a lot changes and has developed certain organisational capabilities such as the reliance of the firm on data from the Rx claim system to make real-time decisions. This has led to Nationwide creating a data-driven culture as well developing its organisational learning using big data. Nationwide as a result of the big data system has created a greater awareness in the firm for data privacy, transparency and confidentiality due to the sensitive nature of the health data as well as data collected from members through the mobile app. It has also created new policies to govern its big data capture and use at the health service provider systems and the use of the mobile app by its members. Managerially, Nationwide's top management seems to push for more creativity like the big data system and invest in such innovations whiles pushing staff to depend on the innovations in their work. This managerial approach has greatly help the big data system to succeed.

7 Discussions

The data gathered on Nationwide as depicted in the case study suggest that for most parts, Nationwide's hierarchical model of the typology of big data capabilities follows what this research has proposed. However , there are some bottle necks for which Nationwide as a health insurance firm must address to be able to derive the maximum benefits out of developing big data capabilities.

For technological capabilities more data sources must be gradually encouraged to join the mix of data portfolios so as improve insights derived from big data. Beyond that a drive towards more prescriptive analytics should be encouraged to further make nationwide more profitable by cutting down cost based prescriptive analytics for the firm and its clients.

With respect to human skills capabilities there seems to be a lack of data science skills in the firm. In addition, business analytic skills seems to be scattered in the firm with the resources involved distributed among different departments at Nationwide. Perhaps this is a reflection of the need for academic institutions in developing countries such as Ghana to equip students with relevant skills to become business analyst and data scientist. This urgent need for data science and business analytic skills cannot be underscored since it has been predicted that by 2018, even the United States alone despite its advancement will face a shortage of 140,000 to 190,000 people who have deep analytical skills (Manyika et al., 2011). In addition, Manyika et al.(2011) predicts a shortfall of 1.5 million data-savvy managers with the know-how to analyse big data to make effective decisions in the USA.

Beyond the skills set, the desires of management as well as the leadership or managerial styles which reflects in the planning, investment, coordination and control greatly influences the development of big data capabilities. This calls for the need to ensure that management skills among top management are regularly upgraded to be in line with the firms big data vision and strategies to have the best possible influence from top management.

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8 Conclusions

This research has through a review of the literature on big data capabilities established the need to have hierarchical model of the typology of big data capabilities. The hierarchical model per the literature reviewed suggest a model which begins at the resource base of the firm and rises through the first order capabilities to the second order capabilities and finally the third-order capabilities at which big data capabilities assumes a dynamic capability nature.

Based on the hierarchical model, the research establishes that big data capabilities is made up of three core second order capabilities namely technological capabilities, human skills capabilities and organisational capabilities. The technological capabilities consist of infrastructural capabilities, data management capabilities and analytical capabilities as first order capabilities. The human skills capabilities consist IT skills capabilities, data science capabilities and business analytic capabilities as first order capabilities. The organisation capabilities consist of management capabilities, organisational cultural capabilities and data ethical capabilities as first order capabilities. The resources -assets and capabilities- which make up the various first order capabilities are shown in Fig. 1.

An analysis of the typology of big data capabilities indicate that for most parts of the evidence obtained in this research is in tandem with the typology of big data capabilities proposed by this research. However, there is the need to look for more data sources and move analytics towards prescriptive analytics. In addition, there is the need for firms and academia to collectively help train the needed data science and business analytic skills which is seriously in short supply. Finally, management must constantly be oriented to develop managerial skills which are in support of a firms big data vision.

For future research direction, a deeper understanding of the dynamic capability process that occur in the development of big data capabilities will give a much clearer understanding to firms seeking to adopt big data. Furthermore, an understanding of the antecedents that influence the dynamic capability process to generate big data capabilities will help firms know what influences their adoption of big data. Finally, there is the need for research into the kind of data science and business analytic curriculum being taught by academic institutions in developing countries to help suggest ways for it to meet the demands of industry.

