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Editorial to JHIA Vol. 4 (2017) Issue 2

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The Journal of Health Informatics in Africa is the official journal of the Pan African Health Informatics Association (HELINA) and publishes the proceedings of the HELINA conferences, as well as open-call issues. This issue is an open-call issue comprising of four papers submitted directly to the journal. These papers have been double blind peer-reviewed before being accepted for publication. Although papers written in French are also published by the journal, all four papers in this issue was written in English.

The papers all fall within the scope of JHIA – the use of information and ICTs in the healthcare sector in the broad sense in Africa. The focus of these papers range from leveraging cloud technology for reporting purposes in Ghana, mobile solutions for the management of HIV/AIDS, the process of IS integration in a resource constrained context, to a review of research focused on diabetes information retrieval.

This issue then concludes volume 4 of JHIA. Thank you to the editorial team, authors, and peer-reviewers that made this issue possible.

Nicky Mostert-Phipps, 15.01.2018

Journal of Health Informatics in Africa

Diabetes information retrieval research

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Background and Purpose: For researchers and others making use of information retrieval systems, choosing the most effective phrase terms to retrieve relevant documents remains a challenge. The purpose of this study is to establish, test and evaluate a standard set of phrase terms within a text collection.
Methods: 52 phrase terms were extrapolated from the literature concerning diabetes, and were used to create nine queries each relating to a diabetes classification. A specificity information retrieval system was used to assess and retrieve documents using those queries. Results were analysed to measure research interest and phrase term usage.
Results: 9,106 documents were retrieved from the collection. Diabetes research interest is in: 'type 2 diabetes mellitus', 'type 1 diabetes mellitus' and 'gestational diabetes mellitus' with the classification 'type 2 diabetes mellitus' having three times more research interest than 'type 1 diabetes mellitus'. The top five frequently used phrase terms were: 'type 2 diabetes', 'type 1 diabetes', 'diabetes mellitus', 'type 2 diabetes mellitus' and 'prediabetes'.
Conclusions: Most research interest is vested in 'type 2 diabetes mellitus' and 'type 1 diabetes mellitus'. Research interest is increasing for 'prediabetes' and 'gestational diabetes mellitus'. Phrase term usage tends to increase when research interest is low.

Keywords: Information retrieval, query, phrase term usage, diabetes, research interest.

1 Introduction

The general challenges in retrieving special-interest documents have prompted experts to test and evaluate different ideas and theories of information retrieval [4] [5] [6]. These evaluations apply to many disciplines [4] [5] but in particular to healthcare [6]. The goal of a retrieval system is to improve the efficiency of document retrieval from a collection and to retrieve those documents that are most relevant to a user's information need [4] [5], but for academics, researchers, family members and others involved in healthcare [1] making use of the Web [2], electronic documents [3] and various information retrieval systems [4] to find relevant documents about diabetes remains a particular challenge.

Various multi-word phrase terms are typically used to retrieve documents that might be relevant [5] to a particular classification of diabetes but the phrase terms used to describe a diabetes classification have evolved over time [7]. There are two main forms of diabetes: references to one have evolved from: 'fat diabetes' [8], to 'adult onset diabetes' [9], to 'non insulin dependent diabetes mellitus' [10], to 'type 2 diabetes mellitus' [7]; references to the other have evolved from: 'thin diabetes' [8], to 'juvenile diabetes' [11], to 'insulin dependent diabetes mellitus' [12], to 'type 1 diabetes mellitus' [8]). Hence using an information retrieval system to search for these phrase terms, measuring the usage of these phrase terms, and measuring the research interest into diabetes classifications becomes challenging. The queries used in the searches must be carefully constructed, making use of appropriate phrase terms to improve the efficiency of retrieval and the relevance of the documents retrieved [5].

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In this exploratory study, existing literature was collected and analysed in order to understand and document the phrase terms used to identify the different diabetes classifications, and to reveal the frequency of interest and usage.

2 Purpose of the study

The overall objective is to assist academics, researchers, family members and others to understand how diabetes classifications are structured, and to develop terms to use in a search query. With this in mind, the particular purpose of this study was to examine the use of a custom-designed specificity information retrieval system employing two indexes with multi-word phrase term search capabilities; one index based on *the content of the conference texts*, and the other on *the content of the queries* that might be used to search them.

Two research questions are addressed:

- What is the level of research interest in the various diabetes classifications, based on the occurrence of the standard phrase terms?
- What phrase terms are most frequently used to describe a form of diabetes in some way?

With this understanding, it becomes possible to re-organise the way that specialist literature such as this is accessed, and to bring together the various vocabularies and ontologies that specialists use to render their work comprehensible and meaningful as well as accessible.

3 Materials and methods

The published material that was used to exercise the specificity information retrieval system was drawn from five conferences of the International Diabetes Federation (IDF). 9,106 IDF conference paper abstracts and posters were downloaded from the five IDF conferences held over the past ten years: Cape Town (2006), Montreal (2009), Dubai (2011), Sydney (2013) and Vancouver (2015). First, a standard set of phrase terms was derived from the collected texts; then, the occurrence of those phrase terms was analysed across all the articles within the collection.

A custom-designed information retrieval system was used to process phrase term queries efficiently. The original design approach was design science research [40] [41] [42] [43] that led to a trio of new artefacts: the two hybrid indexes and the specificity information retrieval system that employed them. The specificity information retrieval system has a dual process (Figure 1): the first gathers information from the documents in the collection, and the second processes queries using its search engine [5] [4]. All data pertaining to the documents is placed in the information retrieval systems data store [4].

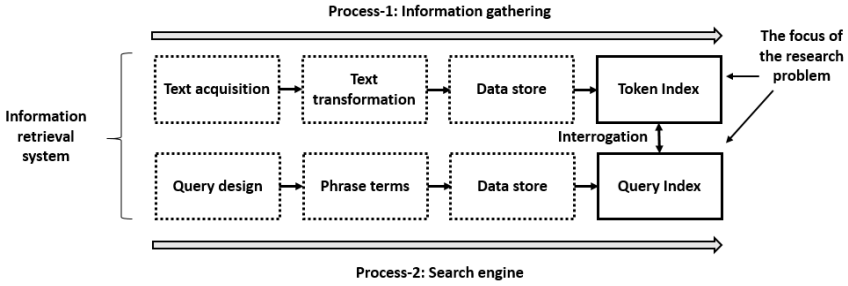

Figure 1: The building blocks of the specificity information retrieval system

3.1 Developing the token index

The first stage, information gathering, used the specificity information retrieval system to acquire, transform and store the textual content in a hybrid token index. All documents in each of the five sub-collections were converted to text files, case folded to lowercase [5], with white spaces and special characters replaced with a pipe delimiter [44], thereby allowing words (or tokens) to be extracted from the texts; these tokens were then used to populate a *hybrid token index*, keeping word ordinality and proximity

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intact. In essence, reading the contents of the hybrid token index (represented as a database table) from top-to-bottom mirrored a reading of the original text from left-to-right.

3.2 Developing the phrase index

With the data collection and organisation now complete, the second stage (the search engine processes) could begin. This stage is described in some detail, as the provenance of the phrases to be included in the index is important. 52 phrase terms extrapolated from the healthcare literature (each describing a variety of diabetes in some way) were arranged into nine diabetes classifications hierarchically using the four levels illustrated in Figure 2. The sources of the terms are provided following the explanation of the figure.

The top node of the hierarchy represents classification-1 at level-1. Diabetes itself is not a singular disease but a group of diseases [7] that at level-2 is divided into two classifications: classification-2 as ‘diabetes mellitus’ and classification-3 as ‘diabetes insipidus’ with the former comprising of multiple different forms. Therefore ‘diabetes mellitus’ is a combination of at least four disparate forms of diabetes at level-3: these are described as classification-4 for ‘gestational diabetes mellitus’, classification-5 for ‘type 1 diabetes mellitus’, classification-6 for ‘type 2 diabetes mellitus’ and classification-7 for what we call ‘other forms of diabetes mellitus’ - a collection of phrase terms describing other forms of diabetes not officially classified as a type. To understand which phrase terms to use in a search for each of these four classifications at level-3 we need to gather the information, those phrase terms authors have used historically and currently, from the literature.

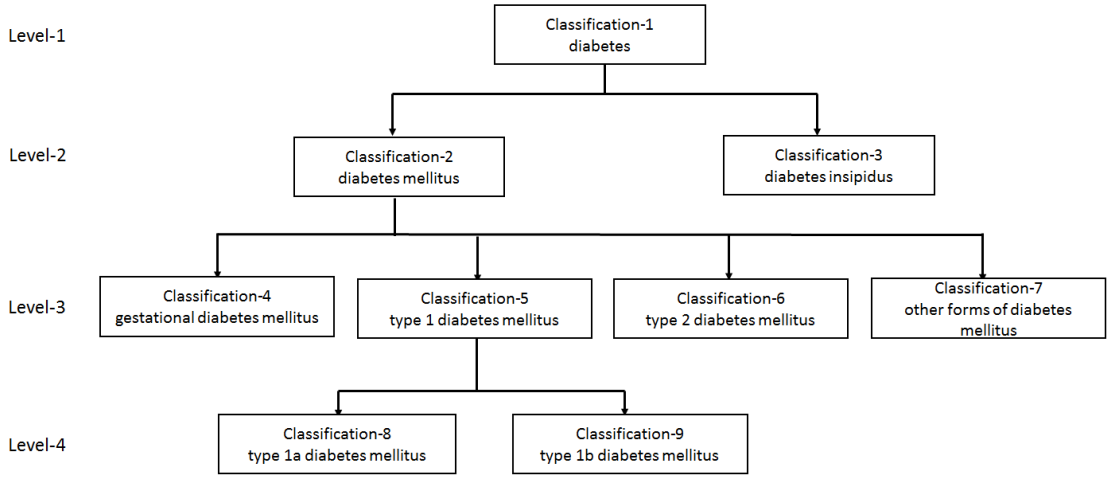

Figure 2: A hierarchy of diabetes classifications

Firstly, we begin with ‘gestational diabetes mellitus’ where two phrase terms were retrieved from the literature ‘gestational diabetes mellitus’ [13] and ‘gestational diabetes’ without the mellitus [14].

Secondly, we have ‘type 1 diabetes mellitus’ that is the only classification at level-3 that has a lower level. Therefore at level-4 there are two sub-types of ‘type 1 diabetes mellitus’ and these are ‘type 1a diabetes mellitus’ related to an autoimmune process [7] and ‘type 1b diabetes mellitus’ [7] related to an unknown cause. The phrase terms used to describe ‘type 1a diabetes mellitus’ from the literature are: 'autoimmune diabetes' [15], 'autoimmune type 1 diabetes' [16], 'immune mediated type 1 diabetes' [17] and 'type 1a diabetes' [7]. The phrase terms used to describe ‘type 1b diabetes mellitus’ from the literature are: 'idiopathic diabetes' [8], ‘idiopathic type 1 diabetes' [18] and 'type 1b diabetes' [7]. Other phrase terms not specific to the two sub-types are: 'brittle diabetes' [19], 'diabetes mellitus type 1' [20], 'diabetes type 1' [21], 'insulin dependent diabetes' [22], 'insulin dependent diabetes mellitus' [12], 'juvenile diabetes' [11], 'juvenile onset diabetes' [22], 'juvenile onset type diabetes' [22], 'slowly progressive insulin dependent diabetes mellitus' [23], 'spontaneous autoimmune diabetes' [24], 'thin diabetes' [8], 'type 1 diabetes' [25], 'type 1 diabetes mellitus' [26], 'type i diabetes' [27] and 'type i diabetes mellitus' [16].

Thirdly, we have ‘type 2 diabetes mellitus’ with 11 phrase terms retrieved from the literature and these are: 'adult onset diabetes' [9], 'diabetes mellitus type 2' [28], 'diabetes type 2' [29], 'fat diabetes' [8], 'non insulin dependent diabetes' [22], 'non insulin dependent diabetes mellitus' [10], 'stable diabetes' [30], 'type 2 diabetes' [31], 'type 2 diabetes mellitus' [32], 'type ii diabetes' [33] and 'type ii diabetes mellitus’ [33].

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Fourth and finally, we have ‘other forms of diabetes mellitus’ with 16 phrase terms retrieved from the literature and these are: 'ketosis prone diabetes' [22], 'ketosis resistant diabetes' [34], 'latent autoimmune diabetes in adults' [35], 'latent diabetes' [36], 'malnutrition modulated diabetes' [23], 'malnutrition modulated diabetes mellitus' [37], 'malnutrition related diabetes' [38], 'malnutrition related diabetes mellitus' [37], 'maturity onset diabetes' [8], 'maturity onset diabetes of the young' [31], 'maturity onset type diabetes' [22], 'potential diabetes' [22], 'prediabetes' [39], 'protein deficient diabetes mellitus' [37] and ‘'secondary diabetes' [36].

3.3 Design of queries

With the hierarchy of phrases, a classification can now be represented by a query containing one or more of these phrase terms. For the top node at classification-1 we use the anchor word *diabetes* as it occurs in each of the 52 phrase terms, surrounded by inverted commas, and is represented by query 1 as: q01 = [“diabetes”]. For classifications two through to nine we make use of query expansion [4] where each phrase term is sequentially placed and separated by the Boolean logical OR operator [45]. For example, the query for classification-8 at level-4 ‘type 1a diabetes mellitus' is represented as: q08 = [“autoimmune diabetes” OR “autoimmune type 1 diabetes” OR “immune mediated type 1 diabetes” OR “type 1a diabetes”].

To exercise information retrieval, each of the nine queries was submitted to the search engine, thus creating the hybrid query index “on the fly”; those documents judged by the information retrieval system as ‘relevant’ and those that were judged ‘non relevant’ [5] were retrieved and the data store [4] was populated with the document statistics ready for data analysis.

3.4 Data analysis

Data analysis was performed utilising the information retrieval systems data store making use of the measurements: document frequency and collection frequency [5] [4]. ***Research interest*** is established as the number of documents (retrieved as “relevant”) that contain at least one of the phrase terms in the query. ***Phrase term usage*** is the number of times a phrase term occurs, here measured within each of the five collections separately and together. During analysis we allowed for phrase term co-existence [46], a phenomenon that occurs when one phrase term co-exists within another, for example, *‘diabetes mellitus’* and ‘*type 1 diabetes mellitus’* where the former co-exists within the latter.

4 Results

The results are presented in Tables 1, 2 and 3; the results are discussed in the section that then follows. First, it is useful to summarise the number of documents in each sub-collection from the five IDF conferences. Table-1 below presents the results for these five sub-collections and the total number of documents in the collection.

Table 1. Number of documents in collection

IDF Year	IDF conference venue	No of documents in collection, N
2006	Cape Town	2,123
2009	Montreal	1,739
2011	Dubai	1,833
2013	Sydney	1,891
2015	Vancouver	1,520
Total		9,106

4.1 Research question 1 - Research interest

The first research question was to determine the research interest into the various types of diabetes classifications. Table-2 presents the results of research interest per diabetes classification in rank order using the descending document frequency and as a percentage of the document collection.

Table 2. Research interest

Rank	Classification	qt	2006		2009		2011		2013		2015		Total	
			df	%	df	%	df	%	df	%	df	%	df	%
1	diabetes	q01	2,123	100	1,556	89.48	1,648	89.91	1,711	90.48	1,387	91.25	8,426	92.53
2	diabetes mellitus	q02	1,213	57.14	981	56.42	1,042	56.85	1,209	63.93	939	61.78	5,384	59.13
3	type 2 diabetes mellitus	q06	843	39.71	682	39.22	704	38.41	809	42.78	606	39.87	3,644	40.02
4	type 1 diabetes mellitus	q05	282	13.28	189	10.87	205	11.18	264	13.96	199	13.09	1,139	12.51
5	gestational diabetes mellitus	q04	55	2.59	59	3.39	70	3.82	79	4.18	70	4.61	333	3.66
6	other forms of diabetes mellitus	q07	25	1.18	47	2.7	55	3	52	2.75	55	3.62	234	2.57
7	type 1a diabetes mellitus	q08	8	0.38	4	0.23	7	0.38	5	0.26	9	0.59	33	0.36
8	diabetes insipidus	q03	0	0	0	0	0	0	1	0.05	0	0	1	0.01
8	type 1b diabetes mellitus	q09	0	0	0	0	1	0.05	0	0	0	0	1	0.01

4.2 Research question 2 – Phrase term usage

The second research question was to determine the usage of phrase terms used to describe a form of diabetes in some way. Table-3 presents the results of phrase term usage in rank order using the descending collection frequency over the ten-year period.

