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Editorial to JHIA Vol 3 (2015) Issue 1

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This fourth issue of the *Journal of Health Informatics in Africa* (JHIA; ISSN/NLM abbreviation *J Health Inform Afr*) passes an important milestone in the life of an academic journal. With this issue, the JHIA has published altogether 32 double-blind peer-reviewed full research papers: 15 in 2013 in volume 1 issue 1, 4 in 2014;2(1), 10 in 2014;2(2), and 3 in this 2015;3(1).

It is important for authors and their institutions to publish their research in journals that are internationally acknowledged. In practice, journals are regarded acknowledged when they are indexed in one or more of the main scientific literature databases. In health-related fields, the most important literature database is MEDLINE, operated by the U.S. National Library of Medicine (NLM).

To be considered for indexing by MEDLINE, all articles published in an electronic open-access journal like the JHIA must be available in a digital archive. The most feasible open-access archive for journals in health-related fields is the PubMed Central (PMC), also operated by the NLM.

PMC has certain scientific quality and technical criteria for electronic journals for being archived by it. One of the minimum criteria is that the publisher has at least a two-year history of quality scholarly publishing in the life sciences, with the minimum of 30 published articles. The JHIA has now fulfilled these minimum criteria, and is able to apply for digital archiving in PubMed Central. If or when the PMC's scientific quality and technical evaluation processes are completed successfully, the publisher of JHIA, Koegni-eHealth Innovation for Development e.V., can make an agreement with PMC and the full-text contents of JHIA will be archived with full global visibility, accessibility and stability. After that the JHIA will apply for becoming indexed by MEDLINE.

The current issue contains three full papers. Common to all of them is that they report scientific research conducted in the scientific field of Health Informatics on empirical cases in Africa, by African researchers, most of whom affiliated in African institutions. No other journal in the world has such a focus. Each one of the three papers, however, has quite different a methodological approach and comes from different areas of the continent. The paper by Caroline Ngoma and Faraja T. Igira is a qualitative analytical study among community health workers in maternal and child health in Tanzania. Eustache Muteba Ayumba's paper has a software engineering approach and deals with medical decision support in malaria diagnosis and treatment in D.R. Congo. The third paper, by Gebrehiwot Yehualashet, Mulusew Andualem and Binyam Tilahun, is a quantitative questionnaire study on the attitude towards and use of an Electronic Medical Record system at a hospital in Ethiopia. The papers thus nicely cover qualitative, quantitative and constructive approaches as well as North-Eastern, Eastern and Central Africa.

The second issue of 2015 is under preparation and to be published around the end of the year. New submissions are welcome – if you submit soon and the reviewers do not require time-consuming modifications, your paper can still be published this year. The first issue of volume 4 in 2016 is scheduled to be published in the first half of next year, and it will also be an open-call issue (that is, based on individually submitted papers instead of a conference proceedings).

The current issue is also the last one for which I am the editor in charge. Dalenca Pottas is in charge of the next issue. As another sign of the journal becoming an established one, the publisher has invited Frank Verbeke and Nicky Mostert-Phipps, the Scientific Programme Co-Chairs of HELINA 2014, to join the editorial team. Ulrich Kemloch continues his invaluable work as technical editor.

Personally I wish to express my full-hearted gratitude to the team who have brought JHIA from an idea to the threshold of becoming an indexed, acknowledged and stable international scientific journal for the Health Informatics in Africa community. Particularly Ghislain, Dalenca and Ulrich – it has been a privilege to complete my academic life with you.

Mikko Korpela 27.10.2015

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Full Papers

Journal of Health Informatics in Africa

Empowering Community Health Workers to Collect and Record Maternal and Child Health Data by Resolving Contradictions

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Background and Purpose: It was noted that traditional birth attendants, village health workers and health facility workers to a substantial extent failed at collecting and recording maternal and child health data in the community.
Methods: This is a qualitative study and data was collected using interviews, observations, participant observations, focus groups and document reviews. To analyse the data, we used the concept of contradictions from the Cultural Historical Activity Theory (CHAT) as an analytical tool to understand manifestations of contradictions that hindered collection and recording of the data.
Results: Based on the analysis, results indicate that, traditional birth attendants and village health workers were empowered to adapt new information practices, which led to improvements in recording and reporting of births, follow-up on pregnant women and an increase of referred women for deliveries to the health center.
Conclusions: This study demonstrates that traditional birth attendants and village health workers' information practices can be changed through understanding and resolving manifestations of contradiction that hinder them to collect and record maternal and child health data. This study also indicates that, traditional birth attendants and village health workers should be empowered to improve their performance and confidence in capturing and communicating these data.

Keywords: Information practices, Empowerment, Transformation, Community health workers, Contradictions.

1 Introduction

Sub-Saharan countries are challenged with higher rates of maternal and child mortality which results from different factors. Studies have shown that it is difficult for most developing countries to meet the Millennium Development Goals (MDGs), especially goals 5 and 6 that stress on the improvement of maternal and child health. There is evidence that, involving community-based health workers in capturing and communicating community health data is a crucial step to achieve the health related MDGs [1-4].

Community health workers provide preventive healthcare services to the majority of the population in rural communities in most developing countries. They are the first contact of women and children before the health facilities. However, research indicates that they lack appropriate skills and they are hardly motivated [1-3] [5] [6]. In this regard, research has emphasized the need for empowering community health workers in order to improve the collection of complete and accurate data from the community level.

The availability of reliable data is specifically important for local management as well as overall management of Health Information System (HIS) [7]. In provision of maternal and child health, information on check-ups made, vaccinations and medications provided to pregnant women and children, and information on births is crucial for health workers because it enables and facilitates management and provision of continuous care to women and children [5] [8]. However, in most developing countries, the reliability of maternal and child health data is questionable. To improve production of and access to reliable information in HISs in this context, research emphasise on using Information Technology (IT) [9-

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13]. But still little is understood about how to develop technologies that will be suitable in the developing countries' context.

Research on information systems development within healthcare in developing countries critically emphasise the need for understanding the context where the technology will be used [14-19]. Due to the nature of healthcare provision, that involves complex procedures and social relations, research has proposed to use of Cultural Historical Activity Theory (CHAT) to understand the context in order to be able to identify requirements, to inform system development, that reflect the lived practices of health workers [14] [15] [17] [18] [20]. CHAT provides analytical lens to focus on people's daily activities, tools they use in those activities, the social and contextual relationships established by rules and division of labour among the people collaborating in those activities.

Korpela et al. [17] describe that health information system context can be understood by understanding the context of health providers, technology providers and the people who receive the services. A systemic view of these stakeholders is crucial in providing insights on tension and misfits in their daily practices. Focusing on health workers, Igira [14] describe that to understand their practices, special consideration on how the work practices are affected by the dynamics of everyday life must be taken into account. Igira emphasizes a holistic understanding of tensions that face health workers in providing health services, data collection, management and reporting, and managing the health facility logistics. Considering the fact that communities and health facilities are the major sources of health data in the HIS, research however, has put more emphasis on understanding information practices of health workers at the health facility levels than at the community levels. Understanding the community health workers' information practices is highly important specifically on improving the quality of maternal and child health data within the HIS. Since the completeness of health facility data highly depends on the data reported from the communities. This paper covers this gap in literature by describing a case that involves re-organisation of work practices of traditional birth attendants and village health workers that led to improvements in referral cases of pregnant women to health facility and recording of births they conducted.

Furthermore, research also emphasises on the importance of putting work processes in place before the implementation of IT [21]. Few studies, example Freitas and Byrne [21] have demonstrated how to do this. This paper also contributes to the IS development community by demonstrating the necessity of re-organising the existing paper-based system and changing information practices among stakeholders involved as a way of developing information systems to facilitate collection and recording of maternal and child health data. To elaborate and analyse the work practices, we have adapted the concept of contradictions as conceptualized in CHAT [22]. CHAT emphasizes the collective nature of human activity and view organizational change as a sequence of events around which practices are transformed, following a process of resolving contradictions [23, 24].

In this paper we will answer the question: How to change community health workers' information practices in order to improve reporting of maternal and child health data from the community level?

The organisation of the rest of this paper is as follows. Section 2 presents the literature review; particularly focusing on discursive manifestations of contradictions and their contribution in transformation of work practices. Furthermore, the section presents related approaches in organizational learning. Section 3 presents research approach and data collection methods. Section 4 presents the empirical material, data analysis and discussion. Section 5 presents concluding remarks.

2 Literature Review

In this section, we describe literature review on CHAT's concept of contradiction to describe manifestations of contradiction and their resolutions as a way of establishing balance in an activity system. We also describe the concept of motivation and training to elaborate their importance in creating actions that can empower individuals to direct behaviour towards performing their activities.

2.1 The Concept of Contradictions

CHAT describes that, to understand context, one must understand the relationship between individuals and their daily activities. These are cultural-historical influences that can be understood by examining tools used, rules enforced and organization of roles in the division of labour [25]. The tools, rules and division of labour mediated the interactions between individuals and their daily activities [18] [23] [26] [27]. The mediators have the power of enabling and restricting the interactions. Engeström [23] describes that an activity is a "system of collaborative human practice" whereby each component of an activity can

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be a product of other activities as demonstrated in Figure 1. Thus an activity can be analysed in relation with other activities connected to it. This analysis can be guided by identifying contradictions within and between the activity systems.

Contradictions constitute a key concept in CHAT and are characteristic of activity systems [23] [28]. They are not simply conflicts or problems, but are "historically accumulating structural tensions within and between activity systems" Contradictions are important, not in and of themselves, but because they can result in change and development [28]. In analysing human activity Engeström [23] propose four levels of contradictions; primary, secondary, tertiary and quaternary. As presented in Figure 1 (numbers 1-4);

1. Primary contradictions appear within each component of an activity system
2. Secondary contradictions appear between components
3. Tertiary contradictions appear between object of the central activity and object of a more advanced central activity
4. Quaternary contradictions appear between the central activity and other activities in the network.

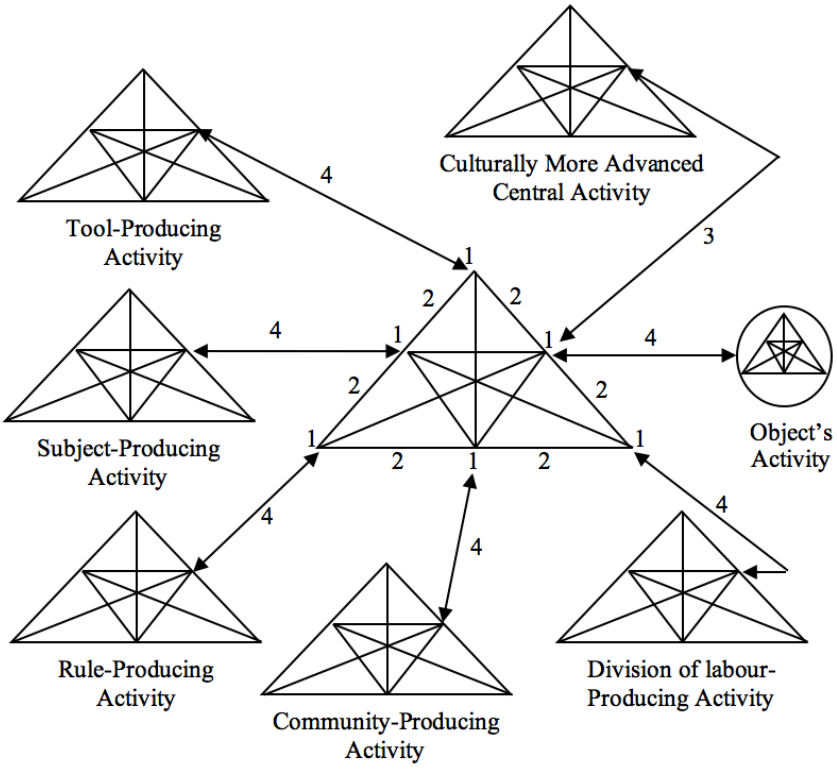

Figure 1. Network of Activities [23]

According to Engeström and Sannino [22] these contradictions can be understood through their manifestations. They argue that in current organizational literature and research, the meaning of the term contradiction is commonly left vague and ambiguous. In this regard, they clarified this vagueness and ambiguity by identifying four types of discursive manifestations of contradictions: dilemma, conflicts, critical conflict and double bind.

Dilemmas are incompatible evaluations on whether to perform the activity or not. Tensions that take form of dilemmas are rather difficult choices that lead to selecting one of two alternatives [29]. Dilemma is more hesitations such as on one hand and the other hand type of condition. A dilemma is typically reproduced rather than resolved, often with the help of denial or reformulation [22].

Conflicts are resistance, disagreements, arguments and criticisms. It occurs when a divergence of interests take place. Conflicts are typically resolved by means of finding a compromise or submitting to authority or majority (ibid).

Critical conflicts arise from neglections that paralyse people from performing the activity. In social interaction context the person in critical conflict feels isolated, guilty and even silenced [30]. Critical

conflicts are resolved through finding new personal sense and negotiating new a new meaning for the initial situation [22].

Double binds are pressing and unacceptable alternatives faced in performing an activity. They involve circumstances of being under enormous pressure and cannot be resolved by an individual alone. A double bind is resolved through practical transformative and collective action that goes beyond words (ibid).

The analysis of the four discursive manifestations of contradictions serves as the basis for planning steps to be taken in resolving contradictions and thus bringing transformation. This is like putting a mirror before an organisation and reflect on the reality and from there learn how people encounter "impossible tasks, stress and failure" [31] in performing their daily activities. Since we can hardly detect contradictions we need to uncover them by using their potential manifestations.