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Analysing inhibitors of integrating and routinizing Health Information Systems for Universal Health Coverage: the case of Cameroon

Flora Asah[a], Johan Ivar Sæbø[a]

[a] University of Oslo, Oslo, Norway

Background and Purpose: The purpose of this paper is to describe the state of HMIS in Cameroon, with particular emphasizes on the organisational factors affect integration, routinization and use of information for decision-making for the achievement of UHC goals.
Methods: This paper is based on an interpretative case study on the implementation of electronic data-based in Cameroon. Data was collected through interviews conducted with District Health Managers, Facility Information Officers, and Matron-In-charge of healthcare facilities from December 2015, to January and July 2016. Document review was used as secondary data collection. Multiple variation sampling technique was used to select interviewees.
Results: Though there is a "general expectation that as electronic IS (DHIS) has been implemented, computers and Internet dongles provided to district and facilities information managers, the quality of information generated will certainly become of good quality and could be used for decision making". This assumption neither concurs with the perspective of ICTs for development nor ICT as an agent for institutional change. According to advocates for ICT as an agent for changes IS is an institution and in order for it to bring about change, all aspects (human and non-human, social, cultural and political factors) have to be given equal attention.
This paper analysed inhibitors of HMIS integration in Cameroon. Factors that affect effective routinizing, integrating and use of HMIS are; multiple data collecting tools, centralized information management, inadequate information system infrastructure, lack of IT specialist and basic computer skills and non-culture of information use.
Conclusions: HMIS offers a remarkable potential for improving the efficacy and effectiveness for healthcare and also for achieving the goal of UHC. However, its integration, routinization and use are quite variable depending on the context.

1 Introduction

Universal Health Coverage (UHC) promotes equity in health by ensuring that all the people of the world have access to, and obtain health services they need without suffering financial hardship when paying for the services (WHO 2010, Sachs 2012). UHC is the world's political agenda for the next 15 years (2015 – 2030) on health system strengthening. To achieve these goals, WHO-World Health Report (WHR) (2008), states that the Primary Health Care (PHC) basket of services has to be expanded to include the following; cases of morbidity, common non-communicable diseases (NCDs) such as obesity, hypertension, cancer and blindness (WHR 2010; Sahay & Sundararaman 2015). Consequently, governments of lower and middle-income countries (LMICs) are called to scale-up activities and services to accelerate access to affordable and quality healthcare services.

The expansion of PHC services would affect information needs of healthcare providers and managers. Managers would need more information, from multiple information systems, from across public and private care providers and across different levels of care, to make decision, track, and monitor and allocate resource.

*Corresponding author address: Phone number: +47 94720435, E-mail: florana@ulrik.uio.no
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Today, countries are implementing information systems (IS) in the healthcare sector, aimed at improving health information. A case at hand is the introduction of Web-DHIS in Cameroon. Like in many other LMICs, electronic database DHIS was introduced and implemented to address the information needs of managers and policy makers. Upon implementation of the database, we observed that technology is considered as a "black box", where its introduction will inevitably improve information. As articulated by one of the national directors: "*We have just introduced to you web-based DHIS. All district managers have been provided with computers and internet dongle. Same goes with hospital information managers. Data for internet will be sent to you on your dongle monthly. No more complains. You should go ahead and start submitting facility data without further complains*" (July 2016). Upon listening to these statements, I felt there is a general expectation that by implementing electronic information system, providing computers and Internet dongles to district and facilities information managers, the quality of data generated will certainly become good and will be used for decision making.

Information technologies have great potentials to support planning, monitoring health services and to communicate more effectively across organisational hierarchies (Bhatnagar, 1992). For example, the implementation of IT-based HMIS will provide health programmes, service providers with reliable and relevant health information to optimally allocate resources, improve quality of health services (Braa and Blobel 2003). However, the literature explains that the implementation and adoption of IT does not imply the provision of technology. The literature explains that if emphasis is laid on the technology alone, it (technology) fails to capture the rich and multifaceted nature of ICT (see, for instance, Kling 2000; Orlikowski & Iacono 2001). Doherty and King (2001) explain that by concentrating much on the technical issues is at the expense of the organisational once. This is what the authors call failure to a universal problem (Doherty, et al 2001). Aanestad (2002) added that when implementing ICT such as IS, there are two elements to it; human and non-human. These elements are related and interwoven. Therefore, in order to integrate, routinize and use IS both elements should be given equal attention (Aanestad 2002). In a similar vein, Heeks (2002) points out that in the case of development countries implementing IS, what is transferred is not only machines and software, but also attitude and values of the system, together with the social, political and cultural structures. While it could be relatively easier to transfer technology, socio-cultural settings have to be cultivated and technological learnings have to be ensured (Hanseth, 2002).