Table 3. Phrase term usage

Rank	pt	Phrase term	cf 2006	cf 2009	cf 2011	cf 2013	cf 2015	cf Total
1	pt47	type 2 diabetes	1,483	1,226	1,176	1,376	954	6,215
2	pt43	type 1 diabetes	514	312	321	481	347	1,975
3	pt06	diabetes mellitus	405	349	394	223	162	1,533
4	pt48	type 2 diabetes mellitus	234	211	233	241	194	1,113
5	pt36	Prediabetes	19	84	138	117	109	467
6	pt12	gestational diabetes	65	99	81	73	88	406
7	pt13	gestational diabetes mellitus	43	28	57	71	52	251
8	pt44	type 1 diabetes mellitus	66	41	44	43	32	226
9	pt10	diabetes type 2	30	19	23	11	12	95
10	pt08	diabetes mellitus type 2	24	20	14	7	9	74
11	pt09	diabetes type 1	26	6	14	13	4	63
12	pt02	autoimmune diabetes	8	10	9	9	12	48
13	pt51	type ii diabetes	19	0	8	10	8	45
14	pt07	diabetes mellitus type 1	11	8	11	3	1	34
15	pt49	type i diabetes	10	4	9	5	0	28

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16	pt19	juvenile diabetes	2	2	3	3	11	21
17	pt31	maturity onset diabetes of the young	5	7	0	5	2	19
18	pt17	insulin dependent diabetes	7	1	3	3	4	18
19	pt38	secondary diabetes	5	7	3	0	2	17
20	pt24	latent autoimmune diabetes in adults	7	2	1	2	1	13
21	pt33	non insulin dependent diabetes	4	1	5	0	0	10
22	pt03	autoimmune type 1 diabetes	1	1	1	2	4	9
22	pt18	insulin dependent diabetes mellitus	4	1	0	3	1	9
22	pt52	type ii diabetes mellitus	0	0	4	4	1	9
23	pt01	adult onset diabetes	1	1	0	2	3	7
24	pt22	ketosis prone diabetes	0	1	0	1	3	5
25	pt29	malnutrition related diabetes mellitus	2	0	0	2	0	4
25	pt35	potential diabetes	1	1	2	0	0	4
25	pt45	type 1a diabetes	3	1	0	0	0	4
26	pt04	brittle diabetes	2	0	0	1	0	3
26	pt50	type i diabetes mellitus	0	1	1	1	0	3
27	pt34	non insulin dependent diabetes mellitus	0	1	0	1	0	2
28	pt05	diabetes insipidus	0	0	0	1	0	1
28	pt14	idiopathic diabetes	0	0	1	0	0	1
28	pt20	juvenile onset diabetes	0	0	0	1	0	1
28	pt27	malnutrition modulated diabetes mellitus	0	0	0	0	1	1
28	pt37	protein deficient diabetes mellitus	1	0	0	0	0	1
28	pt39	slowly progressive insulin dependent diabetes mellitus	1	0	0	0	0	1
28	pt40	spontaneous autoimmune diabetes	0	0	0	0	1	1
29	pt11	fat diabetes	0	0	0	0	0	0
29	pt15	idiopathic type 1 diabetes	0	0	0	0	0	0
29	pt16	immune mediated type 1 diabetes	0	0	0	0	0	0
29	pt21	juvenile onset type diabetes	0	0	0	0	0	0
29	pt23	ketosis resistant diabetes	0	0	0	0	0	0
29	pt25	latent diabetes	0	0	0	0	0	0
29	pt26	malnutrition modulated diabetes	0	0	0	0	0	0
29	pt28	malnutrition related diabetes	0	0	0	0	0	0
29	pt30	maturity onset diabetes	0	0	0	0	0	0
29	pt32	maturity onset type diabetes	0	0	0	0	0	0
29	pt41	stable diabetes	0	0	0	0	0	0
29	pt42	thin diabetes	0	0	0	0	0	0
29	pt46	type 1b diabetes	0	0	0	0	0	0

5 Discussion

5.1 Number of documents in the collections

Table-1 shows that the total number of documents in the collection, from the five IDF conferences, was 9,106. The number of documents per sub-collection varied over the years with 2,124, 1,729, 1,833, 1,891 and 1,520 representing Cape Town (2005), Montreal (2009), Dubai (2011), Sydney (2013) and Vancouver (2015) respectively. The sub-collections continually declined in volume from a peak at the first conference in Cape Town; the conference in Sydney showed a slight improvement in volume over the previous conference held in Dubai, but these variations are seen as spurious because of the large number of unknown factors involved.

5.2 Research question 1 – Research interest

The first research question concerned the level of research interest in the various types of diabetes classifications. The results from Table-2 are now discussed in rank order using descending document frequency as a percentage of the document collection.

Rank-1 - Diabetes
Of the nine classifications, 'diabetes' was ranked first, with the highest document frequency thus representing the highest research interest. Referring to Table-2, and for Classification-1 at Level-1, a total of 92.53% or 8,426 of 9,106 documents were relevant to diabetes in some form as all these documents contained at least one occurrence of the phrase term 'diabetes' in their text. Conversely 9,106 – 8,426 = 680 documents did not contain the phrase term 'diabetes' and therefore did not refer to this classification directly. In 2006 all documents referred to diabetes but over the following four conferences they consistently averaged around 90% suggesting there were other areas of research interest bundled into these conferences.

Rank-2 - Diabetes mellitus
Ranked second was 'diabetes mellitus'. The results would have been based on a combination of unique occurrences of the phrase term (phrase term co-existence was considered) not related to the other phrase terms in the queries in addition to the 50 other phrase terms (phrase terms 'diabetes' and 'diabetes insipidus' were excluded from this query). For this classification-2 at Level-2, a total of 59.13% or 5,384 of 9,106 documents were relevant to 'diabetes mellitus' in some form as all these documents contained at least one occurrence of the phrase term 'diabetes mellitus' or at least one other phrase term within query number two. During the first three conferences, the research interest purely into this classification averaged 57% but this increased to around 62% for the latter two.

Rank-3 – Type 2 diabetes mellitus
Ranked third was 'type 2 diabetes mellitus' and for this classification-6 at Level-3, a total of 40.02% or 3,644 of 9,106 documents were relevant in some form as all these documents contained at least one occurrence of the eleven phrase terms in its query. During four of the conferences the research interest into this classification averaged 40% but this increased to nearly 43% in 2013 suggesting either more research interest into 'type 2 diabetes mellitus' or less interest into the other classifications.

Rank-4 – Type 1 diabetes mellitus
Ranked fourth was 'type 1 diabetes mellitus' and for this classification-5 at Level-3, a total of 12.51% or 1,139 of 9,106 documents were relevant in some form. During 2009 and 2011 the research interest into this classification dropped below the average while in other years was just above average.

Rank-5 – Gestational diabetes mellitus
Ranked fifth was 'gestational diabetes mellitus' the form that occurs in pregnant woman. For this classification-4 at Level-3, a total of 3.66% or 333 of 9,106 documents were relevant in some form to 'gestational diabetes mellitus'. The research interest into this classification has continually increased over the ten year period with 2.59%, 3.39% 3.82%, 4.18% and 4.61% possibly suggesting a new focus for diabetes research.

Rank-6 – Other forms of diabetes mellitus
Ranked sixth was 'other forms of diabetes mellitus' where specific diabetes typing for these forms has not occurred. For this classification-7 at Level-3, a total of 2.57% or 234 of 9,106 documents were relevant in some form. Similar to 'gestational diabetes mellitus' the research interest into this classification has continually increased over the ten year period with the exception of 2013. The percentages of interest were 2.5%, 2.7%, 3%, 2.75% and 3.62% for 2006, 2009, 2011, 2013 and 2015 respectively. These figures suggest research interest for this classification is growing, albeit slowly.

Rank-7 – Type 1a diabetes mellitus
Ranked seventh was 'type 1a diabetes mellitus' one of two sub-classifications for 'type 1 diabetes mellitus'. For this classification-8 at Level-4, a total of 0.36% or 33 of 9,106 documents were relevant in some form.

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During 2009 and 2013 the research interest into this classification dropped below the average while in the other three years they continued to increase from 0.38% in 2006 to 0.59% in 2015. This form of diabetes is the deadly one that traditionally targets young children and creates an autoimmune response. These figures suggest that at last there is a slight increase in research interest into this classification.

Rank-8 – Diabetes insipidus and type 1b diabetes mellitus
Ranked eight were both ‘diabetes insipidus’ and ‘type 1b diabetes mellitus’. The former is the only non ‘diabetes mellitus’ form of diabetes in this research. For this classification-3 at Level-2 only one document was retrieved relevant to this classification suggesting very low, if not insignificant, research interest. A similar result was obtained for ‘type 1b diabetes mellitus’ again with only one document over the ten years. This form of diabetes is also a deadly one that traditionally targets young children but does not create an autoimmune response.

5.3 Research question 2 – Phrase term usage

The second research question concerned the usage of phrase terms used to describe a form of diabetes in some way. The results from Table-3 are now discussed in rank order of descending collection frequency.

No usage – Rank 29
Of the 9,106 documents in the collection the usage of 13 of the 52 phrase terms (rank 29) were not evidenced at all. These were: 'fat diabetes', 'idiopathic type 1 diabetes', 'immune mediated type 1 diabetes', 'juvenile onset type diabetes', 'ketosis resistant diabetes', 'latent diabetes', 'malnutrition modulated diabetes', 'malnutrition related diabetes', 'maturity onset diabetes', 'maturity onset type 'diabetes', 'stable diabetes', 'thin diabetes' and 'type 1b diabetes'. Interestingly even though 'type 1b diabetes' is a type of diabetes its alternative synonymic phrase term ‘idiopathic diabetes’ was the preferred choice albeit only once in the collection.

Low usage – Rank 22 to 28
From the document collection 18 of the 52 phrase terms (rank 22 to 28) had low usage where their collection frequencies were below ten. In rank order these were: 'autoimmune type 1 diabetes', 'insulin dependent diabetes mellitus', 'type ii diabetes mellitus', 'adult onset diabetes', 'ketosis prone diabetes', 'malnutrition related diabetes mellitus', 'potential diabetes', 'type 1a diabetes', 'brittle diabetes', 'type i diabetes mellitus', 'non insulin dependent diabetes mellitus'. Ranked 28th with a collection frequency of 1 were” 'diabetes insipidus' the only non diabetes mellitus related phrase term and ‘idiopathic diabetes' a phrase term used to describe a form of ‘type 1b diabetes mellitus’. Then 'juvenile onset diabetes' similar to ‘juvenile diabetes’ and an antonym to ‘adult onset diabetes’ once popular phrase terms to describe ‘type 1 diabetes mellitus’ and ‘type 2 diabetes mellitus’ respectively. Other phrase terms with a low usage collection frequency of 1 were: 'malnutrition modulated diabetes mellitus', 'protein deficient diabetes mellitus', 'slowly progressive insulin dependent diabetes mellitus' and 'spontaneous autoimmune diabetes'. Ranked 22nd with nine occurrences were: ‘autoimmune type 1 diabetes', 'insulin dependent diabetes mellitus', 'type ii diabetes mellitus', followed by 'adult onset diabetes' with seven,, 'ketosis prone diabetes' with five, 'malnutrition related diabetes mellitus', 'potential diabetes' and 'type 1a diabetes' all with four, 'brittle diabetes', 'type i diabetes mellitus', with three and finally 'non insulin dependent diabetes mellitus' with two occurrences. The phrase term ‘non insulin dependent diabetes mellitus' once a popular synonym for ‘type 2 diabetes mellitus’ has reduced in usage over the years. Those low usage phrase terms that have increased in usage over the years are: ‘autoimmune type 1 diabetes', 'adult onset diabetes' and 'ketosis prone diabetes'.

Medium usage – Rank 9 to 21
From the document collection 13 of the 52 phrase terms (rank 9 to 21) had medium usage where their collection frequencies of between 95 and 10. In rank order these were: 'diabetes type 2', 'diabetes mellitus type 2', 'diabetes type 1', 'autoimmune diabetes', 'type ii diabetes', 'diabetes mellitus type 1', 'type i diabetes', 'juvenile diabetes', 'maturity onset diabetes of the young', 'insulin dependent diabetes', 'secondary diabetes', 'latent autoimmune diabetes in adults', and 'non insulin dependent diabetes'. It is interesting to evident word order reversal in a number of the phrase terms and the use of letters as roman numerals instead of numbers for example: 'diabetes mellitus type 2' and 'type ii diabetes'. This supports the design of the specify

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information retrieval system and its pair of indexes that keep word ordinality and proximity intact. The usage of most of these phrase terms are in decline except for: ‘autoimmune diabetes’ increasing in usage from 8 to 12 in 2006 and 2015 respectively and ‘juvenile diabetes’ increasing from 2 to 11 in 2006 and 2015 respectively. Again, the phrase term ‘non insulin dependent diabetes’, without the ‘mellitus’, has reduced in usage over the years to zero in 2015.

High usage – Rank 1 to 8

The high usage phrase terms evidenced for the document collection ranked 1 to 8 encompass eight phrase terms with collection frequencies of between 6,215 and 226 and these are: 'type 2 diabetes', 'type 1 diabetes', 'diabetes mellitus', 'type 2 diabetes mellitus', 'prediabetes', 'gestational diabetes', 'gestational diabetes mellitus' and 'type 1 diabetes mellitus'. These eight phrase terms represent a formal classification in the diabetes hierarchy with exceptions of using or not using the word ‘mellitus’. Ranked first, the most used phrase term to describe a diabetes classification in some form was 'type 2 diabetes' without the ’mellitus’ has decreased in usage from 1,483 occurrences in 2006 to 954 in 2015. Similarly, with a rank of 4, ‘type 2 diabetes mellitus' with the ’mellitus’ has decreased in usage from 234 occurrences in 2006 to 194 in 2015. With a rank of 2 ‘type 1 diabetes’ without the ‘mellitus’ decreased in usage from 514 to 347 and ranked 8 ‘type 1 diabetes mellitus’ with the ‘mellitus’ decreased in usage from 66 to 32 over the ten year period. The usage of the phrase term ‘diabetes mellitus’, that excludes its use within other phrase terms because phrase term co-existence was excluded, was ranked 3 but also decreased in usage. Those phrase terms that did increase in usage were 'prediabetes', 'gestational diabetes' and 'gestational diabetes mellitus' ranked 5, 6 and 7 respectively. 'prediabetes' increased from 19 to 109 occurrences while 'gestational diabetes' and 'gestational diabetes mellitus' increased from 65 and 43 to 88 and 52 respectively.

6 Conclusion

6.1 Frequencies and trends

The five most frequently used phrase terms used to describe a form of diabetes in some way were: ‘type 2 diabetes’, ‘type 1 diabetes’, ‘diabetes mellitus’, ‘type 2 diabetes mellitus’ and ‘prediabetes’. Research interest into ‘type 2 diabetes mellitus’ is more than three times that of ‘type 1 diabetes mellitus’. Within the classification ‘type 1a diabetes mellitus’ the phrase term ‘type 1a diabetes’ is one of the least used with a collection frequency of 4. The most popular are: ‘autoimmune diabetes’, ‘insulin dependent diabetes’, ‘autoimmune type 1 diabetes’ and ‘insulin dependent diabetes mellitus’. Within the classification ‘type 1b diabetes mellitus’ the phrase term ‘type 1b diabetes’ was never used, only the phrase term ‘idiopathic diabetes’ was used and only once. There is a tendency for authors to drop the mellitus when describing a diabetes classification in some form. Phrase term usage tends to increase when research interest into a specific diabetes classification is low. Research interest into ‘prediabetes’ and ‘gestational diabetes mellitus’ is increasing albeit slowly.

6.2 Successful retrieval using queries

What was achieved in this study was the successful and efficient retrieval of documents relevant to each of the nine classifications of diabetes. Through the use of expanded queries making use of specific phrase terms that have described a diabetes classification in some way over time, all documents relevant to each diabetes classification were retrieved judged relevant by the information retrieval system. By defining the phrase terms to use upfront, and by using query expansion to increase the size of the net, more relevant documents were retrieved (and fewer that were not relevant).

6.3 Outcome

The 52 phrase terms that were developed are found to describe diabetes classifications effectively for the purposes of retrieval. There may be many more phrase terms used in the literature, but this is a good starting point to help experts and lay-people to search the literature and to retrieve documents that are more relevant, more easily. As research across the world evolves and becomes more global, and as informed patients and carers read more deeply into such areas of special interest, it is important that the words and phrases that

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are used are properly defined and understood. The work reported here is a first step towards a future where it will be possible to improve the way that specialist literature is organised and accessed, and to bring together the work of experts in a more comprehensible and meaningful way.

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Statement on conflicts of interest

There was no conflict of interest in this study.

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Leveraging on Cloud Technology for Reporting Maternal and Child Health Services at the Community Level in Ghana.

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Background and Purpose: The Millennium Development Goals (MDG) has served as a catalyst in galvanizing governments and ministries to refocus their development agenda to meet set MDG targets. Similarly the Ghana Health Service (GHS) recognizes the importance of an efficient health information system (HIS) for generating quality data for monitoring progress towards achieving set targets of the health related MDGs 4, 5 and 6. This paper is therefore to describe the GHS effort in using electronic health record system called the e-Tracker to support the provision and reporting of primary healthcare in the area of maternal and child health services at the community level.by leveraging on contemporary cloud computing technologies.

Methods: The research approach was case study of selected facilities in one pilot district. Empirical data was collected using qualitative methods such as participant observations, interviews and supplemented by secondary data sources such as training manuals and other official documents. Philosophically the research was informed by interpretive paradigm through subjective meaning for understanding the sociotechnical complexities of implementing the e-Tracker in the health domain. Actor-Network Theory (ANT) was considered as an appropriate theoretical lens to conceptualize and investigate the dynamics of introducing a technological artefact into a social system such as the health domain.

Results: Findings were that there was realignment of work practices with resultant reflexive effects (positive and negative) on the working environment as a result of introducing information technology artefact into the health domain. And that the sociotechnical effects are emergent and cannot be determined a priori because of the multiplicities in complexity when the social reacts with the technical.

Conclusions: These findings corroborate findings in similar studies in the IS literature in that effects of technological artefacts in complex social-technical system are emergent and cannot be predetermined due to their unpredictability. Furthermore, in sociotechnical systems such as the health domain best practice is for the coexistence of electronic and paper systems. Therefore, an attempt to completely replace the paper system with the electronic system may result in system challenges.

Keywords: e-Tracker, Electronic Health Record, Maternal and Child Health

1 Introduction

The year 2000 was the birth of the eight Millennium Development Goals (MDG) when 189 countries declared at the millennium summit of the United Nations to achieve set targets by the year 2015 [47]. In the health domain this declaration served as a catalyst to galvanize governments and health ministries in developing countries to revamp their health systems to meet set targets for the health related MDGs 4, 5 and 6, that is, Reduction in Child Mortality (MDG4), Improving Maternal Health (MDG5) and Combating HIV/AIDS, TB, Malaria and other Diseases (MDG6) [16][49][55].