The resolution of contradictions brings back order in an activity system. CHAT demonstrates this as a re-mediation or re-organisation of an activity system whereby the relationship between the components will change and a new context with new practices will emerge. Despite of the fact that CHAT emphasises on re-mediating activity to bring about transformation, CHAT does not describe how individuals can change their behaviour towards engaging in an activity. Literature on empowerment can bring more insights on this matter.

2.2 Health Workers' Empowerment

According to Castelloe & Watson [32], "empowerment occurs when people come to critically understand, then act to change, their personal, social, economic, political, and cultural situations". This can be realized when individuals participate in activities that are likely to be driven by goals that promise some type of pay-off such as "satisfaction, sense of accomplishment, expansion of action possibilities, expansion of control over life conditions" [33].

In most developing countries, studies indicate the state of poor quality of data collected in health information systems [3] [6] [12] [15] [16] [34-37]. To improve the situation, research emphasise on the need for empowering health workers. Braa et al. [37] and Lippeveld [36] describe that, health workers can be empowered by improving their skills on understanding and using their data instead of obliging them to collect and report more data. Other studies emphasise on motivating health workers by providing them with adequate supportive supervision, meaningful feedback and incentives [38] [40] [42] [45].

Though health facilities and communities are the major sources of data in HIS, there are few studies conducted at the community level with a specific focus on maternal and child health data [3] [4] [6]. Health workers at the health facility level will necessarily be empowered by different things/situations as compared to community health workers who are volunteers and regarded as periphery workers without a job description or salary scheme. Research from the community level emphasise that, community health workers can be empowered by involving them in collecting and reporting the data from the community. To do so, Kanjo [3] urge policy makers to revise policies that discourage TBAs to report births. [4] [6] propose the need for providing health extension workers with appropriate and adequate data collection tools. Even though these studies describe how to empower community health workers, they have not demonstrated how this can be done.

With a specific focus on improving collection and reporting of data from the community level, this study demonstrates the importance of empowering TBAs and village health workers by providing them with appropriate data collection tool and motivating them to record the data. Since health workers view data collection as an excessive demand from higher authority and not as a part of their job [37], it is necessary to understand what can encourage them to record data despite their reservations. In the following sub-sections, we describe motivation and training as major factors that can encourage a change of behaviour towards performing actions.

Motivation.

Motivation is "an individual's degree of willingness to exert and maintain an effort towards organisational goals" [38]. Behavioural psychologists who regard that actions of human beings are governed by rewards and punishments and their motives are governed by behaviours to seek pleasure (food, sex, companionship) and avoid pain (social rejection, physical harm, lack of food) have promoted the concept of motivation. Luoma [39] describes this as an expectation for personal reward whereby workers will initiate and sustain to work if someone cares about their performance and whether there is a reward in return. In this regard, the concept of motivation brings an understanding that, in a collective activity [26], behaviour is expected to be created towards gaining a reward.

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Studies elaborate that motivation mechanisms such as provision of support, supervision, feedback and incentives to health workers can create an atmosphere for behaviour change [40-43]. Health workers in Kenya and Benin indicated "supervision provides the feeling of being cared for and of appreciation" [42]. Mathauer & Imhoff [42] indicated that when health workers receive meaningful feedback during supervision, their performance was improved. Ashford et al. [44] also elaborate that people seek feedback for many reasons; one reason is "to attain a goal and perform well". In this manner feedback is a reflection from which, one reflects on their performance with regard to goal attainment through making a change.

Incentive as another form of motivation reward that associates positive meaning presented after the occurrence of an action with the intention to cause the behaviour to occur again. Provision of incentives has been applied as a motivational factor to improve work performance [41-43] [45]. In the study of motivating health workers by giving incentives conducted in Cambodia, results indicated that provision of performance-based incentives led to provision of "better quality health services" and "increased health worker productivity". According to Dieleman et al. [41] provision of incentives, being it financial or non-financial, can achieve better performance if it is focused on "showing appreciation and respect". However, these attributes are highly grounded in the context; they may produce different results in different contexts.

Furthermore, designing incentive mechanisms for health care workers in developing countries can be difficult when it comes to deciding "what to measure and how to measure it" [39]. Luoma proposes using 'general productivity measures' such as "hours worked, patients seen per day, cases treated and immunizations delivered" and 'specific performance measures' such as "adhering to clinical counselling guidelines, ensuring supply stocks, making supervision rounds and promoting condoms".

The emphasis of this study is to motivate TBAs and village health workers to record and report the data. Doing so, an incentive mechanism was designed to monitor their performance by measuring the amount of records they kept on births conducted, referral cases made and pregnant women they registered as well as the health facility records on births conducted at the health facility. To be able to do so specific data collection tools were designed to keep these records. To enhance data recording, training was given to improve skills including using the data collection tools.

Training.

From organisational learning studies, the process of changing organizational behaviour by improving actions through better knowledge and understanding can be achieved through learning [31] [46-48]. An organisation is considered to learn when organisation members use knowledge acquired through training, workshop, seminars etc. to make better decisions, improve the organizational ability to develop and apply specific tactics that will improve organisational performance.

Research has shown varying reports on the impact of training community health workers in improving women's health during pregnancy, birth and after delivery [49-52]. However there is a consensus that when community health workers are trained, there are significant improvements in linkages between the community and the health facility level. This link is significantly important in improving reporting of maternal and child health data. However previous studies have not looked into the impact on data, this study covers this gap in literature.

This paper conceptualizes training as defined by Nadler [46] as "activities that are designed to improve job performance by introducing a new behaviour or modifying existing behaviour s." Training has been widely used to impart knowledge to learners in different disciplines including HISs [53] [54]. However training is often ineffective if is not properly arranged and conducted. Ngoma [53] describes that when health workers gained skills on data collection, report aggregation and data utilization, they changed their perceptions toward the data and started to ensure its completeness and accuracy in order to make appropriate decisions out of it.

Though CHAT emphasizes on re-mediation as a way of resolving contradictions, it is also important to understand what actions will enforce change of behaviour toward performing actions especially when the components of an activity system are a product of a management activity system. Empowering individuals to be aware of the positive consequences of their performance can enforce a change in behaviour.

3 Research Context and Data Collection Methods

In this section we present the empirical setting and data collection methods used.

3.1 Context

The intervention study that is reported in this paper was conducted in Kibaha district of the Coastal region in Tanzania as part of the ongoing efforts in improving reporting of maternal health data from the community level. The community is the lowest level of health care provision in Tanzania that provides preventive health care services. These services are provides by Village Health Workers (VHW) and Traditional Birth Attendants (TBAs). TBAs assists mothers when there are emergency deliveries.

TBAs are supposed to record the name of the mother for each delivery they conducted. The records of deliveries were supposed to be collected by district health managers and reported to the districts. They do not have professional medical training; rather, they use experience and knowledge gained through family relations. Most of the TBAs cannot read and write. The VHW also do not have professional medical training and they are supposed to report data on the provided services to the village government, vertical programs and a nearby health facility.

3.2 Data Collection Methods

This study used qualitative data collection methods: interviews, observations, participant observations, meetings, focus groups and document reviews. We chose this approach to gain an in-depth understanding of social meanings and social relations between TBAs, VHWs, Health facility workers (health center nurse and doctor in-charge) and health managers (TBAs' Coordinator and VHWs' Coordinator) in collecting and recording maternal health data. The analysis of the empirical material was informed by the four discursive manifestations of contradictions as discussed by [22].

Interviews.
Interviews were conducted with 6 VHWs, 7 TBAs, 2 health facility workers and 3 district health managers. These interviews were conducted between January and March 2010. The objectives of interviewing VHWs and TBAs were to understand the data they collected in the community, how they were collected and recorded, where they were reported and challenges they faced in collecting, recording, transferring and storing the data. The objective of interviewing health facility workers was to get an understanding of how they worked together with VHWs and TBAs and how they supported and supervised them in their daily activities. The district health managers were interviewed with the objective of understanding how they perceived, valued and supported the contribution of community efforts in reporting maternal health data from the community. Another objective was to assess procedures used in designing data collection registers and report forms, and providing feedback and supervision.

Observations.
Observations were conducted with the objective of understanding how the activity of data collecting and recording was taking place in everyday practices of TBAs, VHWs and health facility workers. We observed execution of different tasks, the environment within which VHWs, TBA, and health facility workers operated and the tools that were used to accomplish their activities. We also observed practices in recording information used by VHWs while they were doing household visits and compiling monthly reports. In the health facilities, we observed health facility workers during provision of maternal health services in antenatal, postnatal and children clinic sessions.

Participant Observations.
We also used participant observations where we were actively involved in the intervention. We participated in training sessions where district health managers and health center nurse in-charge conducted training to VHWs and TBAs. In the TBAs' training session, twenty TBAs attended and the training took five days with six hours every day. VHWs training session included eleven VHWs and they were trained for three days with nine hours every day. In these sessions we were actively contributing our views in the discussions. We were also involved in designing new data collection registers where we

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contributed on what data should be collected and how it should be presented on the registers. The usage of new data collection registers also involved re-defining rules and roles in the division of labour regarding data collection and recording. The process of re-designing the registers and re-defining rules and roles was done by the health managers in collaboration with the health center nurse in-charge, VHWs and TBAs. We were involved in these activities as consultants to share our experiences.

The objective of collecting data using participant observations was driven by the intervention approach we applied in bringing about a change in work practice. With this approach we were involved both as researchers, as practitioners and as consultants. Even though we were not the main drivers of this intervention, our contributions were taken aboard.

Document Reviews.

To further improving the richness of data collected in interviews and observations, this study reviewed several documents. At the district level, documents reviewed were epidemiology reports, country demographic surveys and ministry of health curriculums for training community health workers. In the health center we reviewed data collection registers (5 reproductive and child health registers) and reports (quarterly reports from January to December 2009). In the community, documents reviewed were data collection tools used by TBAs and VHWs and government registers.

These documents were reviewed to get an understanding of the problem domain, guidelines for collecting and reporting maternal health data, what data were collected and reported at the community and health facility levels and different roles and responsibilities of VHWs, TBAs, health facility workers, district health managers, village government and vertical program in accomplishing collection, recording and reporting of maternal health data.

Focus Groups.

In focus groups data was collected for the purpose of identifying contradictions and evaluating results of the intervention. The focus groups were created in meetings. These meetings were held at the village where training was conducted. One meeting was on the 22nd January 2011(one year after the intervention) and the second was on 18th June 2011 (one and half year after the intervention). In both meetings a focus group of nine VHWs and one health center nurse in-charge that was assigned the role of supervising VHWs and TBAs in a new organisation of work were created. The aim of these focus groups was to evaluate the work done by VHWs and TBAs after the intervention and to identify TBAs and VHWs with outstanding performance.

In these groups we introduced discussion topics on the achievements and challenges encountered in collecting and recording maternal health data as experienced by TBAs, VHWs and health center nurse in-charge. In the discussion we were able to collect data on changed behaviours and practices among VHWs and their collaborations with TBAs and health facility workers.

4 Findings

This section presents findings of the study by elaborating how the work practices of TBAs and VHWs were transformed through an intervention.

We started our intervention by studying the execution of tasks in collecting and recording maternal health data as it was done by VHWs and TBAs (see [5]). The findings indicated manifestations of contradictions as summarized in Table 1. We further present the reflection of the intervention after training was done, new and improved data collection tools were introduced, and an incentive mechanism was introduced.

Table 1. Manifestations of Contradictions and their Proposed Resolutions

Manifestation	Features	Indicative Findings	Proposed Resolution
Double binds	TBAs and VHWs faced unacceptable alternatives in recording and collecting data	The need for data recording Vs inadequate and/or lack of delivery registers, use of unstandardised registers, not having reading, writing and medical skills, limited stationeries, unreliable transport means and receiving no incentives.	- Introduce new and improved tools (standardised registers, stationeries, transport means and incentives) - Ensure adequate supply of the tools - Provide training to improve skills
Dilemmas	TBAs and VHWs faced incompatible evaluation on whether to record and collect data or not	- TBAs were torn between helping women and gaining income, and recording deliveries. - VHWs were torn between voluntary workers with no income, and recording and reporting information as a responsibility of a VHW	- Translating the directed goals for performing the actions to a motivating goal by rewarding TBAs and VHWs to record data instead of ordering them to record - Re-defining the rules enforced
Conflicts	Unpleasant working relation between TBAs and health facility workers	TBAs referred women with critical conditions to the health center and when confronted, they stopped referring women and also did not record deliveries	Re-defining the roles and rules to open-up communication among and between TBAs, VHWs, health facility workers, women and village members whereby the use of mobile phones is one thing that can facilitate the communications.
Critical Conflicts	TBAs and VHWs were unmotivated to perform any actions in their activity systems	Inadequate and irregular provision of support, supervision and feedback to VHWs and TBAs by health facility workers and district health managers	Re-defining the roles of health facility workers and district health managers in providing support, supervision and feedback

In the activity of collection and recording of maternal and child health data, Ngoma & Igira [5] presented the TBAs' and VHWs' activity systems as central activities under analysis. In both activity systems, the tools used, the rules enforced and the division of labour were produced by the management activity system, the Health Management Information System (HMIS). These are illustrated in Figure 2.