The purpose of this paper is to analyse the state of HMIS in Cameroon, with particular emphasizes on the organisational factors that would affect the integration, routinization and use of information for decision making. Considering the unexplored domain of HMIS for UHC, this paper focuses on the following research questions: What factors would affect the integration, routinization and use of health information to monitor and track activities of UHC goals.

2 Related Literature

Universal Health Coverage (UHC) is a foundational element of health strengthening efforts. UHC discourse emphasized the development of health systems that will enable all people to have access to services without suffering financial hardship when paying for them (WHO-WHR 2010). According to the WHO-World Health Report (WHR) (2008), Primary Health Care (PHC) is the vehicle to achieve UHC through financial risk protection. This will require that the PHC baskets of services are expanded.

The expansion of PHC services would impact on the information needs of health care providers, managers, and policy makers. Information from multiple systems will be needed, such as civil registration and vital statistics, including unique identifiers (UID), and community health services (WHO-WHR 2010; MA4Health 2015). They will also need information to support continuity of clinical care across public and private providers and across different levels of care. Financial information will be required to track out-of-pocket payment (OOP). Health Management Information System (HMIS) would be expected to communicate with these multiple systems across public and private providers and across different levels of care, to support the extraction and processing of information on health indicators, health systems performance and health status of the population. HMIS would be expected to provide increased access to reliable information, increase transparency and allow government to better understand the challenges of improving health. It should also be able to support the evaluation of health programs and inform policies

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(Mutale & Chintu, et al. 2013). The system should be capable of capturing a broad range of data on both patient-based and aggregated data, for both private and public healthcare facilities (Fichman, et al 2011), thus the importance of HIS in strengthening health system.

In Lower and Middle Income countries (LMICs), the traditional HMIS have been described as weak, inadequate, fragmented data collection processes, with centralized information management, and inadequate infrastructures (Lippeveld 2001; Heeks 2006; Chilundo and Aanestad 2004; Braa et al 2007; Nielsen, et al 2016). The quality of data generated is not of good quality and cannot be used for decision-making. Other factors facing IS include high organisational costs involved in managing, planning and maintaining ICTs (Heeks & Kenny 2002). There are also problems due to the political nature of the systems; (see, for instance, Schmidt and Werle 1998, Bunduchi, et al 2005). Silva and Figuerao (2002) highlight the issue of power exercised by international agencies implementing ICT in LMICs, and also issues relating to the socio-political nature of HMIS (Walsham, et al 1988, Orlikowski and Baroudi 1991, Avgerou 2002, Kimaro and Sahay 2007).

3 Context, settings and methods

The empirical setting within which the study was conducted is Cameroon. It is a low-income country, situated in the sub-Saharan Africa (SSA) region. It has an estimated population of 20.6 million (Chen, et al 2004). Healthcare services are being delivered in a context of severe resource constraints. Basic public and social amenities for the vulnerable are either absent or inadequate. Nationally, 29.7 percent of the population does not have access to safe drinking water and 66.9 percent lack adequate sanitation, resulting in regular outbreaks of cholera and other water-related diseases (UNICEF 2015). Healthcare services are not available to all due to physical distance and cost. Public health care is not free. Fees charged at health facilities are often higher and the burden of healthcare financing is born largely by households through out-of-pocket payments (OOP). The government of Cameroon spends an average of USD 61 as per capita per person on health. Out of this amount, only USD 17 paid by the state, USD 8 comes from international donors, and USD 36 is OOP (Cameroon Economic Update 2013). Seeking health is often not the first option; patients have often approached traditional health first or attempted self-treatment. For example, first-line malaria drugs are available through pharmacies and on the black market. Malaria is endemic and accounts for more than 40 percent of all deaths in children under 5 (UNICEF 2015). Mortality rate for children under 5 is 148 per 1000 live births, ranking Cameroon as 18th amongst 20 countries in the world with the highest mortality rate. Only 13 percent of children under the age of five sleep under insecticide-treated nets, in a country where malaria accounts for more than 40 percent of all deaths in this age group. Maternal mortality rate is alarmingly high, 670 per 100,000 births as compared to 546 per 100,000 live births in SSA. In addition, many women and girls have limited access to, and utilization of, prevention-of-mother-to-child transmission (PMTCT) services, resulting in HIV infection transfer to children (UNICEF 2015).

In Cameroon, the healthcare system adheres to the district health approach, organised in three levels: the operational level, corresponding to district health care; the intermediate level which is responsible for technical support, while the central level deals with the development of health policies. Different programmes operate at all three levels, engaged in the provision of specialised services such as maternal and child health, malaria, HIV/AIDS, TB, and are supported by different donor agencies.