Maternal and Child Health (MCH) services form part of the universal health coverage package for the under privileged and this is very significant in developing countries where majority of the population live in the rural areas where healthcare infrastructures are in very deplorable state or non-existent [56]. The safe motherhood and child welfare services include Antenatal Care (ANC), supervised Deliveries, Postnatal Care

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and Family Planning (FP) services respectively. Under these programmes it is assumed a pregnant woman will receive the necessary quality healthcare through pregnancy, delivery and after delivery. And the child similarly, going through all the child welfare programmes from infancy to about five years when it will be out of danger zone for possible childhood diseases [57]. Because of the poor state of the health infrastructure in developing countries health ministries are finding it difficult to provide these range of MCH services and in cases where they are provided, the quality is found wanting. Studies have therefore shown that many pregnant women and children do not receive the full range of the MCH services especially in rural settings. In addition, these studies have also shown the existence of gaps in terms of service provision and reported data for monitoring and evaluation of such services [11][17][29][56].

In the contemporary health domains records of health service provision and the corresponding data generated are managed by a combination of paper and electronic systems. In many countries today Electronic Health Record (EHR) systems are seen and being implemented as a way of bridging the quality gap in providing healthcare and reported health data [26]. With respect to developing countries the literature talks about studies on implementation of EHRs to support healthcare. However, the common characteristics of these EHRs implementations are that they mostly are on pilot basis and target specific health service area or programmes (diseases, logistics, some family health services such as ANC, FP, etc.). These projects normally fail to scale after project expiration because of lack of funds for sustenance [9][18][31][36][41][42]. Furthermore the evaluation of such EHR projects in developing countries are said to focus on rational quantitative outcomes which often lack scientific rigour and also downplay the social dimensions of human-technology interplay.

The GHS is implementing an Electronic Health Records (HER) system called the e-Tracker at the Community-based Health Planning and Services (CHPS) compounds and zones to support MCH services and data reporting which hitherto has been facing a number of challenges. The e-Tracker is an individual client-based module in the DHIS2 which is being implemented in public health facilities in Ghana. The GHS' experience in EHR implementation in its facilities has been just up to the district level and it is now in the process of scaling to the community level. This paper is therefore on the experiences in piloting the e-Tracker in selected districts prior to national rollout. The practice of scaling or decentralizing a national HIS to the community level in developing countries may not be possible due to peculiar problems such as the availability of appropriate infrastructures and personnel. And it may be of interest to study Ghana's effort in relation to the effects of technology on work practices, the health domain and health personnel using the system.

The objective of this study therefore is to use qualitative techniques to understand the dynamics of the emergent effects of using the e-Tracker in providing MCH services at the community level in Ghana. In doing so the research will try to answer the following question: *How will the implementation of Electronic Health Record system impact on the provision of Maternal and Child Health service at the community level in Ghana?* Here community level refers to rural settings in Ghana. Answers to the research question could give insights into providing and improving the quality of MCH services and reporting in similar settings.

The rest of the paper is organized into the following sections. The next section presents the materials from relevant literature and theoretical concepts. Section three presents the research context followed by research method in section four. Case description, findings and discussions, and concluding remarks are presented in sections five, six and seven respectively.

2 Materials from Related Literature Review

The past three decades have seen many advances in Information, Communication and Technology (ICT) and their use in many spheres of human endeavours. In developing countries ICT is being used in commerce, banking, health, oil exploration, to mention a few [3][19][33][43]. The IS literature reports of variants of EHR systems implementations in the health sector to support and enhance different health services and programmes. For example, there have been reports on implementation of EHR projects to support MDG6 (combating HIV/AIDS, TB, malaria and other diseases), primary healthcare programmes such as safe motherhood and child welfare, human resource and clinical care [16] [27][28][44][53][57]. In executing such EHR projects and depending on the context, one could see the use of combination of ICT artefacts such as mobile phones, tablet computers, laptops, desk top computers, internet, cloud technology, different software, etc. These assorted technological artefacts have a range of functionalities that comes to bear on EHR implementation in developing countries. And these can be seen in clinical care, data processing, logistics management, continue of care, health statistics generation and reporting, and so on [1][4][10][54].

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Implementation of EHR systems in developing countries has been associated with a number of challenges. Some of the challenges that have been identified are lack of basic infrastructure such as supply of regular electricity, poor internet connection, technical support in case of equipment failure, high staff turnover and lack of skilled manpower e.g. computer literacy, in that most often end-users have to be trained in basic computer skills prior to EHR deployment. The implication of these challenges is increased workload on the few available staff [3][11][12]. Characteristically most of these EHR projects are donor initiatives which are executed on pilot basis for quick results with little or no local government's influence. And very often when the project period expires the local government is unable to find the necessary funds to continue from where the donors left off. The implication of these scenarios is pilot projects dotting EHR landscape and unable to scale to become sustainable [2][25].

Despite these challenges there have been some success stories in EHR implementations. The literature reports evaluation studies where EHR systems have been used for continue of care of clients' enrolled in MCH services, TB and HIV/AIDS programmes where clients are followed up on medication and for defaulting on treatment [24][48][49]. Other studies have also reported efficiency in the provision of healthcare by reduction in waiting time at health facilities, electronic transmission of laboratory reports on radiology between different facilities located at different places in a country, patient notification on treatment regimens, etc. [44][45]. One other area where studies have shown positive benefits in EHR implementation is in improving the quality of health data. Inscriptions of validation rules during the design of EHRs had resulted in reduction in data entry errors during implementation. The implication of this is to make end-users aware of the essence of inputting the correct data in order to improve data quality [11][13].

However, in many of these EHR studies the tendency has been to focus on predefined and rational effects to the neglect of emergent sociotechnical effects emanating from interaction between technical artefact and the social context [50, 6]. Researches in the IS domain underscore that such effects are best understood by adopting sociotechnical perspective using qualitative techniques. It is argued that using qualitative techniques permit an in-depth and thorough investigation of planned and emergent effects [6, 5, 50]. EHR implementation in the health domain results in technical artefacts interacting with the social and affect work practices, the health domain and introduces other side effects. This study will therefore try to evaluate these sociotechnical effects in the evolution of the e-Tracker in Ghana [6][22][50].

2.1 Theoretical Concepts

This study draws on network concept in Actor Network Theory (ANT) and how actors in the network align themselves at different phases of the network formation [39][40]. The central idea of ANT is to investigate and theorise on formation of networks, to follow what associations exist, their trajectory, enrolment of actors into a network, and how networks achieve temporary stability or otherwise. The purpose is to gain detailed insights into the manifestation of sociotechnical effects. This conceptualisation provides an analytical tool for investigating complex interaction between human actors and non-human actants in a social system where actors are considered equals.

The introduction of a new EHR system such as the e-Tracker in the health domain requires the formation of new connections with existing network components to re-organise around this new actor. And ANT can help to gain a deeper insight into the processes involved in the network formation. This can then result in recommendations of how to make the new network - i.e. one now including both humans and technology - more stable and in so doing facilitate the effective integration of the technology into the healthcare environment. Despite ANT's practical applicability it has been criticised as being too descriptive, failing to offer suggestions of how actors should be seen, and how their actions should be analysed and interpreted [37].

3 Context of Ghana

This study was conducted in one of the coastal districts of Ghana where majority of the population are subsistence farmers, fishermen and petty traders living in villages and small towns. In Ghana the MOH is the largest stakeholder in the provision of formal healthcare. Their effort is complemented by private, faith-based and quasi-government health facilities. Informally healthcare is also provided by divine healers in prayer camps, shrines of traditional healers, herbalists and Traditional Birth Attendants (TBA).

The MOH provides health services at three levels namely the primary, secondary and tertiary respectively. Health facilities at the primary level consist of the health centre (HC), clinics and CHPS compounds/zones,

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with the CHPS compounds and zones being the lowest health facility at the community level [27]. The difference between a CHPS compound and a CHPS zone is the former has a fixed structure within the catchment area comprising of a clinic and living quarters for the health staff. Whist for the latter the health staffs live outside their catchment area and visit the communities for outreach services. The secondary level of healthcare comprise of the district and regional hospitals, and the tertiary level is made of specialist health facilities such as leprosaria, teaching and psychiatric hospitals, cancer and cardio centres respectively.

At the primary level the CHPS compound is the most easily accessible health facility with catchment population of between three to five thousand people. The CHPS compounds are managed by two to five Community Health Nurses (CHN) who are MOH/GHS staff. They are supported by Community Health Volunteers (CHV) who together are expected to provide among others MCH services such as ANC, Deliveries (where there is a midwife), PNC and FP services. The health staffs at the CHPS also provide outreach services to all households in the catchment area with the intention of bringing healthcare to the people wherever they are domiciled. The CHPS concept in Ghana is a novel model that strives to bring healthcare to the door steps of the people in their various communities [20][21]. Any health complications observed at the CHPS level are referred to the HCs and the HCs likewise refer any health complications that could not be handled at their level to the hospitals which provide a range of health services capable of handling most complications.

According to the 2010 Population and Housing Census (PHC) report the Ghanaian population is slightly urban with 50.9% living in towns and cities with the remainder living in the rural areas. The country is divided into 10 regions and apart from Greater Accra (90.5%) and Ashanti Regions (60.6%) which are urbanized; the remaining eight regions have their populations concentrated in the rural areas. That is Volta (66.3%), Northern (69.7%), Upper East (79.0%) and Upper West (83.7%) regions have most of their populations in the villages.

This study evaluated the implementation of the e-Tracker in two Health Centres (HC) and two CHPS compounds in the selected district. This is for the purpose of having an overview of the full range of services provided under the MCH programme. The reason is that almost all the CHPS compounds do not have midwives and so do not conduct deliveries unless in emergency cases. The study will also look at the sociotechnical factors impacting on the implementation of the e-Tracker in the district. Lessons learnt may therefore inform improvement in the artefact design and scaling-up to the rest of the country.

4 Research Method

This is a case study of the e-Tracker pilot in some selected facilities at a district in Ghana. Case study was used because it enables an in-depth understanding and analysis of contemporary contextual issues and their relationships [40]. The epistemological lens is qualitative and interpretive where environmental actors' subjective meanings are studied and analysed [32][34]. I also participated in the implementation process with respect to system development, training and deployment. Such close involvement in this project has given me the opportunity to observe system activities, access documents, discuss and interview many stakeholders at different levels over time and space.

4.1 Data Collection

Data collection was through participation in software customization processes, training of end-users and software implementation at pilot sites. Other qualitative data collection methods used were observation of work processes and practices at health facilities with focus on health service delivery and data reporting, discussions with health staff at the facilities, 12 interviews with different heads of departments (ANC, Delivery, PNC and Family Planning) and analysis of different documents such as ANC registers, Child Health Records, Maternal Health Records, etc. and training manuals. At the facilities visited care-givers as well as pregnant women and mothers attending PNC and Child Welfare Clinics were interviewed. These pregnant women (5 in number) were interviewed with the view of knowing the level of appreciation and satisfaction of health care service they were receiving. Interviews were interactive and were used in an attempt to have a deeper understanding and obtain information of the phenomenon under study [32][38].

The study period spanned 10 months, that is, from July 2014 to March 2015. Within this period two technical boot-camps were held. The first was in July 2014 and the second was in November 2014. At the first meeting the different data collection instruments such as ANC, PNC registers and Child and Maternal Health Records were reconciled and standardized to enable customization of the e-Tracker module in the DHIS2. Standardization of these documents was necessary prior to customization because of the existence of different

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versions in the public health system. At this first boot-camp only the ANC register was updated to the required standard because stakeholders who were supposed to have made inputs for the updates were not present. In view of this challenge only the ANC component of the e-Tracker was developed, end-users trained and decision taken to pilot the system in one district. A number of supporting and monitoring visits were also made to the twenty-one facilities within the pilot district. Lessons learnt from these visits fed into the second technical boot-camp in November 2014. At this meeting the Delivery, PNC and FP registers were standardized and components of the Maternal and Child Health (MCH) services were programmed into the e-Tracker module. This was followed by on-site trainings conducted for end-users to enable them commence inputting 2014 MCH service data.

Amongst the 21 health facilities in the selected district, four were purposefully selected for in-depth studies [53]. Other reasons for purposefully choosing these four facilities were easy access to research sites, limited resources and the likelihood of getting the required data for analysis. These health facilities are from two sub-districts within the selected district and from each of these one HC and one CHPS compound were chosen for in-depth studies. Even though the CHPS compounds chosen were equipped with delivery wards and are supposed to be able to conduct deliveries there were no midwives due to lack of this calibre of health staff.

4.2 Data Analysis

In qualitative research data collection and analysis go hand-in-hand as field work progresses. The data collection informs the analysis and vice versa [34][35]. Field diaries were kept in which field notes were taken during interviews and when observing health staff at work. Field notes were also supplemented with photographs of health staff at work, end-users inputting data into the e-Tracker, data capturing instruments such as summary forms, registers and clients receiving MCH services. The analysis of the field notes involved transcribing and organising the notes into themes informed by the interview guide, the theoretical concepts and the research question [32][38]. These themes were on work practices, effect in the use of the e-Tracker on work flow, merits and demerits of the system, issues of the system relating to data reporting, organizational influences, socio-cultural issues and recommendations for system improvement and sustainability. Particularly the study focused on the interactions of the e-Tracker in the health domain by trying to understand the dynamics of socio-technical effects in ANT terms of translation and alignment of actors in a network, work practices, organizational influence or focus, and emergent tensions or conflicts or threats [6][8][50].

5 Findings

This section describes the CHPS concept as a vehicle for providing primary healthcare at the community level within the public health sector in Ghana. The section also highlights the activities and the workflow of the health staff as they discharge their duties in both the paper-based and the EHR systems respectively.

5.1 Providing MCH Services at the Community Level

The strategic policy of the GHS is to have a three tier level of healthcare within a district. These are the district level where we have the District Hospitals (DH), the sub-district level where we have the Health Centres (HC) and the Community level where we have the CHPS compounds. At the CHPS compound primary healthcare is provided to the population by resident CHOs who are assisted by community social structures and volunteer systems [20].

The CHPS initiative by the government of Ghana is a strategy for providing sustainable healthcare to the population in the rural communities. The basic structure for CHPS implementation is a Community Health Officer(s) (CHOs) resident in the community who serves as a representative of the GHS, the existence of active Community Health Management Committees (CHMCs) responsible for managing the CHPS compound and Community Health Volunteers (CHVs) who serve as a link between the members of the community they represent. The health service on the other hand is represented by the CHOs who are normally Community Health Nurses (CHNs) [20].

A range of services both curative and preventive are provided by the CHOs at their catchment areas. Some of these services are provided at static clinics at the CHPS compound or as outreach services in the community and households. With regards to MCH services the CHO is expected to carry out regular home visits, provide

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ANC services both in the homes and the community, monitor the growth and development of children in the community, provide immunization to children and pregnant women in homes and the community, create awareness and provide appropriate FP methods to individuals and couples, conduct emergency deliveries, recognise complications in pregnancy, delivery and post-delivery and make prompt referrals. In addition the CHO is also expected to monitor the activities of Traditional Birth Attendants (TBAs) and as well as the activities of private midwives.

In pursuance of his/her duties the CHO is expected to keep stock of his/her activities by compiling and updating health service registers on ANC, Deliveries, PNC and FP. Reports on these activities are expected to be submitted on time to the district. Hence the focus of this study was on the activities of the CHOs in the performance of their duties in providing and reporting of MCH services at the point of care using the e-Tracker. These activities have been categorized into three thematic areas namely (a) Provision of Community MCH Services, (b) Continue of Care in the Community and (c) Reporting on Service/Healthcare Delivery.

5.2 Provision of Community MCH Services

The CHOs at the CHPS zones and compounds have the oversight responsibility of providing antenatal services to pregnant women and postnatal care to mothers and babies especially at the early stages of birth. This entails a number of household visitations to provide service to pregnant women, mothers and babies (or static clinics at the compound). The findings are that during pregnancy the CHO visits their clients at least each trimester to assess their health status and counsel accordingly. Where there are complications clients are referred to a higher health facility for medical attention by specialists. During these household visits pregnant women are also prepared for delivery. These preparatory stages are recorded in a booklet called 'what every pregnant woman should know'. This is provided by the MOH of which copies are given out to clients to keep.

By policy all CHPS compounds are supposed to have a midwife but this is not the case at the sites visited even though there were delivery rooms at the compounds. The findings were that this is also the case in most CHPS compounds in Ghana. This is due to lack of midwives in the sector and the few there are, are quite old and nearing their retirement age. Clients in their late pregnancies were monitored by household members and/or CHVs. At the onset of labour the CHO is informed in person or by phone who in turn notify the village/community ambulance for the expected mother to be conveyed to the HC to deliver. At the sites visited the village ambulances were privately owned motorbikes that are hired for a fee. After delivery the CHO continues the household visitations to provide postnatal care and this is intensified for the first twenty-eight days when mother and child are most vulnerable.

In the paper-based HIS ANC, PNC, Delivery and FP services are recorded in the Maternal Health Records and Child Health Records booklets which are kept by the mother. The contents of these booklets and that of the paper registers for these services are the same. At the end of every month health statistics are compiled from the registers onto paper summery forms for submission to the district for input into the DHIS2 by the district Health Information Officer (HIO). These data processing activities described above were before the implementation of the e-Tracker. But after the implementation of the system it is expected that all data collection and reporting would be done at the point-of-care electronically in the e-Tracker.