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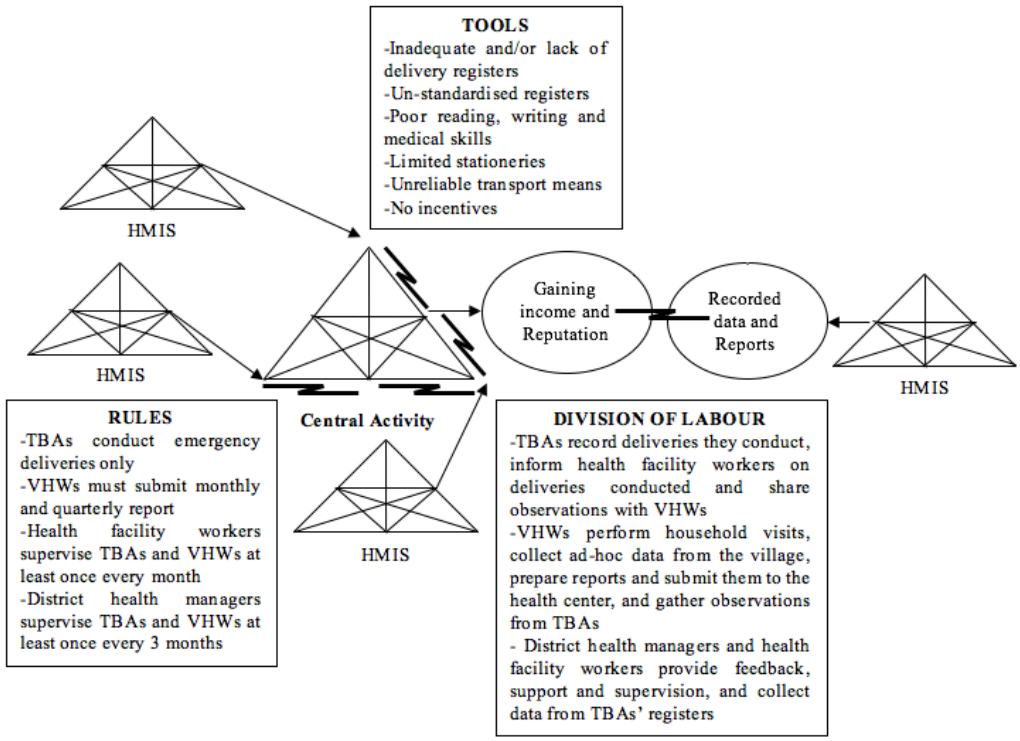

Figure 2. Primary and secondary level contradictions

Primary contradictions within the object of the activities were manifested through dilemmas whereby TBAs and VHWs had to choose to record the data or not. In cases where they chose to record the data, findings indicate that they were faced with unacceptable conditions that discouraged them to do so. These were identified as double binds and critical conflicts that were a result of available tools to perform the activity, established rules and regulations, and organization of roles in the division of labour. These led to secondary contradiction indicated by the lightening arrows in Figure 2. Another primary contradiction was identified as a manifestation of conflict between TBAs and the health facility workers within the division of labour.

4.1 Intervention

In this study an intervention was introduced as a solution that will resolve the identified contradictions as presented in Table 1. Training was proposed as a mechanism for improving skills of TBAs and VHWs in data collection and recording. Training was also aimed at raising awareness of the importance and procedures that need to be taken to improve reporting of maternal health data. Another solution proposed was to design new data collection tools that will enable and improve collection of data from TBAs and VHWs. Furthermore an incentive mechanism was devised to encourage recording and referring women and children to the health center.

Training.
In 2006, TBAs received training from the TBAs' coordinator from the district for the first time. In that training the emphasis was both on medical practices and recording of births conducted. To support the recording, TBAs were given register to use. In this intervention, TBAs and VHWs were trained with two main objectives. The first objective was to improve VHWs and TBAs' skills and knowledge on data collection, recording and reporting. The second objective was to improve knowledge and skills on professional provision of medical assistance to pregnant women throughout their pregnancy, during delivery and up to forty-two days after delivery together with monitoring health status of the babies from when they are born until five years of age.

Traditional Birth Attendants' Training Session.
This training was focusing on improving skills on keeping up-to-date records about pregnant women and their delivery outcomes, referring women to deliver at the health center, keeping record of the referrals and recording births of new born babies. The skills given to TBAs did not focus on how to read and write but who to inform when they want to record or report something, when they observe something and how to observe danger signs on pregnant women and report them to the health center or VHWs.

Training method used in this session were discussions, questions/answers and singing and dancing. The classroom arrangement was everyone sitting down around the trainer. Since most TBAs could not read and write, all the training materials were composed into songs. There were 4 training sessions in each day and every session lasted for 1 hour. In each session discussions and questions and answers sessions were done in the first 15. The rest of the time was spent on singing and dancing. These training sessions were very interesting because of the unique way they were conducted.

Village Health Workers' Training session.
The goal of training VHWs was to improve community data management in Kibaha district council by improving VHWs' skills and knowledge on data collection, analysis, utilization and storage. The training focused on keeping an up-to-date record of pregnant women and their follow-up throughout pregnancy, delivery and forty-two days after delivery, improving collaboration with TBAs, and improving medical skills of VHWs to enable them to make proper diagnosis and hence recording, and follow-up of women and children. VHWs were also trained on the importance of updating the village register and how to update it every quarter.

Training methods used were brainstorming sessions, discussions, group work, questions/answers and role plays. The classroom arrangement was a traditional classroom with a trainer in front lecturing. Training materials used were flip charts, data collection registers and report forms.

Designing Data Collection Tools.
During the training sessions, we (researchers, district managers, VHWs and TBAs) discussed on the new format of registers that will accommodate standardised collection of data about pregnant women and birth registration and at the same time follow-up on the performance of TBAs and VHWs. We (researchers) proposed a design of an initial version of the registers where we indicated the necessary data elements to be collected. This design was then discussed in the training sessions together with district health managers, health facility workers, VHWs and TBAs. We collected their comments, amendments were made and the final design was agreed upon and it was put on the registers by VHWs. After the training, TBAs and VHWs were given the new registers.

Registers given to TBAs were two; one was a new book that was based on the current design of delivery registers they were using. This was to record all the deliveries they conducted as they did before. The other register book was of a different design where they were to record the names of all the mothers they refer to health center for delivery and to record all the new-born babies. These records were to be verified and signed by the health center nurse in-charge. All the recorded information was to be reported to the health center or to a VHW. With the new register book, TBAs could keep record on how many mothers they have referred to the health center and the number of births they registered.

VHWs were also given two register books and stationeries to support their daily activities. Of the two registers, one was to be used to record pregnant women in their respective village and their outcome of delivery. This was a new register for them to use. The other register book was an additional notebook for their daily activities.

VHWs and TBAs were trained on how to use the register books and how to collect the data from women and children both on interviewing them and on carrying out observations. In addition to the training, VHWs were also given stationeries such as pens and rulers to support them in data collection and preparation of reports. VHWs were thrilled not only because they gained new skills but also because they received registers and stationeries to use.

Incentive Mechanism.
This study also introduced an incentive mechanism to encourage TBAs and VHWs to collect and report complete data from the community. This mechanism was introduced by a district health manager who copied a similar mechanism used in other districts where it has shown improvements on reducing deliver-

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ies conducted by TBAs. However the district health managers declared that they have not been able to introduce it in their district due to shortage of funds. In this intervention, the incentive was given to TBAs if the number of women referred to health center was higher than the ones they assisted for delivery at home. This incentive also was a way of motivating TBAs to record all the referrals and births in their register and to discourage them to conduct deliveries at home.

The training session in itself was taken as an incentive both to the TBAs and VHWs. The new registers together with stationery facilities provided were also considered as incentives. VHWs and TBAs perceived these as means necessary for accomplishing their tasks and also as a way of being recognised and appreciated.

4.2 Results

After the training, introduction of new data collection registers and provision of incentives to TBAs and VHWs, this study evaluated and reflected on the intervention. The evaluation focused on the changed work practices of TBAs and VHWs in collaboration with health facility workers and district health managers based on three criteria; usage of register books to record births, pregnant women and referral cases. The second criterion was on recorded information at the health center on the number of deliveries conducted at the health center as compared with those conducted by TBAs. The third criterion was recording new information in the village registers. Generally we evaluated the improved collaborative work among TBAs, VHWs, health facility workers and district health managers in recording and collecting maternal health data at the community level.

The evaluation was done two times; immediately after training and one year after the intervention. This section presents the results.

TBAs' Work Practices.

Immediately after training, TBAs started to show improvements. For the period of 10 days spent in the field, 3 mothers were referred by TBAs to the health center for delivery. This happened five days after the training. These TBAs were attending the training session and they were taught the importance of bringing women to health center to be assisted for delivery. Instead of assisting the mothers at home, they brought them to the health center. The TBAs also insisted the records to be written in their registers so they can have a good record on referral cases at the end of the year.

After one year, we conducted another evaluation session. During the evaluation, we observed that TBAs started utilising new registers for registering births and recording referrals of deliveries. In several cases, this new behaviour was detected. TBAs started recording the date of birth, name of the baby, gender and place of delivery; Figure 3 presents an example of the registers.

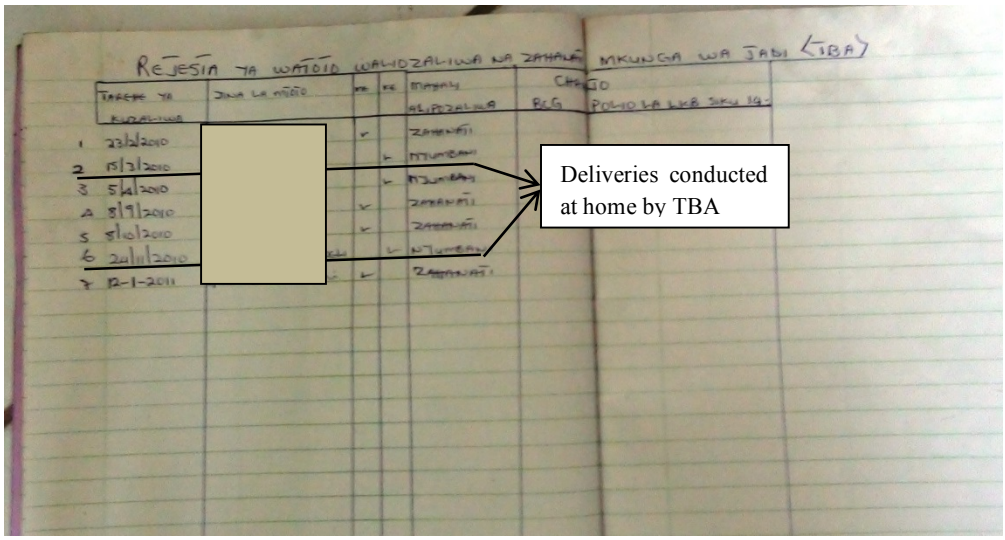

Figure 3. Birth register maintained by traditional birth attendant

As indicated in Figure 3, in a list of 6 births registered in 2010, 2 were conducted at home and the rest at the health center. When asked about how they came up with the records, TBA1 said that;

> "*The record of these babies is from the women I attended when they were pregnant (as their midwife). These records were written by the health center nurse in-charge when I brought the women to the health center for delivery*"

This was an indication that TBAs started to record all the births from the pregnant women they attended and specifically indicating where delivery was conducted. Figure 3 also indicates that TBAs started to record referrals they made for women to deliver at the health center.

A reduction on number of deliveries conducted by TBAs was also observed when comparing what was recorded in TBAs' delivery registers in the year 2009 (before the intervention) with what was recorded in 2010. Samples of the registers are presented in Figure 4 and 5.

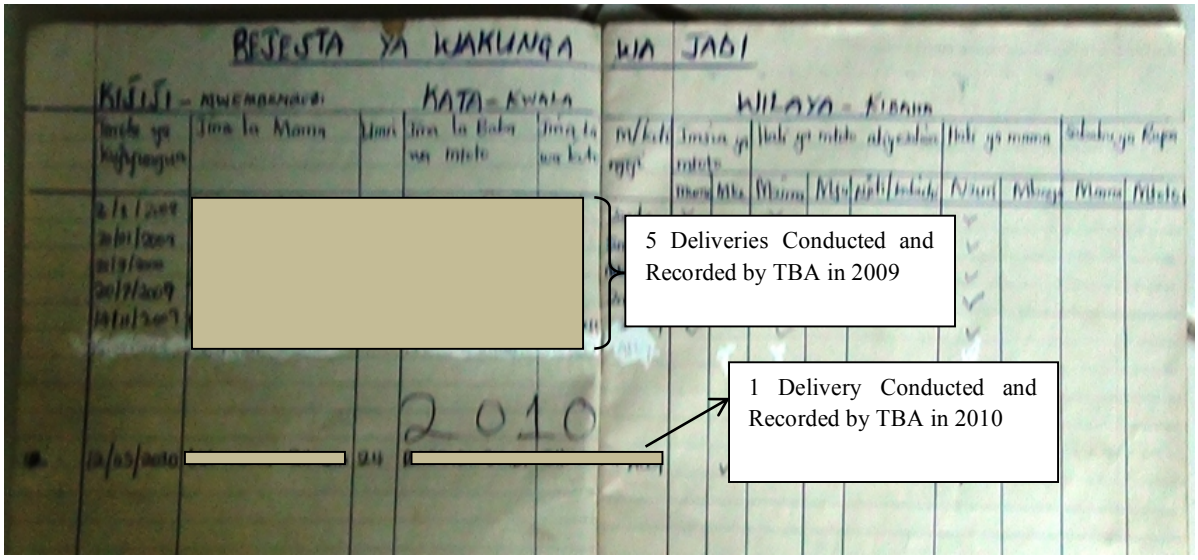

Figure 4. Traditional birth attendant register with records on women who were assisted for delivery in 2009 and 2010

Figure 4 indicates that the number of deliveries conducted and registered by TBA in 2009 were 5 and 1 in 2010.