The health system suffers from shortage of qualified healthcare personnel, lack of technical and managerial expertise. In 2009, the ratio of physician per inhabitants was 1 to 12,000 and nurses and other healthcare cadre was 0.5 to 1000 people. The distribution of health professionals is highly urban-focused and varies significantly by regions (MoPH 2011).

In 2014, MoPH introduced an electronic database; District Health Information System (DHIS) was adopted as the main platform for the management of health information nation-wide. DHIS is open source software developed for public health management information system. In Cameroon, DHIS is presently used at the healthcare facilities (General, Central, Regional and district) hospitals as the main tool for data collection. Data is captured manually at the Integrated Health Centres (IHC) and sent to the District offices, where it is captured electronically.

The study is drawn from an interpretative strand (Walsham, 1995). Interpretive studies attempt to understand phenomena via the meaning people assign to them. Different people's interpretations of the

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same situation differ, and the aim is thus not an objective account but rather a more relativistic but shared understanding of what is happening (Orlikowski and Baroudi 1991). In this study, the purpose was to understand HMIS within the context of Cameroon, what factors affect its integration and routinizing in relation to achieving the goals of UHC.

Data was collected by the first author from January to September 2016. Multiple data sources were used; interviews, participant observation and document review. Three interviews were conducted with the DHIS core team in Yaoundé, 5 district information managers, 3 hospital information managers, 3 district program managers and 3 matron-in-charge of data management in wards, and Sister-in-charge of Integrated Health Centres. The interviews took place within the health facility surroundings, mostly in health workers' offices as they needed to continue their daily activities. Participant observation and informal talks were used to gather an impression of the working conditions in the health facility to understand health workers' working practices in depth and detail. The documents analysed include National HIS strategy document and program reports.

Purposive sampling technique was used to select participants to be interviewed. This technique is used to achieve a homogeneous sample. That is a sample of cases who share the same characteristics e.g. background or occupation (Creswell 2007). In this study, the participants were all involved in a particular activity; data management at their respective facilities. An interview guide with broad themes around HIS and data management in Cameroon was developed. Permission to conduct the study was obtained from the Office of Regional Health delegate of each region and signed informed consent was obtained from each participant. At the start of every discussion, permission to audio record the interviews was also obtained. The principle of data saturation was applied. That is interviews were stopped when further probing was not adding new information.

Data analysis was driven by interpretive process. Content analysis was used to analyse the data (Elo, et al 2008). The interviews were transcribed verbatim. The interviews were read through several times to obtain a sense of the whole. While reading the transcripts, headings were grouped to formulate a general description of the purpose of the research. Understanding from these various sources of research data were developed following the principle of triangulation.

4 Results

The Ministry of Public health in Cameroon achieved its major milestone in 2014 when it opted to implement electronic databases; District Health Information System (DHIS) web-based. This declaration led to the creation of the department for data management, also known as the "Cellular National d'Information Sanitaires" (CNIS). It is situated at the Ministry of Public Health (MoPH), charged with the responsibilities to manage data within the health care system; national, provincial, and district levels, for decision-making. CNIS main responsibilities are to gather, capture, process, analyse and disseminate data and information within the health systems to support decision-making of healthcare providers and policy-makers. Data is collected at health facilities, and reported upward through health districts to the national level in Yaoundé, the capital city. Over the years, web-based DHIS was only used at the central level; National Department of Health in Yaoundé. In June 2015, CNIS decided to up-scale DHIS nationally and created a data collection tool MRA which is similar to the manual data collection tool. This tool was up-loaded electronically on web-based DHIS. Thereafter, there was a nation-wide training on how to capture data directly online on the electronic version of MRA. In the process of routinizing MRA and integrating DHIS as the main platform for the management of HIS in Cameroon, the following were identified:

Cameroon as a well-established information system, but the manner and culture of collecting and submitting data leaves little to desire. It could be said that information management has become an institutionalized routine that must be performed as a part of their jobs and not because the healthcare providers realized the importance of the data they collect. This could be attributed to the following factors:

Centralization of information management: HMIS is planned and managed centrally. Data collection tools and reporting forms are designed at the central level with no input from the district. We also observed that there is a disconnection between the central office and the district health office, in

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terms of communication and support provided between these levels of the health system. The District Information Managers explain "We meet with the CNIS people in Yaoundé only when there is training. These trainings happen once in a while. Apart from such training, we at the district do not have any working relation with them [CNIS]. Even when we have some challenges on the database, we do know whom to talk to for assistance. We report the matter to the regional office, it takes ages for them to come back to us because they also seem to be having problems communication with CNIS" (July 2016).