There used to be some level of collaboration between TBAs and the formal health system when it came to issues concerning MCH, especially deliveries. With support from stakeholders such as the UNFPA, in the past TBAs were trained to assist the health facilities to provide supervised delivery in order to reduce maternal mortality and improve maternal health [46]. Somewhere in the mid-2000s this partnership was abrogated by the MOH and currently TBAs are not by policy recognized as caregivers in the communities any longer when it comes to MCH issues especially deliveries. The situation is somewhat blurred at the sites where this study was conducted because there seems to be some semblance of cooperation between the health facilities and the TBAs.

5.3 Continuum of Care at the Community Level

The CHPS compounds provide both static and outreach services to the population in their respective catchment areas. In the event that clients were absent from scheduled ANC, PNC and Child Welfare Clinics (CWC) the findings were that the CHOs followed-up to find out the reasons for the client's absence. Sometimes these follow-ups were done through the CHVs or through members of the CHMC in situations where the CHO was engaged and cannot perform this service in person. With the advent and proliferation of mobile phones follow-

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up on clients were also done if their contact numbers or those of next of kin were known. This is to ensure continuous care to mother and child. For instance, this continued care will ensure that the children are immunized and protected against all immunizable childhood diseases. Furthermore in situations where clients are referred to the health centre the CHO at the CHPS compound follows-up to ascertain whether clients indeed went to the facility for medical attention.

5.4 Data Reporting on Service Delivery

Every service provided at a health facility generates data that is supposed to be used for planning and making decisions for providing healthcare. At the community level different data-collection instruments were used to record MCH services provided. The findings were that every pregnant woman receiving ANC service for the first time was provided with a Maternal Health Records (MHR) booklet which contains all the information on the pregnant woman from ANC through Delivery to PNC and FP. This booklet contains information on personal history, demographics, obstetric history, medical/surgical history, etc. This booklet is kept by the client and has to be presented whenever she accesses health service at a health facility.

After delivery a similar booklet called Child Health Records (CHR) is given to the child and it contains information on the child, i.e. demographics of the child and the mother, immunization history, growth monitoring chart, breast feeding, management of malaria, information on FP for the parents, etc. This booklet has to be presented by the mother anytime the child accesses health service at a health facility. At the facility level the CHO at the CHPS compound keeps registers on ANC, PNC, CWC and FP services provided. Similarly, the midwife at the HC keeps a register on Deliveries at the facility. These registers contain information on individual clients who have accessed service at the facility and have information similar to that in the MHR and CHR booklets. According to the care givers data from these registers are aggregated on summary sheets and physically sent to the district for input by the district HIO into the DHIS2 database.

The observation at the research sites was that there were disparities in some of these data collection instruments. For instance even though MHR booklets looked the same there were differences in naming of some of the fields e.g. for personal history for the client one field is named location in some and community in others; FP field in some but FP field missing in others. For the registers and monthly summary sheets there were also marked differences in the naming conventions and the number of indicators in these data collection instruments. The reason attributed to this apparent lack of standardization was that the instruments are updated periodically but the updated versions do not get to the facilities on time to be used. Faced with a situation the CHOs said they have to improvise using the old ones where pencil is used to correct the names of the indicators or data elements in question. Such practices obviously have serious implications on the quality of data being reported.

5.5 Implementation of the e-Tracker

The HIS in Ghana is a combination of both paper and electronic. Data is compiled at the point of generation on summary sheets and submitted to the district for input into the DHIS2. Over the years a number of challenges have been identified in the provision and reporting of healthcare services at the facilities. As have been identified in other IS researches some of the reasons for perceived challenges in health data reporting are lack of skilled manpower in data management, lack of standardized data collection instruments, poor infrastructure, lack of resources, etc., and the same can be said about the situation in Ghana [8][23][30]. Recent developments in IT infrastructure in Ghana has lend impetus to scaling the DHIS2 to the community level with the aim of using ICT to support the provision and reporting of healthcare services at that level.

The e-Tracker is an individual client-based EHR system designed to capture data on ANC, Delivery, PNC and FP services provided at a given health facility. It is an inscription of the processes and data attributes in the paper-based system in an electronic format. It also has other additional functionalities to facilitate provision of healthcare and reporting. These functionalities are registration of client demographic data, scheduling client encounters, tracking client progress over time in accessing healthcare, following-up on healthcare defaulters, collating individual data into aggregates for the DHIS2, performing different analysis, and generating different reports. A client (for example a pregnant woman) reporting at a health facility for healthcare is first registered in the system. The demographic data comprising of name, address, gender, age, phone number, next of kin, etc. constitute the registration data attributes.

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After this input the registered client could then enrol in any of the MCH programmes, that is, ANC, PNC and FP. To follow a pregnant woman through ANC the system requires the woman to provide the Last Menstrual Period (LMP) date which will be used by the system to automatically calculate the next and subsequent ANC visits. To search for clients, the e-Tracker's search engine uses different criteria based on unique identifier, name, address, date-of-birth, phone number and/or a combination of these. Most Ghanaians have enrolled in the National Health Insurance Scheme (NHIS) and have unique NHIS number. This is used as a unique identifier in the e-tracker if a client has it. Otherwise a system generated identity number for every registered client is used as the unique identity number.

With these sterling characteristics it was envisaged that implementation of the e-Tracker at the CHPS compounds/zones will facilitate provision of healthcare, address challenges in MCH data reporting and scale the DHIS2 to the community level. It was for this background that a two weeks boot-camp was held in July 2014 to design the system and to train end-users on its use. With support from the University of Oslo DHIS2 the technical team at the GHS undertook the customization of the e-Tracker. Healthcare officers from the Family Health (FH) Division also assisted in standardizing the data collection instruments before incorporation into the e-Tracker. This is because MCH services are under the purview of the FH division of the GHS. Because of data overlaps some indicators and data elements needed further clarification and redefinition before input into the e-Tracker.

Figure 1. E-Tracker Training Session

After this technical work end-users from the pilot district were trained for two days in the use of the system with live data input for 2014. Those trained consisted of the District Director of Health Services (DDHS), District Public Health Nurse (DPHN), Heads of sub-districts, all heads/in-charges of health facilities in the district, all Community Health Nurses (CHNs) at the various CHPS compounds/zones and some midwives.

5.6 Learning Experiences from the e-Tracker Implementation

Facilities were asked to enter 2014 data to test the functionality of the system and followed-up field visits to selected sites yielded some positive comments. All the sites visited were of the accord that the system was quite efficient for record keeping and data management. This in their view was because, compared to the paper system it was easier to retrieve and manage records in the e-Tracker. In terms of archiving users said that it ensures good storage and retention of data and reduces the possibility of losing data. Users further said that with the paper system it is easy to lose data. Users were also of the view that the e-Tracker promotes data transparency and directly ensures that users input correct data in lieu of which peers and superiors are likely to question any spurious data in the system.

At the community level care givers were of the view that the system was particularly useful in scheduling client encounters and following-up on clients to ensure continuity of care especially where there happens to be defaulting clients. When asked what were the merits and demerits of the e-Tracker, some of the responses were:

'.. it is a good system because it keeps all the data at one place and when we need it we can just open the system and get it…with the paper system it is possible to lose the data when you cannot find the paper'

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'.. with this system everybody sees the data when it is captured in the system, this means one has to be careful to input the correct data'

'..the system makes it possible to see which pregnant woman has defaulted in coming to the facility for MCH services…when this happens we can follow-up on the defaulter to find out what was the reason'

'..the only problem with the system is using it at the point of care especially when you are few….this is because we do many things at the same time and it makes service delivery very slow…and also because the keys on the tablet computer are very small and difficult to operate when under pressure'

Above all the e-Tracker was said to be quite user-friendly and could eliminate the monthly trips to the district office for submission of paper reports as these trips also have budget implications and are sometimes inconvenient. Furthermore, the e-Tracker could shorten the hither-to data flow from points of generation in the communities to the next level thereby reducing some of the potential complexities which may lead to data quality challenges.

Despite the good characteristics of the e-Tracker, users reckoned a number of challenges which needed to be addressed for its smooth running and scaling-up. The CHOs complained about the workload, that is, combining provision of healthcare and data management was particularly challenging when one considers the staff strength for MCH services. In fact care givers interviewed said that they were finding it increasing difficult to offer healthcare, complete all paper works (fill out registers, MHRs and CHRs) and then enter data into the e-Tracker. This was found to be true because as at the times of the visits, that is, September 2014, November 2014 and January 2015, none of the facilities visited had completed 2014 entries in the e-Tracker. Users therefore suggested that it would be ideal to increase the staff strength at the facilities with one person responsible for data management. Otherwise it may be impossible to provide healthcare and simultaneously manage the e-Tracker at point-of-care.

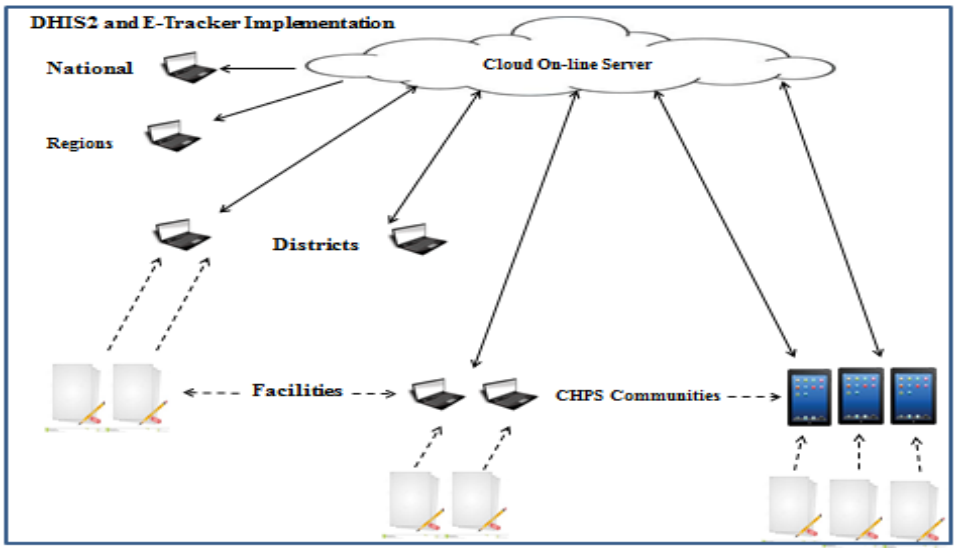

Figure 2. DHIS2 and E-Tracker Implementation in Ghana

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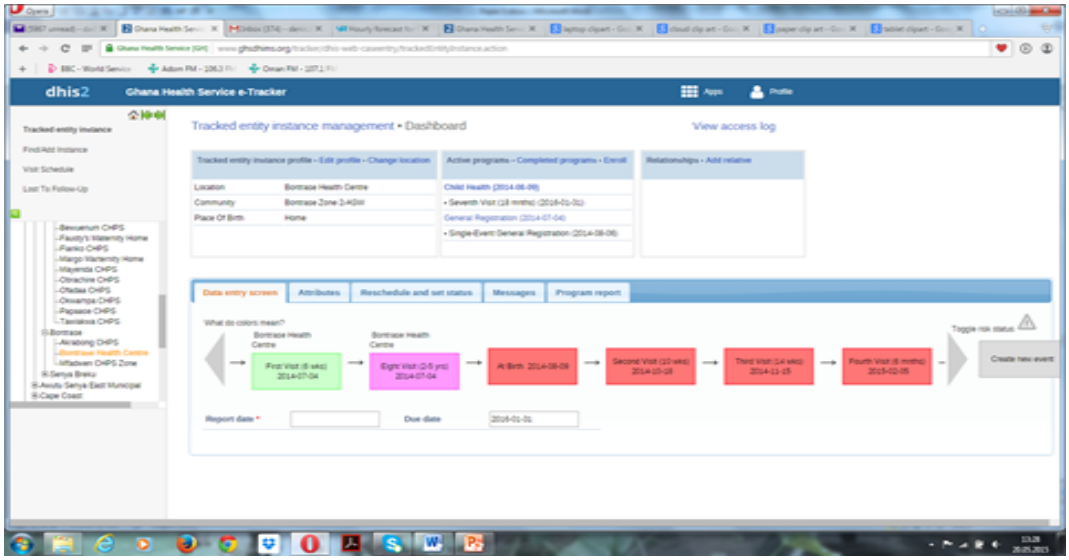

Figure 3. E-tracker Dashboard of a Child/client Enrolled in Child Welfare Programme

For example one scenario sited by a CHO was a comment passed by a client when the CHO was concurrently offering ANC service and entering data in the e-Tracker:

'What is wrong with these nurses these days? Look at this one! Instead of concentrating on her job she is all the time looking at her mobile phone and wasting our time here.'

After this comment the CHO had no option but to stop her data entering and concentrated on providing ANC service! It was also obvious that no sensitization was done to orient clients on the new electronic system.

The CHW(s) were then asked how they were able to capture data into the system because the initial arrangement was to capture data simultaneously at point-of-care. The response was;

'We are only two here and MCH work entails a lot and at the same time we do other clinical work like attending to OPD. So the only time we are able to get data into the system is when the tension has gone down and that is in our free time. Sometimes it's only one person here when the other has to go for a workshop or travel, so it's not possible to combine taking care of clients and at the same time working on the system'

Other challenges relate to suitability of IT equipment, instability of electricity power and erratic nature of internet connection at some of the facilities. Users claim that the keys on the tablet computers were too small thus inputting data becomes somewhat cumbersome especially on very busy days. Otherwise the system is said to be technically quite easy to use. The CHOs therefore expressed the wish for laptop computers instead of the tablet computers. One of the responses concerning the use of tablet computers for service delivery and reporting was:

'…the tablet is good but not easy to use especially when there are lots of clients…we think a lap top computer will be better because one can work faster'

It was also observed that computer literacy was a challenge especially among the old CHOs and midwives. The CHOs who were trained remarked that the number of training days were insufficient to enable them master all the functionalities of the electronic system. This was because some of them who were not very computer literate found it difficult to backtrack when they got stuck in a process. Others also expressed the wish to explore additional features, especially the analytical aspects, of the system but could not for fear of causing some damage to the e-Tracker module.

6 Discussions

The previous sections have been on the account of designing and implementing the EHR system, namely the e-tracker, in health facilities to support MCH services at the community level in Ghana. An evaluation of the system in use have brought to the fore issues which might be identical to some of the issues already mentioned in the IS literature when ICT artefacts are introduced into social systems or organizations such as the health domain [6, 50]. The study looked at the complex interactive effects of the technical artefact, the e-Tracker,

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with respect to the activities and actors involved in providing MCH services in rural communities in Ghana. This section analyses these complex sociotechnical effects on work practices, the health domain as an organization, and possible threats or tensions that might have emerged through this entanglement of the social and the technical.

6.1 Effects on Work practices

Activities involved in the provision of MCH and other services at the CHPS compounds/zones or community levels are to be performed by at least two to five health workers and supported by community volunteers if quality healthcare is to be provided. For ethical reasons I will name facilities by using alphabets. The staff strength at both CHPS compounds A and B visited were two respectively. At CHPS compound A there is one regular ancillary staff responsible for general cleanliness of the compound who also doubles-up as care provider. This ancillary worker at facility A have added responsibility of having to provide care and do data entry due to inadequate qualified health staff at this facility. At both facilities A and B the use of the e-Tracker for MCH services and data reporting is done retrospectively because of lack of staff to enable point-of-care use of the e-Tracker. The scenario was the same at the two health centres visited. The staff strength was low taking into consideration the size of their catchment population. The e-Tracker was being used retrospectively after service provision contrary to initial design intension.

This low staff strength also affects outreach services and household visitations at the communities. Since the CHPS has to provide both static clinics and outreach services it means one CHW has to always be at the compound to attend to clients whilst the other embarks on outreach services. The principle of using the community social structures to support the work of the CHW to provide MCH services as was exemplified when CHPS was a research project seems to be disappearing simply because there are no remunerations or incentives for the volunteers. When the CHPS was conceptualized as a project there were remunerative packages for volunteers from the communities. But this study has observed that the volunteer component of the CHPS implementation in reality is becoming problematic because of lack of incentives possibly due to financial constraints.

From these analyses one can infer that there has been realignment of MCH work practices at the community level as a result of introducing the e-Tracker. As a result of low staff strength at the health facilities there has been increase in the workload in general because health staffs were not being able to use the e-Tracker as a point-of-care system but had to resort to retrospective reporting [6, 50]. But in terms of designated responsibilities others have increased workload than others as in the case of the ancillary staff at CHPS facility A, who was not supposed to be assisting in MCH healthcare services. However, one can discern some degree of collaboration among the workers as they improvised in order to perform MCH activities with the introduction of the e-Tracker. Thus the introduction of the e-Tracker has occasioned the emergence of very complex interactions in the provision of the MCH services.

6.2 Effect at the Organizational Level

Studies have shown that introducing EHR into the health domain could have both positive and negative effects as has been observed in this research [6][50]. Lack of adequate staff has resulted in realignment of work and responsibilities among the few health workers at the health facilities visited. These realignments have resulted into none skilled health workers having to offer some MCH services thereby interacting with the e-Tracker. The knowledge thus acquired by these none skilled staff have direct influence on the healthcare system. These effects could be said to be positive if the acquired knowledge is applied correctly and negative otherwise.

The design of the e-Tracker is also seen to have some effects on the delivery of MCH services. The imposition of system checks on some data elements affects the provision and recording of MCH services. For example it is mandatory to input values for last menstruation period (LMP) for ANC clients in the e-Tracker to facilitate scheduling of subsequent visits. Again the validation rules inscribed in some of the data elements in the e-Tracker prompts health workers to be more fastidious during data entry. This intrinsically makes health staff conscious of the importance of recording the correct data. This system checks essentially promote organizational learning and awareness of the essence of data quality in the health domain. The down side to organizational focus on some data elements is that health staff may not be particular about some data elements which may eventually affect some dimensions of data quality. For example data completeness and accuracy may be compromised if data entry skips some data elements because they are note tagged as mandatory.