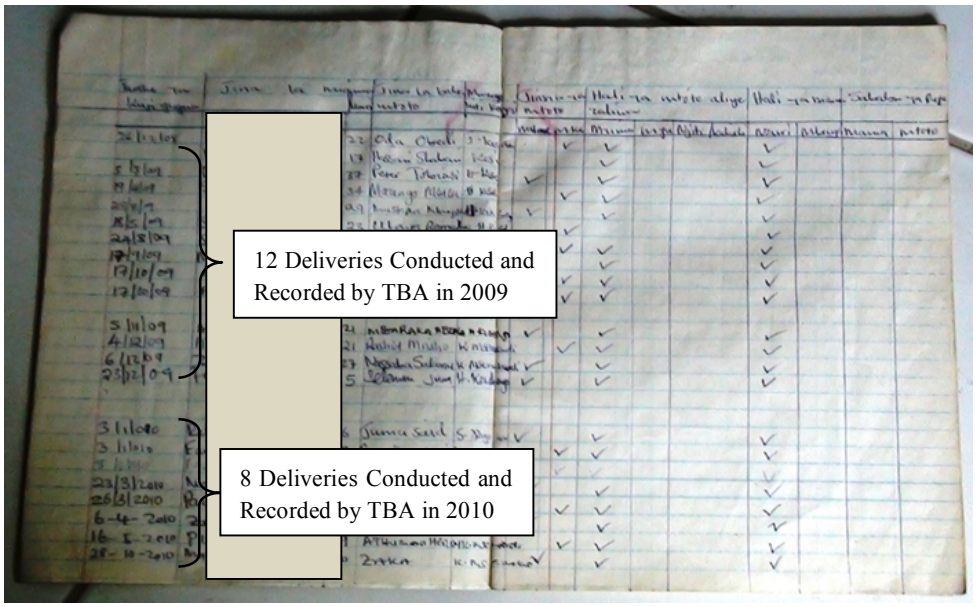

Figure 5. TBAs' register with records on women assisted for delivery in 2009 and 2010

Figure 5 indicates that the number of deliveries conducted and registered by TBA in 2009 were 12 and those in 2010 were 8.

Figures 4 and 5 indicate a reduction of TBAs deliveries. The reduction in TBAs deliveries could however be caused by several factors such as reduction of fertility rate or non-recording of the deliveries. To clear our doubts, we went further to review reports at the health center where training was conducted and where it was not conducted.

From quarterly reports of the health center in the village where training was conducted to TBAs and VHWs, we noted the status of deliveries conducted at health center as compared to those conducted by TBAs. These are summarised in Table 2.

Table 2. Health Center where Training was conducted

Year	Quarter	Number of deliveries conducted at the HC	Number of deliveries conducted by TBAs
2009	**1**	7	2
	2	13	3
	3	13	3
	4	10	9
	Total	**43**	**17**
2010	**1**	16	0
	2	8	0
	3	10	3
	4	18	4
	Total	**52**	**7**

From Table 2, quarterly reports indicated that, in 2009, there was a total of 60 deliveries, 43 of which were conducted at the health center and 17 by TBAs. In the year 2010, which was after the intervention, reports indicated that, there was a total of 59 deliveries, 52 were conducted at the health center and 7 by TBAs. This shows that TBAs have changed their practice of conducting deliveries at home, from 17 deliveries in 2009 to 7 deliveries in 2010. Instead they referred the mothers to the health center, which shows that the health center deliveries increased from 43 in 2009 to 52 in 2010.

Taking a controlled group of a health center in the village where VHWs and TBAs were not trained, we also compared the number of deliveries conducted at the health center and by TBAs. Table 3 presents a summary of the findings.

Table 3. Health Center where Training was not conducted

Year	Quarter	Number of deliveries conducted at the HC	Number of deliveries conducted by TBAs
2009	**1**	3	7
	2	1	8
	3	2	10
	4	11	9
	Total	**17**	**34**
2010	**1**	3	7
	2	3	7
	3	11	9
	4	6	14
	Total	**23**	**37**

The results from Table 3 indicate a relatively small increase (from 17 to 23) of health center deliveries and an increase (from 34 to 37) on TBAs deliveries.

VHWs' Work Practices.

To evaluate transformation of VHWs' practices in collecting and recording maternal health data, three things were checked; utilisation of new registers, mobilisation of TBAs in recording deliveries and births and referring women to the health centre for delivery, and updating the village register

Findings indicate that, VHWs started to utilise the new registers for recording pregnant women and following-up their health status. The collected data also helped them in preparing their reports. One VHW indicated that:

> *"The new register for recording pregnant women helps me to have a proper follow-up and be sure of the correctness of data when I prepare reports"*

This register became a useful tool for VHWs that helped them in accomplishing the activity. Investigating the efforts of VHWs in mobilising TBAs, findings indicate that the success (changed behaviour) of TBAs was behind what was done by VHWs. VHWs indicated that they now understood that they would get complete information if they worked closely with the TBAs because pregnant women followed TBAs and not VHWs.

Evaluating the updating of the village register, findings indicate that the register was not updated. There was no changed behaviour towards updating the village register. VHWs indicated to have negative impressions towards working with the village government head. This study could not further investigate why this practice was not transformed.

In general, the collaboration between VHWs and TBAs, and health facilities workers and district health managers in collecting and recording maternal health data was also evaluated in this study. Through interviews and observations, health facility workers and district health managers indicated appreciation of work done by TBAs and VHWs after a tremendous increase of deliveries at the health centre. One nurse indicated that:

> *"Nowadays I meet with VHWs once a month and we discuss on the issues they face and I give them feedback on the work they have done based on the reports (written and verbal) they present to me…. I am getting busier every day because almost all the pregnant women are brought here (at the health center) by TBAs for deliveries and the TBAs demand that I should record on their registers so they can have a higher number of referrals at the end of the year"*

The nurse also prepared a roster to follow-up on the TBAs referral cases and she said:

> *"I am going to reward a present to all TBAs because they all did well, even though we agreed that the top three winners will be rewarded, I have seen an exceptional energy in all the TBAs"*

Similarly the district health managers indicated to be surprised by the outcomes of the intervention. She was very happy and said that:

> *"I am going to express this success as an exemplary case to the district team so we can introduce the same incentive mechanism in all problematic (more TBA deliveries) health centers in the district".*

5 Analysis and Discussion

This section presents the analysis and discussion of the findings where we elaborate how the intervention empowered TBAs and VHWs to change their information practices. According to Ngoma & Igira [5], TBAs and VHWs were collecting and recording maternal health data with two conflicting goals; motivated goal and directed goal. TBAs aimed at gaining some income from mothers and reputation from their society over having recorded information on births for supervision. Similarly VHWs aimed at providing the service to the society and gaining reputation over having records for reporting and following-up.

The complex relationships within and between the elements of activity systems of TBAs, VHWs and HMIS created contradictions that were manifested through dilemma, conflicts, critical conflict and double-bind (Table 1). The manifestations of double binds and critical conflicts which were a result of the tools used, led to secondary contradictions. And primary contradictions were identified though the manifestations of dilemmas driven by the rules and regulations enforces. Conflicts were driven by the organization of roles in the division of labour. As a result the activity of collecting and recording maternal health data was crippled; and this lead to under-reporting of data.

According to Kuutti [26], the desire to perform an activity is driven by motives/goals. This study has demonstrated how TBAs and VHWs started to effectively involve themselves in collecting and recording the data after the intervention. Previous findings indicated that VHWs and TBAs performed actions that

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were motivating than the others. The analysis indicates that the intervention motivated TBAs and VHWs to record data by imposing actions that rewarded them for doing that instead of ordering them. This empowered TBAs, VHWs, health facility workers and district health managers to create a new meaning [32] for collecting and recording maternal health data.

In the next sub-sections we describe how the resolutions of the manifested contradiction through the introduction of new and improved tools, new and re-defined rules, and new and re-defined roles in the division of labour led to re-mediation/transformation of the activity systems.

5.1 New and Improved Tools

In the TBAs' activity system, the intervention targeted at improving the participation of TBAs in recording deliveries they conducted, referring mothers to the health centre for delivery and registering new born babies. Most TBAs already had delivery registers for recording deliveries. Those who did not have the registers were given a new one and all TBAs were given another register to record referrals and new born babies. Findings indicate that TBAs started to record births and delivery referrals which at the same time; they were referring mothers to the health centre for delivery. Though the new registers demanded more data recording, still the TBAs were motivated to record the data because at the same time they were recording their performance. This was due to an expectation for personal reward as described by Luoma [39] and Roth [33].

Findings also indicate that VHWs' activity system had contradictions (see section 2) that made it impossible to record and collect all the maternal health data at the community. Attempts were made to resolve the contradictions by improving their medical skills, introducing the use of standardised registers to record pregnant women and providing them stationeries to support data collection and recording. Results indicate that the skills gained empowered VHWs to collect complete and accurate information, by including findings from TBAs, and compiling their reports on time.

In both activity systems, the analysis indicates that the presence of new and improved tools resolved the manifestations of double-binds and critical conflicts. As a result, a new context in performing the activity of data collection and recording was created whereby new rules and new roles were defined. This indicates transformation of the wok practices as a result of changed behaviour driven by learning and motivation. Learning manifests itself when the acquired knowledge through training and other means is applied in the daily activities [46] [48] [54]. Furthermore, this study indicates that provision of incentives catalysed the application of knowledge in performing the activities. Incentives created an additional purpose for collecting and recording maternal and child health data, and referring women to the health centre. Transformation of information practices for recording and collecting the data was driven by goals that promised TBAs and VHWs a payoff for performing the activity.

5.2 New and Re-defined Rules

Furthermore, the introduction of new and redefined rules brought about changes in the TBAs and VHWs' activity systems as they enforced performance of roles in the division of labour. The modelled solution in this intervention intended to encourage recording and collecting the data and discourage fear of recording.

The redefined rule was the rule that enforced TBAs to conduct emergency deliveries only in the TBAs' activity system. Instead of conducting deliveries through which they gained some income, TBAs were insisted to refer the women to the health centre and ensure that they keep the records so they can receive an incentive at the end of the year. For the TBAs to be rewarded and to know that someone cared about their performance; this rule was enforced and it led to utilisation of the new register for recording referrals and registering births.

The analysis indicates that, the incentives and training provided to TBAs together with the redefined rules resolved the dilemma on whether to record the data or not and empowered them to collect and record the data. Findings indicate improvements in birth registration and referral cases of pregnant women to the health centre.

5.3 New and Re-defined Roles in the Division of Labour

After the introduction of new and improved tools, and new and re-defined rules as an attempt to re-organize the activity systems; new and re-defined forms of division of labour emerged. This re-organisation led to the creation of new responsibilities for TBAs, VHWs, Health facility workers and district health managers. TBAs started to refer women and children to the health center. VHWs were overseeing the work done by TBA. Health facility workers and district health managers provided support, feedback and supervision to the VHWs and TBAs.

Findings indicate that TBAs, VHWs, health facility workers and district health managers started to adhere to their responsibilities. The health facility workers and district health managers used support, supervision and feedback as empowering communication tools rather than as a means of inspection. As a result, TBAs and village health workers were motivated to record and collect the data because someone cared [39] about their performance. However, VHWs did not update the village register. They failed to collaborate with the village government head so as to execute this role for reasons beyond the scope of this paper.

The re-defining of roles in the division of labour also resolved the identified manifestations of conflicts between TBAs and health facility workers. This opened-up communication between the TBAs and health facility workers which was otherwise unpleasant.

In sum, the manifestations of contradiction in the activity of data collection and recording hindered TBAs and village health workers to perform the activity. They were dis-empowered because they were certain that no one recognized their performance. Though the reception of appropriate data collection tools, training and incentives, they were motivated to change their information behaviour by actively starting to collect and record the data. This implies that, empowerment can be a remedy for contradictions.

6 Conclusion

This study has indicated that the manifested contradictions that hindered collection and recording of maternal health data were the driving forces for bringing about change in TBAs and village health workers' information practices. The analysis indicates that, an intervention was attempted to re-organize the activity systems in order to resolve the contradictions. This re-organisation was accomplished by the introduction of new and improved tools, new and redefined rules and roles in the activity systems of TBAs and village health workers.

To answer the research question: How to change community health workers' information practices in order to improve reporting of maternal and child health data from the community level? This study has shown that through understanding and resolving double binds, dilemmas, conflicts and critical conflicts, a change in data collection and recording practices of TBAs and VHWs can be achieved. Reflections on the intervention indicate that, TBAs and village health workers should be empowered to improve their performance and confidence in capturing and communicating these data. Through the provision of standardized data collection tools, appropriate skills through training, motivation and creation of proper means for sharing information among district managers, health facility workers, TBAs and village health workers, the quality of maternal health data can significantly be improved. Findings of this study indicate that, these attributes can lead to creation of a new context where behaviour towards recording and reporting of the data can be directed.

Furthermore, this study had shown that TBAs and village health workers could be encouraged to record data by providing them with data collection tools that keep record of their performance with a goal of receiving a reward. Their registers should not only be regarded as tool for collecting and reporting data upwards, but also a tool for demonstrating their performances.