When asked the Regional Office why they cannot provide support on DHIS to the district office, one of the regional managers had this to say "*we have been given positions without any support tool. Look at my office, I do not have a computer what sort of assistance can I offer. On DHIS, everything is controlled at the national level*" July 2016.

Inadequate information system infrastructure: Working on electronic database requires constant connections to the Internet. In the public sector in Cameroon, access to and use of the Internet is limited which hampers effective usage and management of the system. Fixed broadband internet connection is limited at the ministry and within the country as a whole. For example, 0.1% per 100 inhabitants and fixed telephone is none existence (Alliance for Affordable Internet 2014). Healthcare facilities do not have regular Internet access. District and facilities information offices have been given mobile Internet dongles with a certain quantity of data to capture and submit data on a monthly basis.

It was observed that most of the dongles are not functional and in some cases the Internet Service Provider (ISP) does not top-up the dongle regularly. As a result, the MRA forms are often submitted late. The situation is even worse at health facilities in the rural areas. In addition to the lack of internet connection, some of these facilities face frequent black out due to the lack of electricity.

Though computers have been introduced at the district levels, It is observed that most are either functional or cannot be used on the network. A Facility Data manager had this to say regarding the type of computers they have: "*there are so many computers in this hospital but I do not have a computer. At my health facility; the regional hospital, data is collection manually on the forms and sent to the delegation to be captured there. Presently, I have decided to use my personal computer but it seems as if the Internet dongle is not functional. I have informed the district office. So far nothing has been done*" (Facility Information Manager, July 2016)."

We realized a lack of basic HIS supplies such as printers, ink cartridges, and paper were often out of stock. Data Manager at a Regional Hospital explains: "*there are some computers others do not meet the required standards to be used over a network whiles others are faulty and cannot be repaired*" (Manager Central level, July 2016).

Another problem that has affecting data management is the lack of resources. For example, sending of data from one level to another is often done late due to lack of transportation. Since there is no transportation, data from periphery arrives is brought to the district by a clinic manager when s/he goes to the district for a meeting. Data are often submitted late.

It was also observed that the English version of MRA is not yet available. Facilities in the English speaking regions of the country had to record data on forms or exercise books which might get misplaced.

Data collation and collection Processes: Healthcare providers focused primarily on the patients. Due to the shortage of staff, the work burden on care giver is extremely high as a result, data reporting and collection is perceived to be a secondary task. Nurses are faced with a dilemma of seeing patients, registering and reporting of data in the various registers. Nurses, have multiple responsibilities, including primary clinical responsibilities, which may interfere with the time they have allocated for data collection. It was observed that nurses have attached more importance to patients' care which has adversely impact on data management as data is recorded many days after the event has occurred. One facility manager explain: "*Nurses often think of registering and reporting data towards the end of the month when the facility information manager comes around to inform them that he will be coming to collect the MRA. As they take long time before recording the figures, some of them do forget and at the end they start to guess numbers and record*" (Facility Information Manager, September 2016).

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Data quality Review.

No data quality checks are done either before or after data are submitted. Whenever data is submitted, no feedback is provided to the lower facilities as a result. A district manager explains that due to the lack of feedback, data clerks have developed the habit of data falsification.

During a data review meeting on maternal health data for 2015, a Provincial coordinator explained: "*while I was going through Maternal Health data for last year [2015] from one of the districts in the central province, a facility recorded 85 maternal deaths in September 2015. I raised this issue with my subordinates; it did not mean anything to them. I asked myself, if this is true or cooked data? If this figure is correct, why issue was never raised at any of our meetings*" (Provincial Program Coordinator July 2016).

Handling and Storing of Registers.

Hospital registers of should be properly stored as evident that a services was offered. Proper care should be taken when writing in these registers and should be properly stored. We observed that pagers of registers were dirty and the edges of some pagers had been ripped off. This reinforced the widespread attitude that information is being collected mainly to satisfy the needs of those in Yaoundé. In general, there seems to be no time for data reporting and registering. Data collection has become an institutionalized routine that must be performed as a part of the job and not because the healthcare providers realized the importance of the data they collect.