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6.3 Environmental Threats

The design and implementation of EHR system in the health domain is to leverage on perceived good characteristics of such artefacts to improve and minimize error in providing healthcare and reporting health data [14][51][52]. In pursuance of this goal research has also shown that IT artefacts behave unpredictably when introduced into social systems such as the health domain. These unpredictable interactive effects are contextual and manifest themselves in a number of ways such as errors in reporting healthcare service e.g. laboratory reports, drug dispensing, data quality challenges and so on [6][50]. Similar observations were made in this study in the area of reporting the MCH services. These in some of the IS literature are called risks or contradictions or tensions [50] and are being referred to in this study as the threats in the health environment as described below.

The data reported in the e-tracker were incomplete and this was attributed to a number of reasons. First due to lack of adequate staff and the huge workload, data was being captured after service has been provided using the various MCH paper registers as the original source instead of point-of-care data entry as originally envisaged. Hence there were some data entry backlogs when data in the MCH paper registers were reconciled with the data in the e-Tracker. Secondly there were gaps in some of the individual records in the e-Tracker. This was due to missing values for data elements without validation rules making such records incomplete and inaccurate. Thirdly, erratic electricity power distribution and unstable internet connection occasioned frequent system breakdowns leading to data entry backlogs which were difficult to clear. Lastly because of poor computer skills and also staff not properly mastering the use of the e-Tracker there were some double registrations in the system. According to the health staff sometimes they were unable to navigate themselves out of a 'fix' when stalled in data entry and have to reregister a client again. These practices occasioned double registrations as staff could not delete the uncompleted records from the system. These observed breakdowns may affect provision of healthcare and reporting of health data in significant ways. and these may therefore be seen as threats to the health domain.

7 Conclusion

This paper is about scaling an electronic health record system called the e-Tracker to the community level for the provision of maternal and child health services to the rural Ghanaian population. This is being made possible because of two reasons. One, the healthcare system in Ghana is decentralized beyond the district to the community level called the CHPS. Two, leveraging on recent ICT developments in Ghana the GHS has also decentralized the DHIS2 system (of which e-Tracker is a module) to all districts in the country using a cloud server-based architecture and hence the possibility of scaling to the community level.

This paper aims to contribute to studies in introducing sociotechnical systems to lower levels of the health domain and also to understand their interactive effects. The findings corroborate findings in earlier studies that interactive effects of actors in sociotechnical systems are complex and cannot be predetermined but are emergent in nature [6][22][50]. And to understand these effects the researcher has to follow the movement of the technical artefact as it interacts with the social domain. In this research these effects were studied through evaluating the work practices of the health workers in their use of the e-Tracker. Concepts from ANT were used as lenses to conceptualise how different realities or effects are experienced and enacted by different actors in a network [39][40].

One of the findings was the observation that there was realignment of work practices among all cadres of health workers which may have the potential of affecting provision of MCH service and reporting either negatively or positively [6][50]. Emergent undesirable sociotechnical effects as conceptualized in the IS literature as risks or tensions or contradictions were also observed and in this study called environmental threats. Some of the desirable effects observed with the introduction of the EHR were ease of use, good data storage, efficient data retrieval, proper scheduling and tracking of clients for continue of care. The import of this is that these effects cannot be predetermined but emergent because of the unpredictable and complex behaviour exhibited when technical artefacts are used in social systems. Therefore observed sociotechnical effects of artefacts in use in social systems could not be generalized because of their emergent nature and may be contextual.

Significantly the intension of completely replacing the paper system with an electronic one could be viewed as clash of standards as the two systems follow different rationalities with respect to work practices [22]. Therefore attempting to replace the paper system with an electronic system by operationalizing the

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electronic system with the paper logic introduces unnecessary complexities and interdependencies which is affecting work practices as has been exemplified in this study. Rather it will be important to ensure the coexistence of the two systems (as has been the case in almost all information infrastructures thus far) by finding a middle ground such as dedicated HIOs at each service delivery point that will ensure part collection of accurate data electronically and also accurate recordings in the paper registers for later input in the e-Tracker. This harmonization and coexistence of these two systems may ensure more credible HIS and improved data quality.

Statement of conflict of interest

I will like to state that there were no conflicts of interest in the conduct of this study.

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A Viable Architecture for the Integration of a Recommender System and Mobile Counselling system for the Management of Chronic Illnesses and Stigma-Related Infections

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Background and Purpose: Mobile devices are a common sight everywhere in the world with attendant phenomenal growth in communication. As a result of their mobility, there has been an increase in telecommunication industry's penetration. Besides, the impact on socio-economic status of the global village is staggering. As a result of this impact, there have been changes in the ways businesses are done in commerce, economic and health sectors. One of the changes this has been brought about is the use of mobile devices in the real-time monitoring of individuals who lack physical mobility due to illness. There have also been reports of their use in the management of certain ailments, drug administration among others. In this work, the mobility and a degree of privacy that mobile devices offer combined with the ability of recommender systems to make personalized medical assistance to individuals with chronic ailments and stigma-related infections is explored. Recommender systems in medical and healthcare context are emerging significantly with attendant positive impacts on the speed and accuracy of diagnosis. A few successful implementation of such recommender systems alongside few with good results have been highlighted in literature. This paper however proposes the integration of two architectures in order to achieve a better result. The fusion of a recommender system into HIV/AIDS mobile management system where personalized assistance can be given to individual who are afraid to seek medical care openly because of stigmatization is the desired goal of this work. While the overall goal of this project is to use the integrated architecture for providing personalised assistance to people living with stigma-related and chronic illnesses, the focus of this paper is on providing personalised assistance to people living with stigma-related infections such as the HIV/AIDS using the integrated architecture. On the potential of mobile devices for use in counselling and discussing health related issues including HIV/AIDS, the result of survey conducted shows that over 80% of the respondents are comfortable using this medium prior to face-to-face contact. This is an indication that mobile devices have the ability to act as the medium for the first contact for victims of stigma-related illnesses and to play a vital role in the disease management. In-depth analysis of the results of the survey revealed that synergies among some key components will produce a desirable architecture presented in this paper

Methods: Questionnaire was administered on potential users who are drawn from 250 youth and health workers from the ages of 18-50. Respondents were drawn from students in three universities in Osun State Nigeria and health workers in a nearby hospital. The analysis was performed using the SPSS.

Results: survey conducted on the potential of mobile phones for counselling those infected with HIV/AIDS shows over 80% of the respondents indicating that they are comfortable discussing health issues (including HIV status) via mobile devices before face-to-face contact. From the analysis of the result of the survey, the need to enhance the performance of the management system was also seen. Integration of a recommender system that would provide the desired personalised services became a desirable option. The architectures for the management system and the proposed integration are presented in this paper.

Conclusions: It can be seen from the analysis of the survey and the presented architectures that mobile devices have a role to play in the management of ailments for which people are stigmatized (such as HIV/AIDS), and is more effective when integrated with dynamic recommender systems.

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Keywords: System architecture, Mobile health, Recommender systems, Health information system, HIV/AIDS

1 Introduction

HIV/AIDS-related stigma, which includes prejudice, discounting, discrediting and discrimination directed at people perceived to be living with HIV or AIDS is a major barrier toward better care for those infected [1,2,5,6,30]. Worse still, those who provide direct services to individuals affected also suffer stigma [32]. The rate of prevalence among the most vibrant population (15-49) is alarming and the effects of HIV/AIDS epidemic on economy can be very damaging. These are slow or reverse economic growth, reduction in savings and investment of families because of increase in expenditures of HIV/AIDs related issues, diversion of public spending from investment on human and capital to health, and increase in poverty rate [14, 18,19]. Globally 35.3 million people were living with HIV in 2012 with Sub-Saharan Africa home to 70% of all new infections [34]. Among the problems responsible for the prevalence is lack of access to medication and good counselling which is due largely to prejudice and stigmatization [34]. A report on how stigma affected women with HIV infection shows that the rejection caused by stigma affects access to health care, medication adherence, social interaction and social support [9]. Another report on HIV-infected individuals' ability to access care shows that more than half of the respondents reported difficulty accessing care at baseline and follow up due to stigma [17]. Even in Diaspora, stigma within the communities has been reported as a barrier to accessing HIV testing and HIV services among HIV-infected African migrants [8].Research has shown that stigma and discrimination in the health care setting and elsewhere contributes to keeping people, including health workers, from accessing HIV prevention, care and treatment services and adopting key preventive behaviours [26]. Surprisingly though despite many positively directed efforts at reducing stigma encountered by infected people in Africa and elsewhere in the world, a recent report has confirmed an upward trend in internalized stigma in an African country [10].While media and social networks have provided help in creating awareness and reducing stigma [15], exploring means of reaching out to individuals with infections in some personalized way can boost efforts to eradicate the infection. Modern technology has provided several means of reaching individuals on a more personal level without fear of stigmatization. One of such means is the use of mobile technology.

Besides their common use in other sectors of the economy, Mobile devices have become a ready and effective tool in healthcare, especially for monitoring, service delivery and sometimes management. There have been efforts to provide effective solutions for mobile health in the broad context of cost reduction and just-in-time services (such as in [34]). The mobile phone has been found useful in patient care and monitoring. Specific example is the use of Smartphone's feature for monitoring patients with Alzheimer's disease. [28].The effectiveness of mobile devices for medical counselling is yet to be fully explored especially in developing countries where individuals living with infections for which people are stigmatized are reluctant to freely seek medical care. Some informal charges such as transportation and other out-of-pocket expenditures can also present a significant barrier to people gaining full access to HIV/AIDS treatment and care services[38] and these become something not to worry about with the use of mobile devices. Listed as one of the areas on which interventions must focus in order to combat stigma in health facilities is the individual [26] and one of the most effective ways to reach people on a personal level without fear of being stigmatized is the use of mobile device. With HIV/AIDS becoming endemic in most developing countries and victims becoming afraid to openly to seek medical care because of stigmatization, mobile-technology-based health management system surely has a unique role to play. It is noteworthy however that use of mobile devices in assisting to care for HIV-infected individuals has been documented in literature. Such interventions are seen in their use to help infected individuals to adhere to treatment [35]. In a project tagged "Cellphones4HIV", conducted in South Africa, three pilot projects were examined to see how mobile technology can be used in the prevention, treatment and care of HIV and AIDS, and to support the HIV sector in general [30]. In this work the need for integrating an HIV/AIDS mobile management system with a recommender system is explored. This is necessary in order to provide a common platform that can be used to achieve the desirable objective of an interactive health management for persons living with HIV/AIDS. Broadly the common features of the proposed system from the viewpoint of users and experts are determined to make the entire system useful and transformative following integration with the existing Hospital Information systems. The resultant architecture is the fusion of architecture for a mobile management of HIV/AIDS infections and that of a recommender system.

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The use of mobile devices in administering care will pose little or no problem because the general perception of mobile phone use among physicians has been shown to be very promising [28]. One typical manifestation of this is seen in a report on acceptance of e-prescription technology among South African Physicians.Data was collected from a sample of 72 physicians. Results indicated a general acceptance of e-prescribing amongst physicians who on average reported strong intentions to use e-prescribing technologies if given the opportunity [13]. Besides the favorable attitude towards electronics tools, accepting mobile technology specifically as an important tool in administering effective care does not pose any serious problem among care providers, even those dealing with HIV/AIDs infections, as different reports have indicated [36, 3, 16]. However, a better intervention can result with mobile technology integrated with other technology-related tools; in this case we are proposing a recommender system.

Recommender systems in medical and healthcare context are emerging significantly with attendant positive impacts on the speed and accuracy of diagnosis. A few successful implementation of such recommender systems with good results have been highlighted in literature [18, 37, 29].A recommender system proactively suggests items of interest to users based on their objective behavior or their explicitly stated preferences [31].Recommender Systems provide users with predictions and recommendations of items [5]. Recommender system has become an important tool in commerce and other sectors (such as health) of our social and economic life. The typical implementation of recommender system known to many people is the search engine such as the Google. The main characteristic of recommender systems is that they can personalize their interactions to each individual user. Personalization involves the design of systems that are able to infer the needs of each person and then to satisfy those needs [33].Some researchers have cited the terms *individualized*, *interesting* and *useful* as differentiating criteria [7, 27].Interestingly these are the desired characteristics of the integrated system this work aims to achieve. Recommender systems have been developed to meet the needs of users in different domains and using different methods and algorithms [33]. Some of the recommender systems highlighted in literature have some form of intelligence built in them but lack the ability to learn and make automatic, personalized recommendation dynamically. Moreover, some diseases change symptoms (e.g. cancer, HIV/AIDS) as they progress to maturity or get worse. Individuals living with such diseases will benefit from personalized recommendations based on the progression. Learning from the user's past activities or requests, useful personalised recommendations are possible.

2 Materials and methods

This work is divided into three different phases. The first phase involves conducting a sample survey. The sampling method used is the convenience sampling of non-probability sampling method. This method was adopted because the part of the population surveyed are easily accessible for follow up during subsequent phases of this work. The population studied consisted of youth between the ages of 18 and 45, and health workers. The sample survey was carried out in three higher institutions of learning in Osun state of Nigeria for two reasons: (i) the population is readily accessible for further research activities such as requirements refinements and testing of the mobile management system prototype, (ii) the assumption that the population represents the age range that is susceptible to the malaise and that easily use the proposed technology. The SPSS was used to do the analysis of the data. The survey was also used to gather features that respondents would like the proposed system to have. The suggested features were ranked in the order of preference by users. The questionnaire used has both open and closed ended features using direct personal interview. This was done in order to obtain correct and reliable information from respondents. Typical questions used are indicated below.

1. *If a mobile phone based system was to be developed for monitoring patients from your health centre, do you think it would be beneficial to you? Yes ( ) No ( )*
2. *How comfortable are you discussing personal issues on a mobile phone?*
   Very comfortable ( ) Comfortable ( ) Hardly Comfortable ( ) Not Comfortable ( )

Following qualitative and quantitative analysis of the data and the development and integration of the architectures, verification was carried out on the architectural model with potential users and identified software developer who have some knowledge of quality assurance. Examples of questions used as a guide are indicated below. The questions were used as guide during the discussion.

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3. *Suggest any areas that you feel require improvement to fully support effective counselling of HIV/AIDs patients:*
4. *What other feature(s) do you want such a system (mobile counseling system) to have?*

3 Results

The sample survey carried out to determine users' perception on the effectiveness of mobile phones in the management of HIV/AIDS patients shows that 70% of the respondents have no problem using mobile technology as a medium of counselling on HIV/AIDS and other stigma-prone infections. 80% of the respondents however show that they feel comfortable using mobile devices for consultation. The result indicates that portability and privacy, especially since encryption of discussions will be ensured, are among the features of mobile technology that respondents chose as the determining factors. Other features extracted are check-up reminders, health information updates, information about drugs and availability, prevention and support, and clinic attendance.

The survey also pointed to the non-functional attribute of viability, usability and usefulness of the entire integrated system.

3.1 What the Study Reveals

The following inferences are drawn from the analysis of the survey considering the aim of the research.

(a) Users are comfortable discussing confidential matters over phone as long as they are sure the person on the other side can be trusted

The result of the survey indicated that phone is a least known device for receiving personalised interactive counselling. Although a greater percentage (96.7%) of the respondents indicated that they had not received any formal counselling through phone but 53.7% of the same population agreed they would feel comfortable discussing some personal matters, including HIV/AIDS and other stigma-related infections, on the phone as long as they are sure that the other person can be trusted. This is especially important because of confidentiality of health information.

(b) Phone is useful for an initial contact to build confidence and learn

Since all the respondents have phones and have been using them for a while, some 62% agreed they were able to build confidence in their mobile friends after discussing together over the phone for a period of time even before they were able to meet face-to-face. This is a promising indication that confidence can be built even if the first the attempt to do this has been initiated through mobile devices.

(c) Updates are desirable (a recommender system has a role to play)

This is a key issue from the outcome of the analysis of the result of the survey. More than 80% of the respondents would like to have updates concerning their health issues. This ranges from check-up reminders to information about drug and recent breakthroughs in treatments and management of ailments and infections such as in HIV/AIDS and other chronic ailments.

(d) Organizations have key roles to play

Since survey respondents emphasized the need to have updates on treatment and drugs from credible and reliable sources, we feel that professionally recognized and internationally certified local and international organizations whose claims are verifiable have vital roles to play in order to achieve this. These supportive roles are relevant in counselling and management of chronic ailments and stigma-prone infections. Information and updates from such organizations must be easily accessible and location-independent. However, the roles of other stakeholders may become clearer during system appraisal in challenging contexts (such as in low resource bloc).

3.2 Architecture for Mobile Management of HIV/AIDS

Figure 1 shows the proposed architecture of the Management component of the integrated architecture. In this architecture there are hospital organization, the international organization, and the users as an entity. The user interacts with national and international organization through the consultant, an entity within the hospital organisation, via the mobile device. If the infected person has not built enough confidence in the

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counsellor and has not revealed his identity to allow face-to-face consultations, then the identity is uniquely coded. He is then given a key that can be used during subsequent contacts for easy identification. The data along with the unique code and the key are kept in the temporary data storage virtually created and accessible to the consultant or counsellor only. The hospital information system is available to provide background medical history of identified individuals who are registered at the hospital.