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References

[1] Otieno C, Kaseje D, Ochieng' B, Githae M. Reliability of community health worker collected data for planning and policy in a peri-urban area of Kisumu, Kenya. J Community Health. 2012;37(1):48-53.
[2] Perez F, Ba H, Dastagire S, Altmann M. The role of community health workers in improving child health programmes in Mali. BMC Int Health Hum Rights. 2009;9(1):1-12.
[3] Kanjo C. Pragmatism or policy: Implications on health information systems success. Electron J Inf System Dev Ctries. 2011;48(1):1-20.
[4] Damtew ZA, Kaasbøll J. Target setting procedures for immunisation services in Ethiopia: Discrepancies between plans and reality. J Health Manag. 2011;13(3):39-58
[5] Ngoma, C, Igira, FT. Contradictions in collecting and recording maternal health data at the community level: A case study from two districts in Tanzania. J Health Inform Dev Ctries. 2012;6(2):509-520.
[6] Damtew ZA, Kaasbøll J. Working towards precise and ambiguous targets: The challenge for health extension workers of Ethiopia. In: Proceedings of IRIS 2008; Åre, Sweden; 2008.
[7] Lippeveld T, Sauerborn R. Introduction. In: Sauerborn R, Lippeveld T, Bodart C, editors. Design and Implementation of Health Information Systems. Geneva: World Health Organization; 2000. p. 1-14.
[8] Ngoma, C, Chawani MS, Herstad J. Adaptation of mobile application to improve flow of birth information from the community to the district level. In: Popescu-Zeletin R, Rai IA, Jonas K, Villafiorita A, editors. E-Infrastructure and E-Services for Developing Countries: Revised Selected Papers; Second International ICST Conference, AFRICOM; Cape Town, South Africa; 2010 November 25-26. Berlin, Heidelberg: Springer; 2011. p. 79-92.
[9] Wilson R. Using computers in health information systems. In: Sauerborn R, Lippeveld T, Bodart C, editors. Design and Implementation of Health Information Systems. Geneva: World Health Organization; 2000. p. 198-212.
[10] Manda TD, Herstad J. Implementing mobile phone solutions for health in resource constrained areas. Understanding the opportunities and challenges. In: Villafiorita A, Saint-Paul R, Zorer A, editors. E-Infrastructures and E-Services on Developing Countries. Proceedings of the First International ICST Conference, AFRICOM; Maputo, Mozambique; 2009 December 3-4. Berlin, Heidelberg: Springer; 2010. p. 95-104.
[11] Wilson RG, Smith DL. Microcomputer applications for primary health care in developing countries. Infect Dis Clin N Am. 1991;5(2):247.
[12] Braa J, Macome E, Mavimbe JC, Nhampossa JL, Leopoldo JC, Manave A, Sitói A. A study of the actual and potential usage of information and communication technology at district and provincial levels in Mozambique with a focus on the health sector. Electron J Inf Syst Dev Ctries. 2001;5(2):1-29.
[13] Bodvala R. ICT applications in public healthcare system in India: A review. ASCI J Manag. 2002;31(1-2):56-66.
[14] Igira, FT. The dynamics of healthcare work practices: Implications for health management information systems design and implementation. Manag Res Rev. 2012;35(3/4):245-259.
[15] Igira, FT. The situatedness of work practices and organisational culture: Implications for information system uptake. J Inf Technol. 2008;23:79 - 88.
[16] Kimaro H, Twaakyondo H. Analysing the hindrance to the use of information and technology for improving efficiency of health care delivery system in Tanzania. Tanzan J Health Res. 2006;7(3):189-197.
[17] Korpela M, Ikävalko P, Luukkonen I, Martikainen S, Palmén M, Tiihonen T, Toivanen M, Vainikainen V. How to co-develop services, work, and information systems in healthcare: The Daisy approach. In: Beuscart-Zéphir M-C, Jaspers M, Kuziemsky C, Nøhr C, Aarts J, editors. Context Sensitive Health Informatics: Human and Sociotechnical Approaches. Amsterdam: IOS; 2013. p. 126-132.
[18] Korpela M, Soriyan HA, Olufokunbi KC. Activity analysis as a method for information systems development. Scand J Inf Syst. 2001;12(1-2):191-210.
[19] Sahay S, Avgerou C. Introducing the special issue on information and communication technologies in developing countries. Inf Soc. 2002;18(2):73-76.
[20] Korpela M, Mursu A, Soriyan HA. Information systems development as an activity. Comput Support Coop Work. 2002;11:111-128.
[21] Freitas MR, Byrne E. Activity Theory as an analytical tool: A case study of IS development for an anti-retroviral treatment clinic in South Africa. In: Proceedings of the 2006 Annual Research Conference of the SAICSIT on IT Research in Developing Countries. Somerset West, South Africa: South African Institute for Computer Scientists and Information Technologists; 2006. p. 90-99.
[22] Engeström Y, Sannino A. Discursive manifestations of contradictions in organizational change efforts: A methodological framework. J Organ Change Manag. 2011;24(3):368-387.
[23] Engeström Y. Learning by Expanding: An Activity Theoretical Approach to Developmental Research. Helsinki, Finland: Orienta-Konsultit; 1987.

[24] Engeström Y. Developmental Work Research. Expanding Activity Theory in Practice, vol. 12. Berlin, Lehmanns Media; 2005.
[25] Nardi BA. Studying context: A comparison of Activity Theory, situated action models, and distributed cognition. In: Nardi BA, editor. Context and Consciousness: Activity Theory and Human-Computer Interaction. MIT; 1996. p. 69-102.
[26] Kuutti K. Activity Theory as a potential framework for human-computer interaction research. In: Nardi BA, editor. Context and Consciousness: Activity Theory and Human-Computer Interaction. MIT; 1996. p. 9-22.
[27] Engeström Y. Developmental studies of work as a test bench of activity theory: The case of primary care medical practice. In: Chaiklin S, Lave J, editors. Understanding Practice: Perspectives on activity and context. Cambridge, MA: Cambridge University Press; 1993. p. 64-103.
[28] Engeström Y. Expansive learning at work: Toward an Activity Theoretical reconceptualization. J Educ Work. 2001;14(1).
[29] Bonneau RJ. Information, Decision & Complex Networks. AFOSR/RTC Overview. Arlington, VA: Air Force Office of Scientific Research; 2013.
[30] Sannino A. Sustaining a non-dominant activity in school: Only a utopia? J Educ Change. 2008;9(4):329-338.
[31] Virkkunen J, Kuutti K. Understanding organisational learning by focusing on "activity systems". Account Manag Inf Technol. 2000;10:291-319.
[32] Castelloe P, Watson T. Participatory education as a community practice method: A case example from a comprehensive head start program. J Community Pract. 1999;6(1):71-89.
[33] Roth W. Emotion at work: A contribution to third-generation Cultural-Historical Activity Theory. Mind Cult Act. 2007;14(1):40-63.
[34] Chambers R: Rural Development: Putting the last first. New York: Longman; 1994.
[35] WHO. The World Health Report 2000 - Health Systems: Improving Perfomance. Geneva: World Health Organization; 2000.
[36] Lippeveld T. Routine health information systems: The glue of a unified health system. In: International Workshop on Issues and Innovation in Routine Health Information in Developing Countries; Potomac, MD, USA; 2001 March 14-16.
[37] Braa J, Hedberg C. The struggle for district-based health information systems in South Africa. Inf Soc. 2002;8(2):113-127.
[38] Franco LM, Bennett S, Kanfer R. Health sector reform and public sector health worker motivation: A conceptual framework. Soc Sci Med. 2002;54:1255-1266.
[39] Luoma M. Increasing the motivation of health care workers. Capacity Project Technical Brief 7. IntraHealth International; 2006.
[40] Hamre GA, Kaasbøll J. Motivation and demotivation: A case study of the Malawian health management information system. Electron J Health Inform. 2008;3(2):11.
[41] Dieleman M, Cuong PV, Anh LV, Martineau T. Identifying factors for job motivation of rural health workers in North Viet Nam. Hum Resour Health. 2003;1(10).
[42] Mathauer I, Imhoff I. Health worker motivation in Africa: The role of non-financial incentives and human resource management tools. Hum Resour Health. 2006;4(24).
[43] Henderson LN, Tulloch J. Incentives for retaining and motivating health workers in Pacific and Asian countries. Hum Resour Health. 2008;6(18).
[44] Ashford SJ, Blatt R, VandeWalle D. Reflections on the looking glass: A review of research on feedback-seeking behavior in organizations. J Manag. 2003;29(6):773-799.
[45] Hongoro C, Normand C. Health workers: Building and motivating the workforce. In: Jamison DT, Breman JG, Measham AR, et al., editors. Disease Control Priorities in Developing Countries. Second edition. Washington (DC): World Bank; 2006.
[46] Nadler L. Developing Human Resources. Houston: Gulf; 1970.
[47] Swieringa J, Wierdsma A. Becoming a learning organization: Beyond the learning curve. Addison-Wesley; 1992.
[48] Fiol CM, Lyles MA. Organizational learning. Acad Manag Rev. 1985;10(4):803-813.
[49] Darmstadt GL, Lee ACC, Cousens S, Sibley L, Bhutta ZA, Donnay F, Osrin D, Bang A, Kumar V, Wall SN et al. 60 million non-facility births: Who can deliver in community settings to reduce intrapartum-related deaths? Int J Gynecol Obstet. 2009;107(Suppl):S89-S112.
[50] Sibley LM, Sipe TA, Koblinsky M. Does traditional birth attendant training increase use of antenatal care? A review of the evidence. J Midwifery Women's Health. 2004;49(4):298-305.
[51] Ray AM, Salihu HM. The impact of maternal mortality interventions using traditional birth attendants and village midwives. J Obstet Gynecol. 2004;24(1):5-11.
[52] Smith JB, Coleman NA, Fortney JA, Johnson J, Blumhagen DW, Grey TW. The impact of traditional birth attendant training on delivery complications in Ghana. Health Policy Plan. 2000;15(3):326-331.
[53] Ngoma C. Cultivation Strategies in the Implementation of Health Management Information System in Zanzibar: An Action Research Study. Oslo: University of Oslo; 2007.
[54] Ngoma C, Kaasbøll J, Aanestad M. From training to in-service support. In: IST-Africa 2008 Conference & Exhibition; Windhoek, Namibia; 2008 May 7-9.

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The Attitude towards and Use of Electronic Medical Record System by Health Professionals at a Referral Hospital in Northern Ethiopia: Cross-Sectional Study

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Background and Purpose: Electronic medical record (EMR) systems are increasingly incorporated into the healthcare systems of developing countries to improve the effectiveness and efficiency of the healthcare institutions. Inaccuracy, non-timeliness, incompleteness and inconsistency of paper-based data are basic triggering points to adopt EMRs in developing countries. The purpose of this study was to assess the attitude, use, and hindering factors of health professionals' use of EMR in one referral hospital in Ethiopia that has used the EMR for the last two years.
Methods: An institutional based cross-sectional quantitative study was conducted in March 2014 among 501 health professionals. Self-administered questionnaire was used to collect data. Data were entered and analysed using Epi-Info version 7 and SPSS version 20 respectively. Descriptive statistics were computed to describe study variables. Bivariate and multivariate logistic regression analyses were used to show the presence of association between the study and outcome variables. Odds ratio at 95% confidence level was used to describe the strength of association.
Results: A total of 428 health professionals participated in the study with a response rate of 86%. The majority, 318 (74.3%) were computer literate and more than half, 246 (57.5%) of them had computer access. A large number (71.0%) of respondents used EMR and more than half (56.1%) had a good attitude towards it. Health professionals' age, computer literacy, computer assess, working experience, regular meeting and training on the EMR system were significant factors (p-value <0.05) to the attitude and use of EMR system. Educational level, knowledge on EMR and using EMR were also variables affecting users' attitude towards EMR.
Conclusions: Majority of the respondents used the EMR system in their daily works and more than half of them had a good attitude towards EMR. Technical (computer literacy, knowledge), organizational (computer access, infrastructure, training access, regular meeting, management support), and personal (age, working experience) variables are significant factors to develop a good attitude towards and high use of the system. Improving skills, awareness, infrastructure, management and resource allocation are important interventions to improve the EMR system performance and positive attitude towards health professionals in the study area.

Keywords: Electronic Medical Record, Ethiopia, Attitude.

1 Introduction

Incorporating different information technologies (ITs) into the healthcare system of developing countries is not all about modernizing the health system but it is about saving life by facilitating communication, practicing evidence based decision, incorporating e-learning to remote health professionals, use it as a medium to access recent healthcare information, data handling and processing activities among staffs [1] [2]. Among the different IT system initiatives in developing countries electronic medical records (EMR)

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systems are becoming dominant with the vision of improving data handling and communication in healthcare organizations [2-5].

It is hypothesized that EMR systems strengthen the health system and clinical care by supporting to have legible and organized medical records and to access clinical information about individual patients [6-9]. Different researches show that the adoption of an EMR system in the healthcare system has the potential to transform healthcare in terms of saving costs, reducing medical errors, improving service quality, increasing patients' safety, decision-making, saving time, data confidentiality, and sharing medical information [6] [8] [10-16].

Various health facilities in developing countries are using EMR systems in varying degrees due to several reasons [10] [11] [17] [18]. Environmental competition, fragmented health information system, incompleteness and inconsistency of paper based data, poor quality and non-timeliness of reports, poor data utilization of health facilities, time/resource consuming of paper based system, innovation of new technologies, and governments' need to deliver evidence based health services were basic reasons to adopt EMR systems in developing countries [9] [18-22].

Despite the high expectations and interest in adopting and using EMR systems worldwide, its overall adoption rate is relatively low, especially in the resource-limited countries where high diseases prevalence and incidence rates are predominant [1] [2] [6] [7] [10] [23]. As indicated by various studies, the adoption and use of EMR systems in developing countries is in its embryonic stage for several reasons [1] [2] [10].

Healthcare infrastructures, health professionals' attitude and awareness level, lack of proper management, resource shortage, skill related issues, users' resistance, policy related issues, poor commitments of staffs, and poor maintenance services are some of the reasons for the limited adoption and use of EMR system in developing countries [19] [24] [25].

Findings of different studies indicate that users' attitude, acceptance and skills are vital in the success of EMR system implementation in the healthcare systems since they are the primary users of the system [10] [12] [13] [14] [18] [20] [26]. It is true that the system will be functional if the users and working environment are ready to adopt and use the EMR system.