Use of information.

The centralized nature of information management also means centralized used of information and decision making. In Cameroon though health systems are decentralised, data management is still very centralized. It was observed that there is a no culture of information use and a feeling of "laissez-faire" when it comes to issues relating to data. Data is collected not to be used for decision-making but an institutionalized routine that must be performed as part of the job to meet the needs of managers at the Central office in Yaoundé. The culture of using information for decision making by manager is practised minimally. Managers often refer to data or statistics as often referred to towards the end of the month or quarter, when preparing monthly reports. A facility Manager explains "*managers at her facility start completing the MRA around the 25th of the month after he must have gone around informing them that he will be coming to collect the forms*" (July 2016)

A Provincial HIV/AIDS Regional Coordinator added that: "as a priority program, at the beginning of the year targets are set in Yaoundé [the capital in Cameroon]. For example: "*Treatment coverage among HIV/AIDS positive pregnant women*". At the end of the month, based on the data submitted from the health facilities, I calculate the indicator and submit the report to the next level." (District Program Manager, September 2016). And a program director at the national level confirms "*districts are not involved in decision-making. Decisions are made at the central level and that is where data is used. Though at the central level information is mostly used to comply reports as well*" (National Program Director, September 2016).

Shortage of human resources and lack of basic computing skills: There is an acute shortage of IT professionals in the public sector and at the MoPH in particular. There is a lack of qualified IT staff, healthcare providers lack basic computer skills. At the regional and district level, those who manage data lack basic data management skills.

At the Ministry of Public Health, IT professionals are a rare profession. Most of these graduates prefer to work in the private sector or non-governmental organisations (NGOs) who offer better working conditions and better pay.

5 Discussion

The purpose of this paper was to analyse organisational factors that would affect the integration, routinization and use of HMIS in Cameroon for the purpose of achieving the goals of UHC. This was in relation to the implementation of web-DHIS, the electronic database. This study found that factors

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affecting HMIS in Cameroon are of multiply levels, ranging from centralized, inadequate information system infrastructure such as computer and internet connection, lack of human resources and no basic computer skills, and none use of information for decision making. This finding coincides with similar studies from (Bhatnagar 1992; Ashraf, et al 2007).

The general expectation that by implementing electronic information system, providing computers and Internet dongles to district and facilities information managers, the quality of data generated will certainly become good and will be used for decision making could only be met if these factors are attended to.

HMIS is the backbone of every healthcare system. In order for DHIS to achieve optimum performance, both the human and non-human factors should be considered (Aanestad 2002). In a similar vein Aquil (2009) articulate that to integrate an IS the following factors should be considered; behavioural, organisational and technical.

The organisational factors are the structure, resources, and support services which are to be used to develop and manage the system. The lack of these elements would crucially affect the performance of the system (Kamadjeu, et al 2005). Behavioural factors include elements of confidence and competence that users need to perform their tasks freely and comfortably. Limited knowledge on the usefulness of data by healthcare providers is a major factor and could lead to poor data quality and none use of information for decision-making (Rotich, et al (2003, Aquil 2009). Knowledge on how to manage the system should also be provided to district health managers. The absence of either of these elements will potentially affect the performance of IS. For example, if indicators are irrelevant, and data collection forms are too complex, will affect the confidence level of the data capturers and Matron in-charge to record data correctly. Also, when the software does not generate data timeously and of good quality, decision-makers will not use it (Odhiambo-Otieno 2005). The technical factors are the specialised knowledge and technology skills required to properly develop and manage the system efficiently (Nsubuga et al 2002). These factors; behavioural, organisational and technical are related and intertwined. Callon and Law argued that “a distinction between technology, context and society is a simplification obscuring the complex processes where technology and human actors jointly take part in forming socio-technical entities” (Callon and Law 1989).

It is undeniable that HMIS is uniquely positioned to capture process and communicate timely information for decision-makers for better monitoring of UHC goals. However, to achieve this aim, there is need to consider all factors of the systems instead of concentrating on technology only as in the case of Cameroon.

6 Conclusion

IT-based HMIS have potentials of improving the quality and use of information in the healthcare system. That is to provide health system and healthcare providers, quality information to monitor and track activities relating to UHC goals will variable depend on the context of the organization. Reasons being the technology and context are related and intertwined. Thus, to optimize the effectiveness and efficiency of the information system both aspects should be given equal attention. This study extends research in Cameroon on HMIS.

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