The hospital is recognized by the organization providing additional services via the mobile device. The provider or the consultant is registered with the hospital and therefore can use its resources and access patients' records that are kept in the hospital database when offering this service. The temporary data storage (database) is provided to keep the data of "unidentified" individuals seeking help. The unidentified individual is a person whose data is not on the hospital database or whose identity is yet to be known so as to determine where the health data is located. Keeping the data of this individual is be necessary for two reasons: (1) to have the records of the individual for reference until he seeks medical attention face-to-face at the clinic, (2) to help the provider give adequate help during subsequent contacts, having reviewed the given information and made further research or consultations before such contact days. This data may be merged with his record in the hospital information system at a later date.

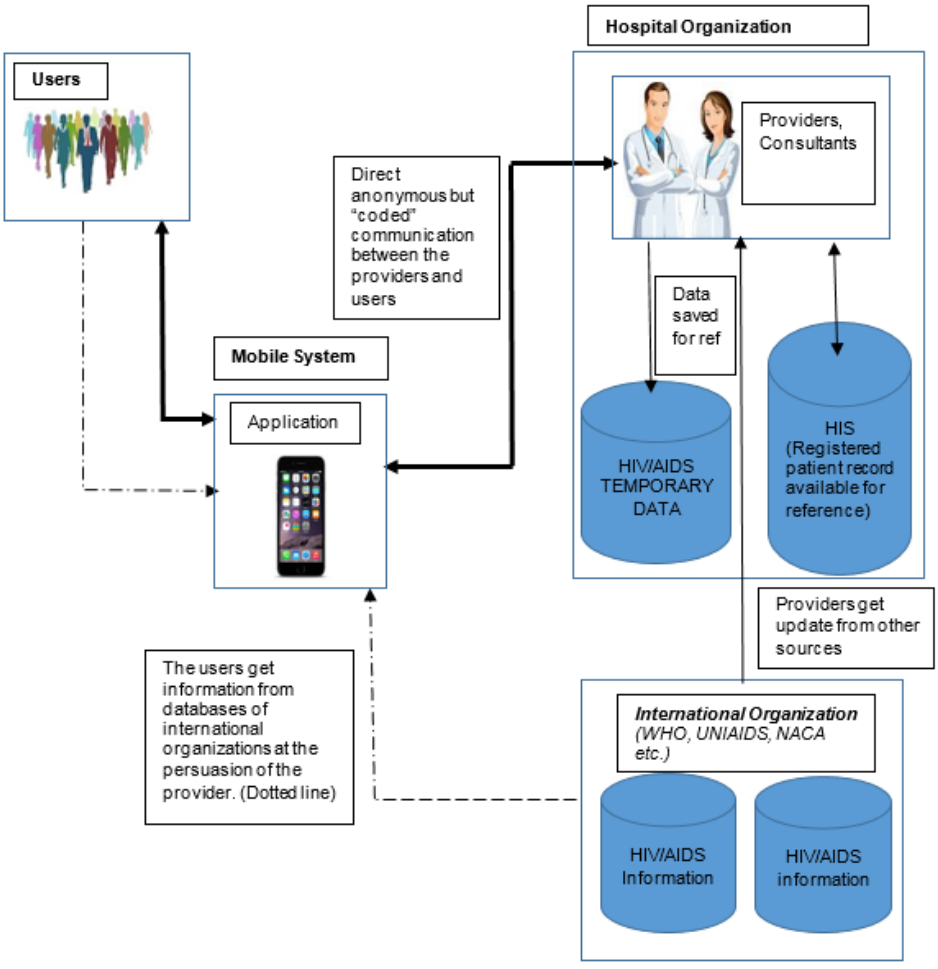

Figure 4. Proposed architecture for Mobile Management for HIV/AIDS

However, the result of the survey indicated the need for users to get update on new treatments, management methods and drugs. This sources should be very reliable and verifiable. Hence, the incorporation of databases from reliable National and International organizations such and the WHO, USAIDS, NACA among others. The hospital organization makes this available to the providers (consultants or counsellors) working within their organization, or as it may be, a provider access them directly as a registered professional in the field.

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No doubt the update from national and international health and HIV/AIDS- related organizations can be very useful and helpful in assisting and counselling the infected individuals. Effective treatment and management procedure used by others may also prove very useful. This informs the integration of another architectural component with the architecture presented in Figure 1. The integrated architecture is shown and discussed in the following section.

3.3 Proposed Integrated Architecture of Recommender System and Counselling System

Figure 2 shows the proposed architecture for the integration of dynamic Recommender system and the HIV/AIDS management system shown in Figure 1. The HIV/AIDS management system architecture has been described in the earlier section. However, the integration is done in order to allow for more effective use of current updates. With the aid of a dynamic recommender system, the provider can search for and automatically receive updates that will help the professional counsellor (or consultant) on treatment and wellness procedures. With the integration, the user may also get updates directly and dynamically. This is done whenever there is an update to any of the connected databases. This feature is however, optional for users and other care-givers.

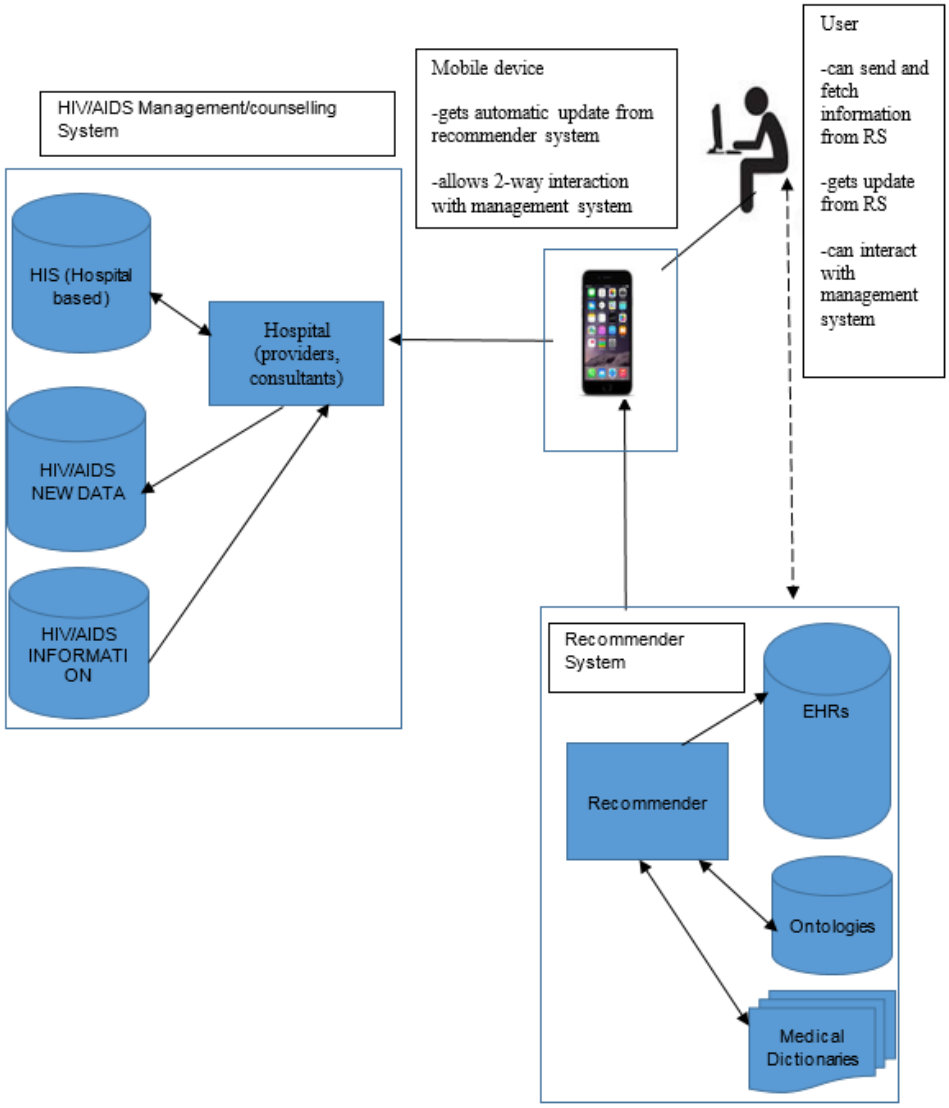

Figure 5. Integrated Recommender System and Management system Architecture

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As a result of the sensitive nature of patient data and information, high level of anonymity will be ensured while transferring data across the mobile devices. This will be done by removing all references to patient's identity. Essential information needed are diagnosis, treatment procedures, and results. As indicated earlier, during interactions between infected persons and the consultants providing assistance the identity of the infected will be uniquely coded until confidence is built between the participating individuals while the data will be encrypted.

4 Discussion

This paper has focused on three important stages. First, what the study reveals. Second the need for a mobile management system of chronic illnesses and stigma prone infections. Finally, the synergy between the mobile management system and recommender system. Two important issues have been raised concerning the drastic reduction of stigma against those suffering HIV/AIDS infection. One major issue is that of providing care tailored to the personal needs of individual. The other is the reduction in cost and time associated with meeting up with counselling schedules [38]. Although the cost may appear to be initially insignificant but the cumulative cost and time spent over time when repeated calls have to be made to clinic can be well beyond what is affordable to infected ones who are generally poor and already weighed down by the burden of the infection. In a report regarding the use of mobile device as a tool, health workers were able to save some hours, transportation costs, and double the capacity for treatment in less than a year [22]. In a similar vein, the care and counseling seekers can also benefit from reduction in cost, time, and efficient care services.

In addition to this is the problem of bureaucracy at the point of care. In some cases, the infected individuals spend so much time because of poor organisation and the long list of others waiting to access the same care. Indeed in the African context, most of what is currently referred to as HIV counseling still means just information giving and supportive counseling and advisement, targeted not to any particular needs of the clients being served [25]. However, from the study conducted more than half of the population surveyed agreed that discussing some confidential matters, which include their HIV/AIDS status, via mobile devices would not be a problem. This is possible even if the other individual has not been familiar with the counselor. This however depends on the assurance that, by virtue of the counselor's profession, some level of trust can be established. The implication of this is that many of these respondents would be willing to volunteer some personal information if it is obvious that they are discussing with care providers and other health workers who have been trained to help them.

Achieving this will pose little or no problem to individual counseling seekers. This is confirmed from the result of the survey. Besides the significant level of confidence they have built using mobile devices in discussing personal issues, all the respondents have one kind of mobile devices or the other and are conversant with their use. They were also able to affirm that they can use mobile devices as a means of first contact before face-to-face meeting. On how long this can go before they can be confident enough to submit to physical contact may depend on the person seeking help, the skills and experiences of the counsellor, and how serious the seeker considers the need. Notwithstanding the highlighted factors good result is achievable if the counsellor has a good knowledge of the infection and a considerable level of trust can be built within some reasonable period. Another important issue is the possibility of having many able to explore this option. There is an undisputed indication that mobile telephony is rapidly developing as the major communications platform in the developing world with mobile penetration in Africa having a growth rate of more than 60 percent from 2006-2011 [23]. Future growth is expected to be very promising. A report has indicated that Africa will witness the fastest subscriber growth and annual Growth Rate of 7.3 percent to reach nearly 8.5 billion by end of 2016. Smartphone shipments in Africa are expected to grow at the fastest rate, and it is anticipated that the African market will grow at a CAGR of 38.6 percent all over the 2011-2016 period[24]. This report has added weight to the availability and the potential of mobile devices to play crucial roles in care giving.

Besides providing counselling and care at an individual level, it is clear from the result of the survey that something more is needed. Such things as check-up reminders, information about drugs, recent treatment breakthroughs and management of ailments and infections are necessary. To show the importance attached to this kind of updates concerning health issues more than eighty percent of respondents would like to see this feature in the proposed system. Reports have indicated that mobile health tools have played a significant

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role in improving medication adherence, health, and appointment follow-up [20, 12, 21].To achieve the credibility of the updates that will be provided these must come from reliable sources, in this instance professionally recognized and internationally certified local and international organizations whose claims are verifiable have vital roles to play. This informs our proposal to have databases of international and national organisations such as the USAIDS, WHO, NACA among others integrated with the system. These databases contain standard procedure for treatments as well as recent breakthroughs on chronic illness and stigma-prone infections as well as other important information that might be relevant to the infection and useful for the infected. Integrating recommender system into the counselling and management system provides a powerful tool for achieving a well-rounded care for individuals infected with HIV/AIDS.

5 Conclusion

Prevalent stigma toward individuals living with HIV/AIDS infection and other ailments for which people can be stigmatized is a major roadblock toward achieving the desired care for those facing the challenge. Hence many of them are reluctant to come to the open to seek the necessary care despite the attendant effects of this on human survival and economic growth. However, with increasing penetration and mobility of mobile technology, it is possible to provide care for the teeming population of people living with HIV/AIDS and other stigma prone infections. The dynamic recommender component integrated with the mobile counselling architecture will make it possible for users to receive useful updates on treatments and drugs. This component of the integrated architecture is also intended to be adapted in the management of chronic ailments. Cost of implementation and security are two important issues toward an effective implementation of this architecture. These will be addressed in our future work.

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Exploring the Role of Technology in the Institutionalization of Health Information Systems: An Actor-Network Analysis of Information Systems Integration

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Background and Purpose: Information systems (IS) integration is a complicated exercise. This paper discusses the process of IS integration for a healthcare sector in a resource constrained context. In recognition of power play between the different actors involved, the paper underscores the complexity related to coordination of actors and institutionalization of organisational routines in order to achieve the goals of Health Information System (HIS) integration. In particular, the paper explores how artefacts (software, policy guidelines documents) can be used to facilitate coordination of the actors involved.
Methods: The study employed actor network theory concepts of inscription and alignment to guide the data collection and analysis. Data collection methods include participant observation, documents review, and interviews, both formal and informal discussion groups.
Results: The study reports implementations of an action research project in Tanzania (Zanzibar, and Mainland), where two case studies are presented, comparing how different technologies in line with implementation mode (decentralized/centralized) occurred. The article describes HIS integration as a combinatory actor network building process that needs to consider the nature of the technological artifact, and the manner in which it is implemented, coupled with the policy guidelines which inscribe and prescribe the use of the system.
Conclusions: The article reveals that success in actor network building process (the HIS integration process) in the backdrop of myriads of heterogeneous actors with multiplicity of interests can be achieved by a combination of interventions where the agenda needs to be inscribed in a technological artefact and policy guidelines, and reinforced with the implementation mode (centralized).
Keywords: integration, power, health information systems, actor-network-theory, inscriptions, alignment.

1 Introduction

As part of development efforts, developing countries are engaging in the process to improve healthcare status of their populations [19]. Development partners, both bilateral and multilateral are highly involved, considering the economic status of the countries which prove difficult for them to catch up with the existing and emerging healthcare needs primarily caused by high disease burdens and poor capacity to provide basic primary healthcare aimed for disease prevention and improving the well being of the people. Donors usually organise their support in 'vertical' health programmes mode, specialising in a particular disease or service. Ultimately, the programmes devised the way to ensure proper accountability of the resources they provide. In this way, information systems (IS) were designed to provide tools for monitoring and evaluation of resources and impacts of individual programme initiatives. In turn this resulted into fragmented IS serving the healthcare sector, and its impact is viewed in both the quality of data collected as well as increasing burden to already overloaded healthcare staff [1][2]. Moreover, by focusing on specific programmes, the fragmented IS failed to address the sector-wide information requirements.

To address this condition of ineffective IS, countries have invested in projects to develop integrated health information systems (HIS) aimed at providing comprehensive and shared data that serve the whole sector. The initiatives are sponsored by individual countries supported by donor agencies, often those involved in healthcare provision initiatives. The health metrics network (HMN) outlined an integrated

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approach to data warehousing as an alternative to providing comprehensive health sector-wide data [3]. Despite these initiatives, integration has proved to be a challenging process, and hence receiving attention from the IS research community. While some research has focused on the technological issues such as challenges of legacy systems, others are more concerned on organisational aspects of integration. This is mainly based on what rise as the enduring challenge in the concerned projects.

In this article, we formulate a discussion on the organisational aspects of IS integration. The context of the study is Tanzania, a developing country in which donors play a major role in supporting healthcare service provision and hence have had myriad influence on the HIS integration exercise. Empirically, our discussion is based on two case studies drawn from two healthcare organisations (Tanzania Ministry of Health and Zanzibar Ministry of Health[1]). The two healthcare organisations has taken measures to integrate various HIS supporting different health programmes and employed District Health Information Software (DHIS) to capture and process data for the sector wide information system. The discussion is centred on the challenges in the coordination of actors and institutionalization of organisational routines in order to achieve the goals of HIS integration project.

Theoretically the discussion is based on actor-network theory (ANT), particularly the concept of inscription which is used to describe the socio-technical configuration of the HIS /integration exercise. The empirical material is construed towards understanding power relations between actors involved and how this affects the coordination of the actors involved and institutionalization of routines necessary to achieve the goals of HIS integration. The pivotal point of the discussion is the role of artefacts (software and policy guidelines) in facilitating coordination of the actors involved.

The article is organised as follows. Following this introduction, a theoretical foundation is built based on ANT concept of inscription and how power is constituted. A section on research methods follows, followed by the presentation of the cases. The case description is followed by the comparative analysis and discussion linking the cases with the theoretical arguments presented earlier. The last section presents the concluding remarks.

2 Materials and Methods

2.1 Actor Network Theory – The Dynamics of Power

Actor network theory (ANT) originated from the field of science and technology studies (STS). Rooted on the study of micro-processes of the way science is actually done and the way technological artefacts are actually designed, ANT is generally concerned to research how actors do what they actually do [4]. It does this by studying the mechanics of power as actors develop them as they construct and maintain actor network [5]. The network is constituted by both human and non-human actors forming a heterogeneous actor-network. Thus, ANT focuses on tracing transformations of heterogeneous networks which includes how they are constituted, how they emerge and come to being, how they are maintained, how they compete with other networks, and how they are extended in space and time.