In Ethiopia, EMR system is one of the major ICT projects among the other different initiatives like health data warehouse, Health-net, tele-education, telemedicine, human resource information system, electronic health information management system, *woreda* based planning system, and health integrated financial information system planned by the Ethiopian Federal Ministry of Health (EFMoH) and its partners [27]. The EFMoH with the support of Tulane University adopted an EMR system called Smart Care in hospitals and health centres to improve healthcare services through quality evidence [27] [28]. Users' attitude, knowledge, technical skills, functionality of the working environment/infrastructure, and adequate resources are pointed out as important determinants for the functionality of the adopted EMR system [29].

Despite the adoption of the system, there is no adequate evidence on the attitude, use and determinant factors of the health professionals towards the EMR system in Ethiopia. In order to effectively implement the EMR in future implementations, evidence on the main factors of EMR success or failures must be studied. However, there is little evidence on determinant factors of EMR success generally in implementations in resource-limited settings where unsustainable power supply and limited computer skills are major concerns. Therefore, the aim of this study is to assess the attitude, use and factors associated with EMR system use among health professionals working in the Ayder Referral Hospital, Tigray Regional State, Northern Ethiopia where the Smart Care system is adopted as a pilot study for the last two years. The main contribution of this work is to identify the main determinant factors of EMR use and attitude of health professionals in the implementation of EMR in hospitals with limited resources. The results are useful for EMR implementers, governmental organizations and non-governmental international organizations for proper planning before costly EMR implementations.

2 Materials and methods

An institutional based cross-sectional quantitative study was conducted in March 2014 to assess the attitude, use and determinants of EMR systems among health professionals in Ayder Referral Hospital, Northern Ethiopia. A cross-sectional study design was selected because we are interested to determine the use and attitude of health professionals towards EMR after two years of use. Ayder Referral Hospital is found in the Mekelle city administration, the capital city of the Tigray Regional State - one of the regions in the nine administrative regions of Ethiopia. The city is located about 780 kilometres away from Addis Ababa, the capital city of Ethiopia [30]. There are two governmental hospitals and seven health centres

within the city administration. Ayder Referral Hospital is giving healthcare services for an estimated of 5 million population. The hospital started EMR system applications as a pilot study since 2012. About 500 health professionals from different categories are employed and working in the hospital.

All the health professionals working in the hospital were the study population of this study. Health professionals with less than 6 months of working experience or absent from their work due to annual leave and maternity issues were excluded from being study participants in the study. All the health professionals were approached for this study.

Health professionals who used EMR system for recording, storing, retrieving and reporting purposes in daily tasks were grouped as EMR system users whereas those who did not use it at all or sometimes for the above tasks were considered as non-EMR system users in this study. Health professionals who responded above the mean score of questions related to their attitude were grouped as having a good attitude towards the EMR system and those scored below the mean score were assumed as having a poor attitude towards the EMR. Respondents who can perform at least basic Microsoft Office applications (MS Word, PowerPoint, Excel, Access and Internet services) were considered as computer literate.

Data on different variables were collected using a pre-tested self-administered questionnaire. The questionnaire was developed based on previous validated instruments [15] [16] [17] [21]. The tool was first prepared in English, translated to Tigrigna (local language), and then back to English by language experts to check its consistency. Socio-demographic, technical, attitudinal and organization-related variables were the major contents of the tool. It was pre-tested in Minilik Hospital, Addis Ababa, to check its validity based on feedbacks.

Four diploma nurses and one health officer were recruited as data collector and supervisor respectively. They were trained for one day on the objective of the study, data confidentiality, data quality assurance, contents of the questionnaire, and the rights of the respondents.

Ethical clearance for this study was obtained from the Ethical Review Committee of the Institute of Public Health, University of Gondar, Ethiopia. Written consent was taken from the Tigray Regional Health Bureau and the hospital manager. Informed verbal consent was also obtained from each health professional after the clear explanation of the study objectives, data confidentiality issues, and their rights during the data collection process. Data collectors collected the required data by distributing the questionnaire among the health professionals. The principal investigator and the supervisor did supportive supervision on the data collectors daily. Data collectors, the supervisor, and authors checked the completeness, consistency, and accuracy of the data daily to take actions on the next days.

After the completion of the data collection, the authors edited data manually. Authors created a data entry template using Epi Info version 7 based on the necessary study variables. The authors did data editing and analysis using the statistical software Epi Info version 7 and SPSS version 20, respectively. Descriptive statistics and bivariate regression analysis were computed to describe the study population and identify associated factors on the attitude towards and use of EMR system respectively. Variables having a p-value of <0.2 in the bivariate analysis were adjusted to the multivariate logistic regression analysis to check the presence of confounding effect in the association. Odds ratio at the 95% confidence level was used to describe the strength of associations between the study and outcome variables.

3 Results

3.1 Socio-demographic characteristics of health professionals

A total of 428 health professionals participated in the study with a response rate of 86%. 248 (58.0%) of the respondents were within the age category of ≥ 30 years. The mean age of the respondents was 27.36 (SD±4.746) years. More than half (53.7%) of the respondents were males. A majority, 75.7% of the study participants had a monthly salary of ≥2225 ETB (Ethiopian Birr). About three quarters (76.2%) of the respondents were degree holders and more than half (52.1%) of them nurses. Majority, 74.3% and 70.0% of the respondents were computer literate and had working experience of ≤ 6 years respectively (Table 1).

3.2 The attitude towards and use of the EMR system by health professionals

Of the total respondents, 125 (29.6%) did not use the EMR system for their daily work and 240 (56.7) of them had a good attitude towards EMR system use (Figure 1).

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Table 1. Socio-demographic characteristics of health professionals in the hospital.

Variables	Frequency	Percent (%)
Sex of the respondents:		
Male	230	53.7
Female	198	46.3
Age of the respondents:		
<30 years	180	42.0
≥30 years	248	58.0
Educational status:		
Degree	326	76.2
Master and above	102	23.8
Professional category:		
GP and specialist	45	10.5
Pharmacy	71	16.6
Laboratory	53	12.4
Nurse	223	52.1
Others	36	8.4
Monthly income in Birr:		
< 2225	104	24.3
≥ 2225	324	75.7
Working experience:		
≤ 6years	299	70.0
> 6 years	129	30.0
Computer literacy:		
Yes	318	74.3
No	110	25.7

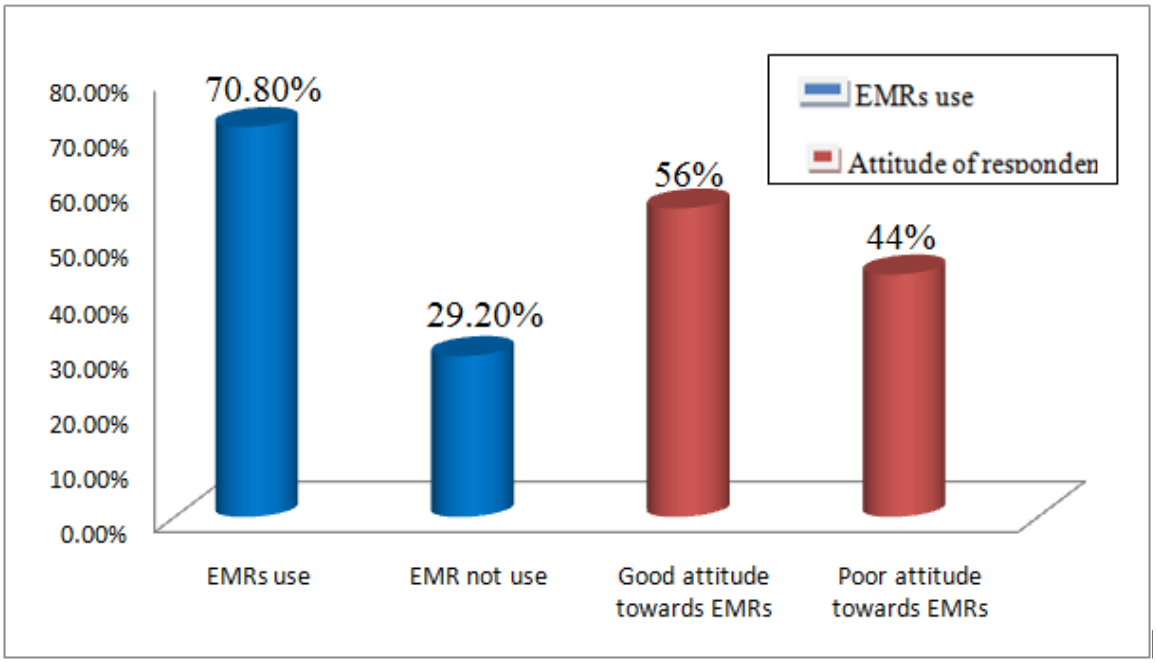

Fig. 1. Attitude towards and us of the EMR among the health professionals in the hospital.

3.3 Technology-related variables of health professionals

Concerning the frequency of EMR system use, 39.3% of the respondents used the EMR system daily, 75.5% three times a week, 4.4% once a week and 20.5% did not remember the frequency of use. The respondents' use of EMR system was as follows: 69.2% for patient data recording, 47.0% for report generating, and 53.3% for data processing and communication purposes (Table 2).

Table 2. Technology-related variables of health professionals in the hospital.

Variable	Response	Frequency	Percent
EMR system used	Yes	303	70.8
	No	125	29.6
EMR system use frequency	Daily	168	39.3
	Three times a week	32	7.5
	Once a week	19	4.4
	I do not remember exactly	87	20.5
EMR system used for	Recording patient data	296	69.2
	Report generating	203	47.0
	Report sending	228	53.3
	Data retrieving and analysis	250	58.4
Prefer EMR instead of paper based	Yes	327	76.4
	No	101	23.6
Reasons for preferring EMR system	More secured	319	74.5
	Time saving	299	69.9
	Store more data	315	73.6
	Easy to access data	323	75.5
	Easy to write report	304	71.0
Reasons for not using EMR	Time consuming	78	18.0
	Difficult to use	51	11.9
	Needs computer skill	67	15.7
	Electric dependent	76	17.8
Refreshment training on EMR	Yes	152	35.5
	No	276	64.5
EMR system acceptance by health professionals	Yes	147	34.3
	No	154	36.0
	Not certain	127	29.7
Functionality of EMR system	Yes	76	17.8
	No	362	82.2

Almost three quarters (72.2%) of the health professionals had awareness on the EMR system. A large number (76.4%) of the respondents preferred the EMR system than paper based for the reasons of high security (74.5%), time saving (69.9%), better data storage (73.6%), ease of data access (75.5%), and ease of generating reports (71.0%). The rest 23.6% of the respondents did not prefer EMR system for the reasons of difficulties to use (17.8%), time consuming (18.0%), demand of computer skills (15.7%), and electric power dependency (11.9%). Only 35.5% of the respondents had access to the refreshment trainings on EMR system.

3.4 Organisation-related variables on the use of EMR system

More than half of the respondents (57.5%) had computer access in their working area. Regarding the purpose, 45.6% of the respondents used computers for data recording, 45.1% for report generating, 40.2% for reading, and 29.9% for videos accessing. Nearly three quarters (72.0%) of the respondents knew the presence of a responsible body for EMR system in their hospital. Duties of the assigned body mentioned were managing the system, conducting trainings, system maintenance, collecting data from each department, and preparing the overall report to the hospital (Table 3).

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Table 3. Organisation-related variables on the use of EMR system in the hospital.

Variables	Response	Frequency	Percent
Computer access in working area	Yes	246	57.5
	No	182	42.5
Purpose of computer use	Data recording	195	45.6
	Report generating	193	45.1
	Reading	172	40.2
	Video accessing	128	29.9
Presence of an assigned body to EMR	Yes	308	72.0
	No	120	28.0
Duties of assigned person	Managing the EMR system	151	35.3
	Conduct training on EMR	89	20.8
	EMR system maintenance	116	27.1
	Generating overall report	107	25.0
	Collect data from each department	107	25.0
Is there management support to EMR system	Yes	170	39.7
	No	258	60.3
Regular meeting on EMR system	Yes	80	18.7
	No	348	81.3
Discussion of EMR issues in any hospital meeting	Yes	44	10.3
	No	151	35.3
	I do not know	233	54.4
Presence of EMR manual	Yes	113	26.4
	No	315	73.6
Access of uninterrupted electric power in your department	Yes	72	16.8
	No	356	83.2
Means of managing patient data during the absence of electric power	Using generator	274	64.0
	Using paper based	33	7.7
	Leaving it unlit light comes	64	15.0
	Using paper temporarily and recording to EMR	13	3.0
Access to standby generator in your department	Yes	272	63.6
	No	156	36.4

Only 39.7% of the respondents mentioned the presence of management support, 16.6% a budget allocation, and 18.7% regular meetings on the EMR system. A small number of respondents (15.4%) responded to have a standard protocol manual to the EMR system available in their working units. Only 16.8% of the respondents reported to have the presence of uninterrupted electric power. Nearly two-thirds (64.0%) of health professionals used a generator when there is an electric power interruption (Table 3).

3.5 Factors associated with the EMR system utilization

In both bivariate and multivariate analysis, age, working experience, computer accesses, computer literacy, management support, uninterrupted electric power, regular meetings on the EMR, the presence of an EMR system manual, the presence of a standby generator, refreshment training and budget allocation were variables showing a significant association (p-value <0.05) on the EMR system use (Table 4).

Health professionals with the age of <30 years were (OR=3.47, 95% CI= [2.18-5.51]) times more likely to use the EMR system compared with those whose age was >=30 years. Health professionals having working experiences of <=6 years were (OR= 2.23, 95% CI= [1.31-3.82]) times more likely to use the EMR system for their daily tasks than those having > 6 years working experiences. The study participants who have computer access, are computer literate and got management support on EMR system were (OR=1.64, 95% CI= [1.06-2.56], OR=2.06, 95% CI= [1.27-3.34] and OR=1.60, 95% CI= [1.02-2.54]) times more likely to use the EMR system than their counterparts respectively (Table 4).