ANT rejects the control of social actors' mastery of technology. Instead of intentionality and consciousness perceived as source of power, the focus in ANT is on the organizing powers of combinations or on the effects of an association [6]. The focus is on what is being generated by virtue of an arrangement, rather than speculation on the intrinsic qualities of different constituent actors. Thus power is not something exercised between two or more combatants or adversaries divided over some issue, one to the other. Rather, power is more a question of ongoing and active structuring of the possible field of action of others, and is always open to resistance, transformation and renegotiation. Those who are powerful are not those who *'hold'* power but those who are able to enrol, convince and align others into associations allowing these initial actors to *'represent'* all the others.

Thus to understand power one need to examine how collective actions come about or how actors come to be associated, and how they work in unison [7]. This is captured very well using the concept of inscription and materials/resources for inscriptions. Inscription refers to the way material resources embody interests meant for structuring possible actions of others. It can also be defined as a process of creating technical artefacts such as software artefacts (for example DHIS in our case), policy guidelines documents etc, that

[1] Organizational setup of healthcare system is outlined in section 3 – Research Context

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would ensure the protection and achievement of an actor's interests [6]. According to Murdoch and Marsden [7], resources play an important role for accumulating power, as they put on:

> *If power 'lies' anywhere it is in the resources used to strengthen the bonds … and we need to analyse how these resources are defined and linked and how actors impose definitions and linkages upon others. To be successful, an actor must 'colonise' the worlds of others.* [7] p.372.

In terms of technological artefacts, Akrich [8] argues:

> *Designers (...) define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovators is that of "inscribing" this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a "script" or a "scenario"* [8] p.208.

The inscribed scenarios of action define roles to be played by users and the system. Thus, by inscribing a scenario of actions into a piece of technology, the technology becomes an actor imposing its inscribed program of action on its users [8]. An example of inscription materials with scenarios of action in our case study is the use of policy guidelines documents which defines some specific routines to be followed by actors including things like reports submission dates, specified category of actors to be sent to, types of reports etc. However, inscriptions vary; some structure the pattern of uses strongly, others weakly. The strength of inscriptions, whether they must be followed or can be avoided, depends on the irreversibility of the actor-network they are inscribed into [9].

A number of researchers have employed the concept of inscription to analyse a number of Information System projects. [10] used the concept of inscription to analyze the challenges of inscribing standardized protocols in an Electronic Medical Record (EMR), whilst taking into account local work practices. The authors argued for the need to implement weak inscriptions of the protocols in some cases and strong inscriptions in other cases as a strategy to address the challenges.

Conversely, [11] used the notion of inscription device to discuss how use cases in a requirements specification for a digital health care information system are used as a frame of reference for how specific clinical work processes are carried out in 14 Danish hospitals. The author argued that use cases share common characteristics with inscription devices, because they translate complex organizational situations - the clinical work processes, rules on reimbursement, professional boundaries, clinical standards, accreditation standard etc. - into agreed representations.

Furthermore, in the study of Electronic Patient Record (EPR) implementation in Norway, [12] looked at how elements of discipline and control are inscribed in the EPR technologies, as it is experienced by health personnel. As the EPR technologies are perceived and used by health personnel, prescribe discipline and control regarding documentation of patient information, use of time, access to information, and the relations between different professions.

Our study attempts to make contributions on the ANT IS studies, by drawing on the concept of inscription to do a comparative analysis between two HIS case studies with a gist to understand how power is constituted, the effect of the network configuration chosen (centralized/decentralized) and how this affects the coordination of the actors involved and the institutionalization of the routines that are necessary for the eventual realization of the HIS integration goals.

2.2 Research Context

The research setting is the United Republic of Tanzania, a low income country. It is the largest country in East Africa, occupying an area of about 945,087 sq. km, and has common border with 8 neighbouring countries. Tanzania is formed by the union of Tanganyika (now referred as Tanzania Mainland) and Zanzibar. The union government is composed by two organs vested with administrative authority, the government of the United Republic of Tanzania and the Revolutionary Government of Zanzibar. Thus, matters that fall under the union are clearly defined and handled by both parties under the Union Government. Other matters such as healthcare are not part of the union. In addition to the union matters, the union government deals with Mainland part for non union matters, since the Mainland does not have her own government, and the Zanzibar government deals with issues related to Zanzibar. Thus, in this article, unless stated otherwise, the Ministry of Health Tanzania means the one responsible for Mainland

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Tanzania, and the Ministry of Health Zanzibar means the one that is responsible for Zanzibar. Although created as independent bodies, there are extensive collaborations between the two healthcare ministries. Specifically, the empirical basis for this research is based on efforts to integrate routine HIS in the two healthcare ministries, Mainland and Zanzibar.

2.3 Research Methodology

The study draws on an interpretive epistemology. Interpretive researchers attempt to understand phenomena through assessing meanings that people ascribe to them [13] [14]. As interpretive researchers, our study relies on participant observation and interviews with healthcare organizational members, and uses qualitative analysis to interpret the HIS integration process. [14] argues that interpretive researchers often use an underlying theory as sensitizing device for collecting and analyzing research data.

The study employed ANT concepts to guide the data collection, analysis and reporting. Both formal and informal interviews were carried out to different actors ranging from the Ministry of Health and implementing partners' officials, regional and district HIS staff, to DHIS technical staff. The interview questions at the national and regional levels focused on the need to understand the availability and use of HIS policy and guidelines, data flows from the sites and whether its accessibility, and coordination of the partners engaging in the implementation process. At the district level, the focus was on the need to know the data capture and submission status, challenges faced in using the new system, and the kind of technical support provided to them etc. Conversely, the focus for the implementing partners' interviews for the was on understanding the scope of their implementation in terms of the data sets, number of districts/regions covered and whether there was a plan to scale up the implementation to other districts/regions. Table 1, shown the number of interviews, formal and informal, conducted.

Table 4. Interviews Conducted

Informants	**Number of Interviews**
National level staff	9
Regional/Zonal staff	5
District staff	7
DHIS technical staff	5
Implementing partners	6
Total	**32**

Authors of this paper have worked with HISP in Tanzania (both Mainland and Zanzibar) since 2005. As participatory observers we have worked with different implementing partners in Tanzania Mainland such as the Clinton Foundation in Mtwara and Lindi, Ifakara Health Institute in 27 districts scattered in all the regions in Tanzania, Japan International Cooperation Agency (JICA) working in Coast region, and Elizabeth Glaser Paediatric AIDS Foundation (EGPAF) working in Arusha region. In Zanzibar, we have worked at the Health Management Information System Unit (HMIS Unit), and hence working with all major players including healthcare programmes and the direct HIS sponsors such as Danish International Development Agency (DANIDA), World Health Organisation (WHO) and Italian Foundation.

The activities embarked on included installation of DHIS in the sites, training, and supporting use of the system for a period of time, as well as the development of data collection tools and HIS guidelines (in Zanzibar). This gave the authors, opportunity to get firsthand experience and learn the challenges in dealing with multiple implementing partners. Moreover, a number of documents were reviewed ranging from DHIS implementers' progress reports, Health sector strategic plan III, to summarized meetings and workshops reports. Furthermore, authors attended a number of workshops, meetings and training programs organized by the Ministry of Health (both in Mainland and in Zanzibar) and sometimes by the implementing partners.

3 Results

Two case studies are presented and are compared to how technology and institutional procedures around the technology affect the coordination of the integrated HIS. In the first case, we present Zanzibar project

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from the period 2006 – 2009 where DHIS 1.4 has been used, and later migrated from DHIS 1.4 to DHIS 2. In the second case we present project implementation in Tanzania Mainland where DHIS 2 is also used. A comparative analysis of the two case studies is later presented.

DHIS 1.4 is freely distributed software with open access to the code. The software is built on Microsoft Access for both front-end and back end. It enjoys a modular architecture and the separation of back end and front end makes it possible for one site to deploy different data files by switching between databases. DHIS 1.4 is a desktop application and its deployment is based on installations at implementation sites. Reporting from one level to another is based on file export (xml or coma delimited txt files) that will be imported into DHIS installed at that site. Data are transferred by emails or physically by exchanging flash disks storing the exported file.

DHIS 2 is platform independent, java based application. It can be installed in a web server or local machine. It can be configured to run in a standalone or online mode, by making use of supporting infrastructures such as local area network or the Internet. DHIS 2 is built in the same logics as DHIS 1.4 but is built in more sophisticated technologies. At the back end it uses PostgreSQL or MySQL, both free database management systems. It also deploys built in geographical information system (GIS) component based on the open source technologies and has a mobile component.

Both DHIS1.4 and DHIS 2 are products of global network of research and development based at the University of Oslo called Health Information System Programme (HISP). HISP aims to develop proper health information system that support data needs for healthcare departments in the developing countries. HISP initiatives in Tanzania Mainland dates back to 2003 while in Zanzibar started in 2005. The project implementation presented in this paper falls under HISP initiatives.

3.1 Case 1: DHIS Implementation in Zanzibar

DHIS 1.4 Implementation

DHIS 1.4 was adopted as the National standard from January 2006 and data from hospitals and primary healthcare units/centres were reported trough two databases, with the master databases located at the HMIS unit. Each district maintained its own instance of DHIS 1.4 where data was captured monthly and exports files sent to the HMIS unit where it was imported into the central level DHIS 1.4 database. Despite some improvements in data collection as compared to the period prior to the integrated HIS, there were some challenges that were noticed that could have jeopardised the future of HIS. These included delays in reporting and hence reducing trust from the programmes, data inconsistency caused by parallel reporting of some data that had to be reported in both systems, and more general the imbalance in the structure of HIS reporting among the stakeholders. Details are presented in [15]. As solution to minimise delays and also improve programmes' accountability on data, which could improve quality, an alternative reporting scheme was suggested. In this scheme, the plan was to utilise the existing resources to improve efficiency in the reporting scheme. Since districts usually use emails to transmit data to HMIS unit, it was agreed that the districts should also copy programmes and zones while emailing to the HMIS unit. Virtually, this would reduce the reporting hierarchy and therefore address the issue of delays.

This solution however, met some difficulties. First, reliance of people to export and import data did not necessarily cut the bureaucracy. While the districts would often send the data directly to the programmes as an email copy of the HMIS unit, most programmes did not show good response to effectively benefit from the new procedure. With the exception of Expanded Programme for Immunization (EPI), Zanzibar Malaria Control Programme (ZMCP) tried the first few months and later the programme turned back to HMIS unit asking for data. The Zanzibar AIDS Control Programme (ZACP) and Reproductive and Child Health (RCH) programmes never bought the idea. Despite the fact that they usually received the emails they never updated their databases. RCH continued to request data from HMIS unit, though on irregular basis. Surprisingly ZACP designed new tools apart from the mainstream HIS tools and distributed to the health facilities. The health facilities never used the tools designed by the programme, and hence the programme missed data for the whole 2009 and 2010.

While the programmes did not fully buy the idea, on the other hand not everyone in the HMIS unit were also happy with idea of parallel reporting. Some, especially non technical personnel still believed that the right reporting mechanism is through the HMIS unit, and the programmes must get data from the unit. For example, in one occasion, RCH programme requested data from HMIS unit and HISP staff supplied the

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data to the programme, when that data was presented in a meeting, a senior officer from HMIS unit claimed that the it was not official, thus insisting that they must be approved before being distributed to programmes.

Following these constraints, HIS implementation team comprising both HISP and HMIS staff discussed the potentials for using DHIS 2 which was well tested in other HISP implementation countries. The need to upgrade to DHIS 2 was highlighted in technical limitations of DHIS 1.4, the problem of version management, and the bureaucratic reporting procedures that caused data delay. This delay had impact on data quality as the programmes could not give timely feedback, and also on the programmes reporting requirements to donors.

DHIS 2 Implementation.

DHIS 2 implementation started in April 2010, first aimed to be pilot project for the whole 2010 and subsequently implemented as the national standard upon successful test. During this transition period DHIS 2 ran in parallel with DHIS 1.4, and the data entry clerks were entering data twice. First, they had to enter data into DHIS 1.4, which was the official data reporting system and later enter the same data into DHIS 2. The purpose of the double data entry was to expose users to the software in order to give them enough experience, at the same time the technical team (local HISP) used feedback as the way to enhance the software as well as learning user perceptions towards the new system. The data entry clerks were paid for the extra work in order to motivate them towards the new software. In January 2011, DHIS 1.4 was phased out and DHIS 2 took over as the national standard.

Contrary to setup in DHIS 1.4 where there were two separate databases, one for hospital and one for primary healthcare data, in DHIS 2 only one database was configured containing datasets for both hospital and primary healthcare data. The database is installed at the central web server located at the HMIS office. Districts and hospitals access the data warehouse to directly enter data from their locations. Zone and programmes can easily access the data once entered. All districts, hospitals, zone and programmes are connected to the internet.

The process of software development and implementation can be described in terms of both technical and political processes that were aimed at addressing the problems that HIS faced during the DHIS 1.4 period. Technically the software was aimed at improving data access through the use of web technologies, seamless integration between hospital data and primary healthcare data, improved version management, and improved feedback mechanism.

On the political and administrative aspects, the software was implemented to solve the problem of reporting where despite the change in reporting procedures that were proposed after the originally planned and implemented reporting scheme failed to improve the HIS especially on timely reporting. With timely reporting and direct access of the data DHIS 2 was aimed to facilitate immediate data analysis by programmes and hence speed up feedback, and subsequently improve data quality. The programmes will also be able to report to their donors in timely manner. Below, we present response of some selected programmes on the implementation of DHIS 2.

Expanded Programme for Immunization (EPI).

DHIS 2 has been used as official data reporting system replacing DHIS 1.4 for just a half a year, from January 2011. However, the Expanded Programme for Immunization (EPI) decided to use DHIS 2 for the year 2010 instead of DHIS 1.4, though it was in the piloting stage.

Responding to the question of how they compare DHIS 2 with DHIS 1.4 in relation to improving their activities, managers from EPI were optimistic:

> *"We are supposed to report to Nairobi regional office not later than 10th of each month. Usually we report any amount of data we have and later update them. The regional office evaluation is based on the day we made our first reporting and then how quick we update the data. The availability of data online really helps to this. For example, last year (2010) we effectively used the system and we have reasonably improved timeliness. We have realised that most districts start data entry earlier than we thought, and thus, we can report earlier too"*

Zanzibar Malaria Control Programme (ZMCP).

With special interests covering wider range of activities, Malaria programme has diversity in type of data collected, from disease surveillance and monitoring mortality, to recording number of households

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covered in indoor residual spraying and recording number of treated bed nets. With this respect, the programme agreed from the beginning that they will collect data from HMIS unit for disease surveillance, monitoring pregnant mothers against the disease, and hospital admissions and deaths. The rest of the data shall be collected by the programme itself through different tools. This means much of the data are collected by the programme itself.

Moreover, the programme does not usually use the data from the mainstream HIS on monthly basis. In the past, the programme seemed to request data on ad hoc manner and thus when the parallel reporting of data using DHIS 1.4 was introduced it did not help them much since the programme officers would usually neglect the emails that consist of the export files and hence often ended with asking back to HMIS unit when they needed data. Often, this caused pressure to HMIS unit and also led to a situation when they could not be guaranteed the data as the HMIS unit officers might be busy with other activities. Thus with DHIS 2, the data is always in the server and the programme can access them anytime they want. A manager from Malaria programme added:

> "*Having the data online makes things easier. You know we have a plenty of data from different systems covering different and we do not always rely on the data from HMIS only. However, when we need data it is usually urgent, sometimes we may be asked for reports by donors and we must call you. This does not guarantee fast response. Now we do not need to worry, as long the server is up we get data without contacting you*".

Zanzibar AIDS Control Programme (ZACP).

Since the new HIS was put into use in late 2005, the programme was in a continuous swing between using the mainstream HIS and using their own system which have been in continuous changes. There are many reasons, which are beyond the discussion on this article, but what is interesting for this paper is how the agreed reporting procedures along with the installed software (DHIS 1.4) could not be institutionalised into the programme's reporting scheme and how DHIS 2 could find its way in the programme's sphere.

In 2009, for almost two years, HMIS unit officers and HISP staff were in negotiation to re-harmonise the data collection tools for the programme after the programme stopped using the mainstream HIS tools. After the new tools were designed (with inputs from both the old tools and the tools introduced by the programme), the development team managed to convince the programme to use the mainstream HIS (as redesigned) with a promise of implementing an online database solution. This, the arguments were made, will help to minimise the programme's reliance on HMIS unit for data reporting. Despite the fact that the programme did not have firm reasons to switch to their own data collection tools, DHIS 2 was used as a tool to clear any doubt they had on the possibility of data delays.

Three months after DHIS 2 was used as national standard, officers in charge of data at ZACP expressed their hope in the new system.

> *"This is promising, when you have all the data available online there are reasons to believe that we are guaranteed with our data. Previously this was not the case"*
>
> *"I like the fact that all data are stored in the same database. Our data are collected from a range of sources from antenatal clinic, VCT [voluntary counselling and testing], STI [sexually transmitted infections] clinics, maternity ward and CTC [care and treatment centre]. When you have different sources captured in different databases makes it difficult for us. But now everything is in one database, including home based care"*
>
> *"I like the comprehensiveness of collecting PMTCT data, the forms collect almost every data we need and we easily access all the data"*

Health Management Information System (HMIS) Unit.

With its role as in charge of coordinating and facilitating availability of data to all stakeholders, HMIS unit maintains the data warehouse located at its office. Interesting in DHIS 2 is the balance between maintaining and coordinating the data warehouse. In DHIS 2 era, the unit is mainly responsible for ensuring the central server is up and running, the database is in good condition and the districts and hospitals enter data regularly and are provided with technical support.

Although a consensus was reached on the decision to use DHIS 2, some reservations are still there and doubts are still to be cleared among non technical officers of HMIS unit. While the technical team (from HMIS and HISP) use the agenda to solve both the technical problems and implementation hurdles, the non

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technical seem to be sceptical about the solution, apparently due to technological fear, but also a fear that the new procedure would reduce the authority of HMIS unit. An administrator at HMIS Unit added:

> *"The good thing with the new system [DHIS 2] is that I can access data any time and I do not need the technical people to load my laptop with data when updates are made. However, I am really concerned with security. I do not believe hackers will not intrude into our data... Another question is who is in-charge? If everybody will access data before we conduct quality check, how can they use the data?"*

While the argument of quality checks makes sense, this has not been the case. The HMIS unit have always been busy with a lot of activities and the quality check is usually done once a year during data cleaning workshop, prior to preparation for annual health bulletin. Moreover, the HMIS capacity is limited as compared to tha t of programmes. Thus, ensuring programmes get data on the right may be a catalyst for quality check and feedback to districts and hospitals, and hence improving the quality of data.

3.2 Case 2: DHIS Implementation in Tanzania Mainland

The current routine HIS in Tanzania Mainland was conceptualized in the 1990s through external consultants with support from DANIDA. The system consisted of paper based data collection tools at health facility and district level and computer based system at the regional and national level. However, a number of studies described the system as dysfunctional and inflexible [16]. Such inflexibilities led to difficulties in absorbing changes and new requirements from different health programs and healthcare services. In an attempt to resolve the HIS challenges, a pilot action research study was conducted in 2002 by HISP team in two districts (Kibaha and Bagamoyo) located in Pwani Region [17]. Implementation of DHIS 1.3, which was later upgraded to DHIS 1.4 in the year 2005, was done as part of the pilot study. The software was installed at district level, where paper reports from all health facilities were captured in a monthly and quarterly basis, depending on the reporting frequency of a particular data set. As a result, the software was demonstrated as flexible and capable to handle multiple programs and data sets in an integrated manner. However, it took almost five years period of intensive translation processes involving negotiations and discussions with the Ministry of Health officials, before the software could be endorsed as a standard for countrywide implementation in 2007 [18].

However, a number actors working with various healthcare programs used their resources to review and standardize their paper based data collection tools, and were in search for an electronic artefact for data processing and management. For instance, National AIDS Control Programme (NACP) supported by the Japanese International Cooperation Agency (JICA) revised paper-based recording and reporting tools for Sexually Transmitted Infections (STI) and Voluntary Counselling and Testing (VCT) services. The actors then approached the Ministry of Health and the HISP team, requesting implementation of DHIS in one region –Pwani. Following the approval, HISP team advised the Ministry and NACP/JICA to use current version of the software - DHIS 2. With the capacity to be used as web solution or standalone, an agreement was made to implement DHIS2 as standalone. Customization of the software was effected where STI and VCT paper-based tools were implemented in the database and rolled out into all six districts in Pwani Region, including regional offices. Data entry is done at the district level and an export file is transmitted to the region where it is imported into the regional DHIS2.

Results from STI and VCT implementations spurred other actors working with different initiatives in the same region to support implementation of other data sets. Supported by the WHO, the national PMTCT program revised their paper tools including registers and monthly summary tools in 2008. In need of an electronic tool for computerizing the summary reports, the national PMTCT officers attended a stakeholders meeting where DHIS2 with the results from the Pwani Region were presented. Among other things the partners learned the capacity of DHIS2 and that it had been endorsed as a national standard. Promptly, a decision was made to implement PMTCT summary tools using DHIS2 within the Pwani Region. By July 2009, all the new PMTCT data sets were codified in DHIS2 and rolled out into all the six districts in the Pwani region. The Norwegian Agency for Development (NORAD) supporting child and maternal health program provided funds to implement the rest of the data sets using DHIS2 within Pwani Region.

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DHIS2 Enrols other Actors to the Network.

Other actors working with different initiatives in various sites using their resources negotiated their way into DHIS2 implementation. For instance Clinton Health Access Initiative (CHAI) has been collaborating with the MoHSW since 2005, to expand access to HIV/AIDS care and treatment in Mtwara and Lindi. In need of a monitoring and evaluation tool CHAI approached the Ministry of Health and the HISP team requesting to implement DHIS2 in the two regions. An agreement was reached to implement DHIS2 in two regions including all data sets implemented in the Pwani Region. By October 2009 DHIS2 training was conducted by the HISP team, followed by installation of the software into all districts and the regional level, both in Mtwara and Lindi. CHAI hired one personnel who was trained on DHIS2 as a super user to provide technical support to the districts and the regional levels.

> *"CHAI provides regular supportive supervision to the districts and the regions. This involves solving problems encountered during use of DHIS"* (Technical personnel, June 2011).

However, due to ICT related problems CHAI contracted a company to provide regular ICT support to both Mtwara and Lindi regions in terms of computer repair and maintenance (hardware and software).

Another actor which drew on their resources and implemented DHIS2 to provide informational support to their programmatic decisions is Elizabeth Glaser Paediatric AIDS Foundation (EGPAF). Among other things EGPAF focuses on expanding the provision of comprehensive PMTCT services and improving access to HIV care and treatment. Arusha is one of the regions where the PMTCT services are supported by the foundation. In January 2010, EGPAF through the HISP team implemented DHIS2 in all districts in Arusha including the regional level. However, the NGO was ready to support only PMTCT data sets. The implementation process included training and installation of the software in all the districts and including the regional level. EGPAF hired one ICT officer who also received DHIS training in order to provide support to the districts and the regional level.

However, some other actors run DHIS2 implementation not just as way to get information support for programmatic decision making but as a separate project with earmarked resources such as funds, and human resources. Ifakara Health Institute (lHI) is a research and training non-governmental institution. In 2010 IHI launched a health research project called Sentinel Panel of Districts (SPD) in 27 districts of Tanzania Mainland, aiming at improving availability of data. According to the IHI official, the project dwell on facility based information and population based demographic and mortality data in all the districts. The project has received support for five years and will provide annual, age, sex and cause-specific mortality estimates from a population of about 25,000 to 30,000 in a sample of 27 districts.

IHI approached the HISP team upon being sanctioned by the Ministry of Health, to implement DHIS2 in 27 districts. The implementation included training of data clerks and CHMT members, and installation of DHIS2 in all 27 districts. IHI recruited one information officer in each district, to do data entry, to follow up reports from the health facilities which have not yet reported and to perform data analysis and transmission to the central IHI offices. IHI maintains a DHIS2 server, where export files from the districts are imported. Moreover, IHI recruited one ICT personnel who was later trained as a super user on DHIS2 to provide recurrent support and maintenance of the district DHIS2 installations.

Challenges in the DHIS2 Decentralized Setup.

To ensure a functioning DHIS 2 in every district the DHIS 2 implementing actors maintain ICT support personnel who provide regular support to the districts. However, user support was reported by some of the district data clerks to be poor. Once DHIS 2 problems were reported to the central support staff, support was not provided on time and sometimes it could be left pending without any response. Other districts reported that sometimes they were given solutions which could not solve their problems. As one of the actors noted, the big problem in the districts with computer systems is viruses causing most of computer crash problems.

> *Our computer running DHIS 2 software crashed several times and we could not enter data for more than three months (District data clerk, March 2011).*

Another challenge experienced in DHIS 2 implementation is the need to ensure uniform versions of the standards across sites. This is important in order to ensure integration and central data analysis. For instance, in most districts visited it was noted that data entry clerk's accounts in DHIS 2 were given full administrative privileges, giving them room to change anything in the system. As a result, one technical

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personnel reported that some actors introduced changes in the system causing difficulties in integrating data across sites.

> *Some users had added new health facilities in DHIS 2 without consulting the central support team. This made their database different from the central database which presented difficulties in importing data sent from the districts (Technical personnel, March 2011).*

Moreover, the problem of ensuring uniform standards across sites is compounded with the need to upgrade from one version DHIS2 to another which requires all sites to be visited and updated. This happens as a result of a new added feature in DHIS2 artefact or introduction of new data sets or data elements which need to be collected and captured across sites. However, the challenge comes when not all implementing actors are ready to incur costs for updating the system at the same time.

Other routines necessary to ensure the decentralized DHIS2 implementation serves the needs of multiple actors, is the need to ensure data transmission to the central data warehouse. Until the time of writing only one actor was transmitting data to the national database – the Pwani region. Explaining the difficulties in coordinating the multiple actors with multiple DHIS2 implementation, one national HIS officer argued.

> "*The implementing partners have resources and multiplicity of interests. That's why after getting what they want, they don't bother about other things like data transmission to the central level*".

Though data flow guidelines were developed during the Pwani DHIS2 implementation, enforcing the routines stipulated in the guidelines proved rather difficult.

> "*Yes, we developed a guideline document for the districts to use. And the districts officers were involved in the process, giving their comments until it was complete. But they don't seem to use it. That's why we are experiencing similar problems addressed in the guidelines"*

4 Analysis and Discussion

The two cases presented have similarities and differences. A common feature for the two cases is the multitude of stakeholders that are involved in the HIS integration projects in both Tanzania Mainland and Zanzibar. However, the differences are on the extent to which donors are directly involved in the project, and on how the ministry of health managed to lobby its role as the coordinator of the HIS integration exercises. Another difference between the cases is the type of technology used and the mode of implementation and how this had great impact on the process to create a common, integrated data repository.

The two cases presented provide a ground to discuss the challenge of coordination as part of HIS integration process. The cases outline the power struggle between actors as they draw on different resources available to them as material for inscribing their interests.

4.1 The Role of Technology in the Institutionalization of HIS: A Comparative Analysis

In our analysis we conceptualize the integration process as an actor networking building process where a number of actants such as the ministries of health, donors, vertical programmes (RHC, HIV, Malaria, EPI, etc), implementing partners, software artefacts' (DHIS), policy and guideline documents, to mention just a few, are engaging in the processes.

Striving to Build and Stabilize an Actor Network amidst Weak Inscriptions

The actor network process using DHIS1.4 artefact in the Zanzibar case was initiated by the Ministry of Health under the HMIS unit supported by DANIDA. By drawing on the financial resources from the donor, the HMIS unit as a focal building actor aligned the interests of all other actors forming one actor network. The activities of aligning all the actors' interests went hand in hand with revision of data collection tools, codifying the tools into the software artefact (DHIS1.4), and rolling out the software and the revised tools to all the districts in Zanzibar.

However, the actor network built using DHIS1.4 was aligned using guidelines which inscribed the manner in which the technology should be utilized by the multiple actors involved. Some of the inscriptions in the guidelines were related to the manner in which data should flow from the districts to the national level and then from the national level to the vertical programs and to other actors.

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Nonetheless, the fact that DHIS1.4 setup configuration was decentralized in terms of having an instance of the same on every district including the national HMIS unit and at the programme level, various challenges ensued related to availability of timely data and in maintaining all the instances led to the weakening of the bonds of the actor network.

Though the HMIS Unit politically had the mandate to prescribe the use of the DHIS1.4 and maintain its position as a focal actor in the network, weakening of the bonds forced it to succumb that position. This is in-line with the argument that those who are powerful are not those who *'hold'* power but those who are able to enrol, convince and align others into associations. As the case suggests, though the actors strived to stabilize the actor network by prescribing that data from the districts could be sent to the programmes via email directly, but this was not bought by all the actors. The instructions lacked the material for inscriptions that could have been used to enforce use by all the participating actors hence it did not work as envisaged.

Similarly, implementation of DHIS2 in the Tanzania Mainland case, commenced with the Ministry of Health HMIS unit as a focal actor endorsing and prescribing the software as a standard to be used country-wide. However while the ministry was in the process of mobilizing funds to start implementation, other actors with their interests started implementation project in their respective sites. Starting from one region (Pwani) with only two data sets (VCT & STI), the enrolment of other actors supporting inclusion of the other data sets, changed the role of DHIS2 from being not just as software being implemented to an actor mobilizing other actors and aligning and enrolling them to the actor network. As a result this saw many other actors join the network supporting implementation of DHIS2 in other regions such as Arusha, Iringa, Mtwara and Lindi. This further confirms power as not being in the hands of someone trying to wield it to others, but the ability of any actor in this case the technology (DHIS2) to align and coordinate the interests of others and enrol in your network.

As was the case for DHIS1.4 implementation in the Zanzibar case, DHIS2 implementation in the mainland was decentralized in the sense that the application was installed at every district, expected to submit data monthly to the regional level and from there to the national level. However as the case suggests not much of the data from the regions was submitted to the national level. As long as the implementing actors in their respective regions fulfilled their interests of data, they did not bother to submit the same to the national level. Though there were guidelines developed to inscribe and prescribe the performance of the actors in terms of data submission routines, like was the case for DHI 1.4 in Zanzibar, they were not followed and adhered to by the actors. Similarly, the actor network bonds in this case was weakened by the fact that the actors did not succeed to inscribe use of the system using resources such as HIS policy documents, and other guideline documents. For according to [7] power lies in the resources used to strengthen the bonds of the actor network and to be successful, an actor must 'colonise' the worlds of others.

Thus the configuration of the technology being decentralized coupled with weak/lack of inscriptions challenged the stability of the actor network in both cases. [9] argued that the strength of an inscription whether it should be followed, depends on the irreversibility of the actor network in which they are inscribed. In this case, the actor network built using DHIS 1.4 in the Zanzibar case proved to be reversible, hence the decision to move to DHIS2 in a centralized mode, as explained below.

Transformation and Renegotiation in the Actor Network Building Process

The decision of the actors in the Zanzibar case of to move to DHIS2, and having it centralized with actors such as vertical programmes having direct access to their data immediately after the districts have captured them in the system, transformed the configuration of the actor network. This time the role of the ministry as a focal actor coordinating the process was taken by another actor – DHIS2 artefact. This affirms power according to ANT being a question of ongoing and active structuring of the possible field of action of others, and always being open to resistance, transformation and renegotiation. DHIS2 artefact as a focal actor altered completely the role not only of the HMIS unit which was hitherto the main actor, but also the role of other actors such as the vertical programmes.

Hence, DHIS2 artefact as an important actor in the Zanzibar case is used to institutionalize the data reporting by virtually eliminating bureaucracy while ensuring that no actor is sidelined whether purposely or accidentally as it was in DHIS 1.4. Under this setup as the case suggests, almost all the actors are happy, however the important question still remains, *"what would be the role of the HMIS unit?"* And as one of the HMIS unit informant asked, *''... who is in-charge?''*. As the case further suggests, this actor would like to maintain its role as a network builder and a coordinator. However the fate of that actor is determined not by its political and bureaucratic mandate to prescribe anything to other actors but by the actor network

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dynamics which asserts that power lies in the ability to translate the interests of others, making them yours. Precisely, the nature of the technological artefact (stand alone or web based) and the manner in which it is implemented (decentralized or centralized), coupled with the policy and guidelines which inscribe and prescribe the use of the system, are the important factors that determine success or failure of the network building process – the HIS integration process.

Moreover, from the DHIS2 implementation in Zanzibar it is clear that, though the technology used was the same as that in the Tanzania Mainland, the mode of implementation used led to the success in the Zanzibar case. Explicitly, the mode of implementation led to the development of an irreversible actor network with strong bonds making DHIS2 an actor aligning all other actors, inscribing and enforcing use. Table 2 compares and contrasts the two cases where DHIS2 was used.

Table 2: Summary of the DHIS 2 Comparative Case Analysis

DHIS2 Implementation in Tanzania Mainland	**DHIS2 Implementation in Zanzibar**
Multiple actors engaging in the implementation process in multiple sites	Single actor engaging in the implementation process by aligning other actors
Decentralized mode of implementation	Centralized mode of implementation
Guidelines are in place but not in use. No policy documents in place as materials for inscriptions	Guidelines and policy documents exists and in use
Limited data submitted to the higher levels and other stakeholders	All data submitted and accessible at higher levels and other stakeholders
DHIS2 as an actor failed to coordinate and align other actors due to its decentralized implementation setup and configuration	DHIS2 as actor succeeded to coordinate and align other actors into a strong actor network due to its centralized implementation setup and configuration.
Expensive and difficult to maintain multiple software instances at various sites	Only single instance exists, hence cheaper and easier to maintain for the common good

5 Conclusion

Information systems integration is a very challenging undertaking, more so in the healthcare context of developing countries, characterised by multiplicity of actors and initiatives to address diseases burden. This comes from the fact that IS integration is not a mere technical exercise rather is a complex socio-technical process of aligning not only the technologies but also routines associated with those technologies. Through two case studies, this article has compared and contrasted the process of integration where the importance of deploying proper technology in line with inscribing right policy guidelines has been highlighted.

By drawing on ANT concept of inscription, the article described HIS integration as a *combinatory* actor network building process that need to consider the nature of the technological artefact (stand alone or web based) and the manner in which it is implemented (decentralized or centralized), coupled with the policy guidelines which inscribe and prescribe the use of the system. The article reveals this combination as an important factor that determines success or failure of the network building process (the HIS integration process) in the backdrop of myriads of heterogeneous actors with multiplicity of interests.

The implication of the study to policy and practice when it comes to HIS implementation in developing countries setting is that first, decentralized mode of technology implementation setup and configuration presents similar challenges irrespective of the technology used (the use of DHIS 1.4 in Zanzibar and DHIS 2 Tanzania Mainland attest to this fact); secondly centralized mode has a very high chance of success when implemented in such a way to cater for the multiple actors involved; and thirdly use of policy guidelines in a centralized mode as material for inscriptions helps to inscribe use of the system which is pertinent for its eventual success in terms of coordinating and aligning the interests of the multiple actors involved.

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