Table 4. Factors associated with the EMR system utilization in the hospital.

Characteristics	Respons e	EMR Utilization		COR(95%CI)	AOR(95%CI)
		Users (%)	Not Users		
Age:	< 30	77(18.0)	103(24.0)	3.47 [2.18-5.51]	2.13[1.51-3.93]
	>=30	44(10.3)	204(47.7)	1	1
Sex:	Male	159(37.2)	71(16.6)	0.84 [0.54-1.31]	0.68[0.45-1.22]
	Female	144(33.6)	54(12.6)	1	1
Educational level:	Degree	225(52.6)	101(23.6)	0.69[0.40-1.18]	0.86[0.57-1.69]
	Master +	78(18.2)	24 (5.6)	1	1
Work experience:	<=6 yrs	105(24.5)	24(5.6)	2.23 [1.31-3.82]	1.81(1.04-3.16)
	>6 yrs	198(46.3)	101(23.6)	1	1
Computer access:	Yes	185(43.2)	61(14.2)	1.64 [1.06-2.56]	1.32(1.04-2.36)
	No	118(27.6)	64(15.0)	1	1
Computer literacy:	Yes	238(55.6)	80(18.7)	2.06[1.27-3.34]	1.74[1.16-2.85]
	No	65(15.2)	45(10.5)	1	1
Management support to EMR:	Yes	130(30.4)	40(9.3)	1.60 [1.02-2.54]	1.21[1.01-2.13]
	No	173(40.4)	85(19.9)	1	1
Presence of an assigned body:	Yes	221(51.6)	87(20.3)	1.18[0.73-1.91]	0.89[0.65-1.78]
	No	82(19.2)	38(8.9)	1	1
Regular meetings on the EMR:	Yes	65(15.2)	15(3.5)	2.00[1.06-3.85]	1.68[1.04-2.64]
	No	238(55.6)	110(25.7)	1	1
Presence of EMR manual:	Yes	95(22.2)	18(4.2)	2.72 [1.51-4.92]	1.52 [1.28-3.86]
	No	208(48.6)	107(25.0)	1	1
Refreshment training on EMR:	Yes	119(27.8)	33(7.7)	2.11[1.31-3.43]	1.98 [1.65-3.02]
	No	174(40.7)	102(23.8)	1	1
Budget allocation for EMR:	Yes	58(13.6)	13(3.0)	2.17 [1.10-4.35]	1.64 [1.08-2.91]
	No	240(56.1)	117(27.3)	1	1
Raising EMR on any meeting:	Yes	32(7.5)	12(2.8)	1.11[0.53-2.38]	0.86[0.36-1.89]
	No	271(63.3)	113(26.4)	1	1
Uninterrupted electric power:	Yes	59(13.8)	13(3.0)	2.08 [1.06-4.17]	1.81[1.13-3.05]
	No	244(57.0)	112(26.2)	1	1
Access to standby generator:	Yes	204(47.7)	68(15.9)	1.73 (1.10-2.70)	1.23 [1.06-2.41]
	No	99(23.1)	57(13.3)	1	1

The presence of an EMR manual has a significant impact on EMR system use, and the study participants who have access to a manual in their working units were using the EMR system (OR=2.72, 95% CI= [1.51-4.92]) times more than those who did not have the access. On the other hand, variables such as professional category, sex, educational level, presence of an assigned body on EMR, and raising the EMR system issues on any meetings did not show a significant association on the EMR system use (Table 4).

3.6 Factors associated with the attitude of health professionals on the EMR system

Age, education level, working experience, regular meetings on EMR, computer literacy, computer access, training on EMR, knowledge on EMR, and using EMR were significant variables (p-value < 0.05) to the attitude of health professionals towards the EMR system (Table 5).

Health professionals with the age of < 30 years were about (OR=1.89, 95% CI= [1.25-2.86]) times more likely to have a good attitude towards the EMR system compared with those >= 30 years old. Health professionals having first-degree education level were (OR= 3.24, 95% CI= [1.98-5.31]) times more likely to have a good attitude towards the EMR system than Master's and above holders. Respondents having working experience on EMR, computer literacy, training on EMR, using EMR for daily tasks, and knowing the EMR system were (OR= 1.80, 95%CI= [1.13-2.86], OR= 3.30, 95% CI= [2.04-5.34], OR= 2.33, 95% CI= [1.51-3.62], OR= 2.00, 95% CI= [1.28-3.11], and OR= 2.26, 95% CI= [1.44-3.56]) times more likely to show a good attitude towards the EMR system as compared with their counterparts respectively (Table 5).

In other words, sex, position/role in the hospital, functionality of the system, presence of EMR manual, presence of an assigned body on EMR, budget allocation for EMR, management support, and presence of

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uninterrupted electric power were found non-significant variables (P-value > 0.05) on the attitude of health professionals towards the EMR system (Table 5).

Table 5. Factors associated with the attitude of health professionals on the EMR system in the hospital.

Variables	Responses	Respondents' Attitude		COR [95% CI]	AOR[95% CI]
		Good (%)	Poor (%)		
Age in years	< 30	117 (27.3)	63 (14.7)	**1.89 [1.25-2.86]**	**1.56 [1.18-2.34]**
	>=30	123 (28.7)	125 (29.3)	1	1
Sex	Male	135 (31.5)	95 (22.2)	1.26 [0.84-1.88]	0.82 [0.32-1.62]
	Female	105 (24.5)	93 (21.8)	1	1
Education level	Degree	205 (47.9)	121 (28.3)	**3.24 [1.98-5.31]**	**2.52 [1.75-4.13]**
	Master +	35 (8.2)	67 (15.6)	1	1
Working experience in years	<=6	183 (42.8)	116 (27.1)	**1.80 [1.13-2.86]**	**1.41[1.06- 2.47]**
	>6	57 (13.3)	72 (16.8)		1
Position	Professional	208 (48.6)	154 (36.0)	1.44 [0.82-2.51]	0.92 [0.48-2.35]
	Head	32 (7.5)	34 (7.9)	1	1
Computer literacy	Literate	202 (47.2)	116 (27.1)	**3.30 [2.04-5.34]**	**2.86 [1.82-4.25]**
	Illiterate	38 (8.9)	72 (16.8)	1	1
Computer access	Yes	153 (35.8)	93 (21.7)	**1.80 [1.20-2.70]**	**1.33 [1.61-2.49]**
	No	87 (20.3)	95 (22.2)	1	1
Functionality of EMR	Yes	50 (11.1)	26 (6.8)	1.64 [0.94-2.85]	0.74 [0.53-1.92]
	No	190 (44.5)	161 (37.6)	1	1
Presence of EMR manual	Yes	60 (14.0)	53 (12.4)	0.85 [0.54-1.34]	0.69 [0.28-1.29]
	No	180 (42.1)	135 (31.5)	1	1
Regular meetings on EMR	Yes	54 (12.6)	26 (6.0)	**1.81[1.05-3.12]**	**1.55 [1.03-2.85]**
	No	186 (43.5)	162 (37.9)	1	1
Assigned body to EMR	Yes	181 (42.3)	127 (29.7)	1.47 [0.94-2.30]	1.25 [0.75-2.06]
	No	59 (13.7)	61(14.3)	1	1
Trained on EMR	Yes	105 (24.5)	47 (11.0)	**2.33 [1.51-3.62]**	**2.14 [1.32-3.26]**
	No	135 (31.5)	141(33.0)	1	1
Budget allocation to EMR	Yes	44 (10.3)	27 (6.3)	1.34 [0.77-2.33]	1.16 [0.69-2.19]
	No	196 (45.8)	161 (37.6)	1	1

4 Discussion

This study mainly tried to assess the attitude towards and use of an EMR system among health professionals working in the Ayder Referral Hospital, Ethiopia. Based on this, only 240 (56.0%) and of the health professionals had a good attitude and nearly three quarters (70.8%) used the EMR system (Figure 1). The utilization is better compared with another study conducted in Addis Ababa [29] and Gondar University Referral Hospital, which was 46.5% [30]. The most probable reason for this variation may be that Ayder Referral Hospital is one of the pilot sites for EMR system for the Federal Ministry of Health and Tulane University. It thus started the service early, and the users may also be informed well earlier than in the Gondar University Hospital. The presence of a higher number of computer literate respondents in this study may be another reason to have relatively better EMR system utilization.

On the other hand, the EMR system utilization in this study (70.8%) is smaller than in study findings from Sweden and the Netherlands, where the overall EMR utilization was 90.0% and 88.0% respectively [13]. The most obvious reasons for this variation mentioned may be electric power interruption, limited standby generator access, poor maintenance, poor management support, limited trainings on EMR system, less attention to EMR and technical problems in our case. However, the utilization in our case is higher compared with study findings from Denmark (62.0%), Finland (56.0%) and Austria (55.0%) [13].

Health professionals' acceptance (56.0%) is almost the same with study findings from the Gondar University Hospital (54.0%) [30]. It is smaller than study findings from Southeast Iran [31], where 64.7% of health professionals preferred the EMR system to the paper-based one. Possible reasons for this

difference may be differences in infrastructure, computer literacy, computer access, management support and personal initiation. In other comparisons, the respondents' attitude in this study is lower than in study findings from Malawi [17] and Norway [21], where 71.0% and 81.0% of health professionals perceived that the EMR system changed the quality of healthcare services and satisfied users, respectively.

Even though various studies [23] [24] [26] [32] indicated that an EMR system is important to improve the efficiency and effectiveness of healthcare institutions, some studies stand in contrary to this by assuming that an EMR system is time consuming, creates additional workload to record data to the system, and also requires computer skills [14] [27]. The findings of the current study supported these previously mentioned issues in both directions.

As indicated by various studies, the adoption of an EMR system is varying across the world due to several reasons. The current study also identified several hindering factors which affect the attitude towards and use of an EMR system by health professionals. Age, working experience, computer literacy, computer access, regular meetings on EMR, and training on EMR were significant variables (p-value < 0.05) with health professionals' attitude towards and use of the EMR system (Tabel 4, Table 5). Respondents in the age category of <30 years old were (OR=1.89, 95% CI= [1.25-2.86]) and (OR=3.47, 95%CI= [2.18-5.51]) times more likely to have a good attitude towards and in using the EMR system compared with the rest, respectively. The reason may be that three quarters of the study participants were within the <30 years age category and computer literate/familiar with different technologies, therefore they are more eager to accept and use an EMR system to deliver their healthcare services than older groups.

Respondents who have ≤6 years of working experience had higher levels of attitude towards and use of the EMR system compared with the rest; (OR=1.80, 95% CI= [1.13-2.86]) and (OR =2.23, 95% CI= [1.31-3.82]), respectively. This finding supports the study findings from Kuwaiti, Saudi Arabian and Malawian hospitals, which showed the inverse association of working experience with the attitude towards and use of an EMR system by health professionals (as working experience increased, the attitude towards and use of the EMR systems decreased [7] [13]). The possible explanation of this finding could be the variation in the access to new technologies, computer literacy, educational level and personal initiation between younger and older staff.

Computer literacy, having regular meetings, and training on EMR system were positive contributors to change the attitude towards and use of EMR system (OR=3.30, 95% CI= [2.04-5.34]), (OR=1.81, 95% CI= [1.05-3.12]), and (OR=2.33, 95% CI= [1.51-3.62]), respectively. From different findings and logic, it is true that training can change the knowledge, attitude and skills of health professionals on EMR systems. Study findings from Iran [9], Norway [21], the Netherlands [24], Ethiopia/Gondar University [30], Iran [31], University of Texas [33], Ethiopia/Bahir Dar [34], Libya [35], WHO [36], Ethiopia/Addis Ababa [37] and Africa [38] support this conclusion.

Additionally, management support, presence of EMR manual, proper budget allocation, uninterrupted electric power and standby generator availability were significant variables to determine the utilization of the EMR system (Table 4). A possible justification to this finding could be that the presence of management support will increase supportive supervision and motivation of the staff. The EMR manual will also serve as guidance for the users and proper budget allocation will improve the refreshment training and timely system maintenance. Different evidences from various places [30] [34] [35] [36] [37] [38] also support this justification.

5 Conclusions

The majority of the respondents used the EMR system in their daily work and more than half of them had a good attitude towards it. Variables related to personal (age, working experience), technology-related (computer literacy, knowledge) and organization-related (computer access, infrastructure, training access, regular meeting, management support) factors are significant to the attitude towards and use of an EMR system by health professionals. Improving skills, awareness, infrastructure, management, and resource allocation are important interventions to improve the EMR system performance in the study area.

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Statement on conflicts of interest

The authors declare that there are no competing interests.

References

[1] International Telecommunication Union. National eHealth Strategy Toolkit. ITU; 2012. Available from: https://www.itu.int/pub/D-STR-E_HEALTH.05-2012

[2] Hughes K, Bellis MA, Tocque K. Information and communications Technologies in public health: Tackling health & digital inequalities in the information age. Liverpool: John Moores University; 2002.

[3] Davies J, Trude B, McConnell H, Ramirez R, Shields T, Drury P, Kumekawa J, Louw J, Fereday G, Nyamai-Kisia C. Improving health, connecting people: The role of ICTs in the health sector of developing countries. A framework paper. InfoDev; 2006. Available at http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2006/10/03/000090341_20061003111321/Rendered/PDF/375210Improving0health01PUBLIC1.pdf

[4] Eid M, Nuhu NA. The impact of learning culture and information technology use on knowledge sharing of Saudi students. Knowledge Management Research & Practice 2011;9:48-57. Available at: http://www.palgrave-journals.com/kmrp/journal/v9/n1/full/kmrp201025a.html

[5] Kalogriopoulos NA, Baran J, Nimunkar AJ, Webster JG. Electronic medical record systems for developing countries: Review. In: Proceedings of the 31st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); 2009 September 3-6; Minneapolis, USA. Piscataway, NJ: IEEE EMBS; 2009. p. 1730-1733. Available at: http://dx.doi.org/10.1109/IEMBS.2009.5333561

[6] Boonstra A, Broekhuis M. Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions. BMC Health Serv Res. 2010;10(1):231. Available from: http://link.springer.com/article/10.1186/1472-6963-10-231

[7] Hillestad R, Bigelow J, Bower A, Girosi F, Meili R, Scoville R, Taylor R. Can electronic medical record systems transform healthcare? Potential health benefits, savings, and costs. Health Aff. 2005;24(5):1103-1117. Available from: http://content.healthaffairs.org/content/24/5/1103.full

[8] Charles D, King J, Patel V, Furukawa MF. Adoption of electronic health record systems among U.S. non-federal acute care hospitals: 2008-2012. ONC Data Brief 2005;(23). Office of the National Coordinator for Health Information Technology; 2013. Available from: http://healthit.gov/sites/default/files/data-brief/2014HospitalAdoptionDataBrief.pdf

[9] Lium JT. Use of Electronic Medical Records and the road towards paperless hospitals in Norway: A socio-technical perspective. Doctoral thesis. Trondheim, Norway: Norwegian University of Science and Technology; 2007. Available from: http://urn.kb.se/resolve?urn=urn:nbn:no:ntnu:diva-1928

[10] Nour EiDin MM. Physicians' use of and attitudes toward electronic medical record system implemented at a teaching hospital in Saudi Arabia. J Egypt Public Health Assoc. 2007;82(5-6):347-364.

[11] Fritz F, Kebede M, Tilahun B. The need for cost-benefit analyses of eHealth in low and middle-income countries. Stud Health Technol Inform. 2014;216:981.

[12] Al-Harbi A. Healthcare providers' perceptions towards health information applications at King Abdul-Aziz Medical City, Saudi Arabia. International Journal of Advanced Computer Science and Applications. 2011;2(10):10-13.

[13] Friedberg MW, Chen PG, Van Busum KR, Aunon F, Pham C, Caloyeras J, Mattke S, Pitchforth E, Quigley DD, Brook RH, Crosson FJ, Tutty M. Factors Affecting Physician Professional Satisfaction and Their Implications for Patient Care, Health Systems, and Health Policy. Santa Monica, CA: RAND Corporation; 2013. http://www.rand.org/pubs/research_reports/RR439.

[14] Mahendra A, Mahendra A, Silabutra J, Keiwkarnka B. Midwives' intentions regarding use of electronic medical records in health centres in Lebak district, Banten province, Indonesia. J Pub Health Dev. 2011;9(3):257-271. Available from: https://www.tci-thaijo.org/index.php/AIHD-MU/article/view/1422/1148

[15] Ashtari N, Su B. A study of Healthcare Training Models for Electronic Medical Record (EMR) System Implementation. In Bastiaens T, Marks G, editors. Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education. Chesapeake, VA: Association for the Advancement of Computing in Education (AACE); 2013. p. 2189-2199.

[16] Kaye R, Kokia E, Shalev V, Idar D, Chinitz D. Barriers and success factors in health information technology: A practitioner's perspective. Journal of Management & Marketing in Healthcare. 2010;3(2):163-175.
[17] Tilahun B. Fritz F. Modeling antecedents of electronic medical record system implementation success in low-resource setting hospitals. BMC Med Inform Decis Mak. 2015;15:61. Available from: http://www.biomedcentral.com/1472-6947/15/61
[18] Davidson E, Heslinga D. Bridging the IT adoption gap for small physician practices: An action research study on electronic health records. Information Systems Management 2007;24(1):15-28. Available from: http://dx.doi.org/10.1080/10580530601036786
[19] Kamadjeu RM, Tapang EM, Moluh RN. Designing and implementing an electronic health record system in primary care practice in sub-Saharan Africa: a case study from Cameroon. Inform Prim Care. 2005;13(3):179-186.
[20] Msukwa MKB. User Perceptions on Electronic Medical Record System (EMR) in Malawi. MPH dissertation. Blantyre: University of Malawi, College of Medicine; 2011. Available at: http://docplayer.net/661872-User-perceptions-on-electronic-medical-record-system-emr-in-malawi.html
[21] Al-Azmi SF, Al-Enezi N, Chowdhury RI. Users' attitudes to an electronic medical record system and its correlates: A multivariate analysis. HIM J 2009;38(2):33-40.
[22] Omary Z, Lupiana D, Mtenzi F, Wu B. Analysis of the challenges affecting e-healthcare adoption in developing.countries: A case of Tanzania. International Journal of Information Studies. 2010;2(1):38-50.
[23] Sood SP, Nwabueze SN, Mbarika VWA, Prakash N, Chatterjee S, Ray P, Mishra S. Electronic medical records: A review comparing the challenges in developed and developing countries. In: Sprague RH Jr, editor. Proceedings of the 41st Annual Hawaii International Conference on System Sciences; 2008 Jan 7-10; Waikoloa, HI, USA. Los Alamitos, CA: IEEE; 2008. p. 248.
[24] Peek ST, Wouters EJ, van Hoof J, Luijkx KG, Boeije HR, Vrijhoef HJ. Factors influencing acceptance of technology for aging in place: A systematic review. Int J Med Inform. 2014;83(4): 235-248.
[25] Al-Nassar BAY, Abdullah MS, Sheik Osman WR. Health professionals use Electronic Medical Records System (EMR system) in Jordan hospitals. International Journal of Computer Science and Network Security 2011;11(8):112-118. Available from: paper.ijcsns.org/07_book/201108/20110815.pdf
[26] Mengesha T. Electronic solutions for Ethiopian health sector: Electronic medical record (EMR) system. Bachelor's thesis. Oulu, Finland: Oulu University of Applied Sciences; 2011. Available from: https://www.theseus.fi/bitstream/handle/10024/36264/Mengesha_Tewodros.pdf?sequence=1
[27] Gebre-Mariam M. Exploring Challenges in Patient Monitoring and Clinical Information Management of Antiretroviral Therapy (ART) and the Perceived Usefulness of Electronic Medical Records (EMR system) in HIV Care in Ethiopia. MSc thesis. Ontario, Canada: Western University; 2010. Available from: https://dspace.library.uvic.ca/bitstream/handle/1828/2616/MikaelGebre-Mariam%20Thesis%202010%20(Final).pdf?sequence=1
[28] WHO. Patient monitoring guidelines for HIV care and antiretroviral therapy (ART), 2005. Available from: http://www.who.int/hiv/pub/guidelines/patientmonitoring.pdf .
[29] Tilahun B, Fritz F. Comprehensive evaluation of electronic medical record system use and user satisfaction at five low-resource setting hospitals in Ethiopia. JMIR Med Inform 2015;3(2):e22
[30] Biruk S, Yilma T, Andualem M, Tilahun B. Health professionals' readiness for electronic medical record system in case of three hospitals in Ethiopia: Cross sectional study. BMC Med Inform Decis Mak. 2014;14:115. Available from: http://www.biomedcentral.com/1472-6947/14/115
[31] Alipour J, Erfannia L, Karimi A, Aliabadi A. Electronic health record acceptance: A descriptive study in Zahedan, Southeast Iran. J Health Med Inform. 2013;4:120. doi:10.4172/2157-7420.1000120
[32] Dimitrovski T, Ketikidis P, Lazuras L, Bath PA. Adoption of Electronic Health Records (EHRs): A review of technology acceptance studies. In: Proceedings of the 16th International Symposium on Health Information Management Research ISHIMR; 2013 June 26-28; Halifax, Nova Scotia, Canada. Available from: http://www.seerc.org/refbase/files/dimitrovski/2013/771_Dimitrovski_etal2013.pdf
[33] Singh B, Muthuswamy P. Factors affecting the adoption of electronic health records by nurses. World Applied Sciences Journal 2013;28(11):1531-1535. Available from: http://www.idosi.org/wasj/wasj28(11)13/8.pdf
[34] Andualem M. Information needs and seeking behaviour among health professionals working at public hospital and health centres in Bahir Dar, Ethiopia. BMC Health Services Research 2013;13:534. Available from: http://www.biomedcentral.com/1472-6963/13/534
[35] Mohamed-Arraid A. Information needs and information seeking behaviour of Libyan doctors working in Libyan hospitals. Doctoral thesis. Leicestershire, UK: Loughborough University; 2011. Available from: https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/8791
[36] WHO Regional Office for the Western Pacific World Health Organization. Electronic Health Records: Manual for developing countries. Geneva: WHO; 2006. Available from: www.wpro.who.int/publications/docs/EHRmanual.pdf
[37] Lemma I. Assessment of access to health information resources among HPs working in HIV/AIDS and family health units of public health centers in Addis Ababa. MSc thesis. Addis Ababa: Addis Ababa University; 2009.
Ojo T. Communication networking: ICTs and health information in Africa. Information Development 2006;22(2):94-101. Available from: http://idv.sagepub.com/content/22/2/94

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Modelling Software Agents: Web-Based Decision Support System for Malaria Diagnosis and Therapy

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Background and Purpose: The aims of our research as presented in this paper consist of formalizing the design of software agents and demonstrating its practicability in a web-based medical decision support system specifically for malaria diagnosis and therapy to assist healthcare professionals at medical consultation in order to optimize the quality of care of the patients with the malaria disease.
Methods: The Software Agent System proposed is a functional model based on a contractual specification as the awareness of an agent in pursuing its goals and executing tasks. The agents are designed according to the requirement for an effective diagnosis and delivering the therapy strategies for malaria as per the supplied sign-symptoms and laboratory test results.
Results: The contribution of our work is mainly the contractual specification, a λ contract. As we demonstrate in the scenarios presented as results, the contract ensures the behaviour of the agents in achieving their goals and executing tasks.
Conclusions: The Software Agent System is adopted to cope with a complex and dynamic domain such as medicine and specifically the web-based medical decision support system for malaria diagnosis and therapy of the Optimization of Malaria Treatment (OMaT) system. Our proposed functional model facilitated the implementation of the SA. Specifically, we point out the fact that a λ contract can ensure the consistency and the credibility of the reasoning of the software agent.

Keywords: Software Agents, Functional Model, Contractual Specification, Medical Decision Support

1 Introduction

The healthcare problems facing developing countries are great. For a long time, malaria is one of the most challenging infectious diseases caused by the parasite called Plasmodium and localized in areas of Central and South America, Asia and Africa. Malaria should be considered a potential medical emergency and should be treated in time. Delay in diagnosis and treatment is a leading cause of death. Thus, the technical capability to perform a correct and a timely diagnosis, with an appropriate treatment of the malaria infection in an ill patient is of critical importance in endemic regions, specifically in rural or isolated areas.

Medical decision support systems [1-4] based on eHealth and mHealth can be used to serve the unserved. [5]

The eHealth revolution in Africa is the main and most suitable vehicle for optimizing the quality of care and reducing the large amount of death being caused by infectious diseases such as malaria where specialists are not available.

"*Developing the advanced care services raises new challenges in terms of modelling, infrastructures, supports tools, and the very understanding of telecaring networks and its operating rules.*" [6]

As stated in [7], "*software agents are a computer software technology that provides a powerful new method for solving complex problems and implementing complex systems*". Also in [8], "*the motivations for the use of agents in the medical domain consist of the multitude of aspects that the agents can analyze during the diagnostics elaborations and the realization of different medical tasks. Agent-based approaches may integrate and extend different problem solving technologies.*"

Our study, as presented in this paper, consists of formalizing the design of software agents and demonstrating its practicability in a web-based medical decision support system specifically for malaria diagnosis and therapy to assist healthcare professionals at medical consultation in order to optimize the quality

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of care of the patients with the malaria disease. The contribution of our work is mainly the contractual specification, a λ contract, as the awareness of an agent in pursuing its goals and executing tasks.

2 Materials and methods

The core piece in our research remains software. Software is a term employed for the various kinds of programs for the operations of computers and related devices. It is covered in software engineering that is a Computer Science discipline dealing with the studies of the methodologies to design and to build software. The process of software development is to translate requirements into code.

A piece of software which performs a given task using information learned from its environment to act in a suitable manner so as to complete the task successfully, is a called a software agent. The environment includes humans, computers, devices, operating systems, computer applications, databases, networks, and virtual domains.

"*Several researchers are working towards the standardization of agent technologies and in the realization of development environments to build agent systems. Such development environments provide some predefined agent models and tools to make easy the development of systems.*"[9]

In the point of view of medical software development, we pay attention to the software requirement specification standard IEEE 830-1998 [10] and medical software design standard IEC 62304 [11].

We also refer to the potential and application of agents in healthcare environment that have been discussed in [12-16]. Mainly, we take in account the survey of agent-based intelligent decision support systems to support clinical management and research, presented by Foster et al. [17].

Our Software Agent System is adopted to cope with a complex and dynamic domain such as medical industry. Specifically, our software agents, developed under the project "Optimization of Malaria Treatment" (OMaT) [18], are focussed on a web-based medical decision support system for malaria diagnosis and therapy. They are designed according to the requirement as described in the consensus guidelines [19] and protocols for the management of malaria [20] for effective diagnosis and delivering the therapy strategies for malaria as per the supplied sign-symptoms and laboratory test results.

2.1 Functional model of software agents (SAs)

In the following lines, the functional model of the software agent is presented to provide an overview of the system.

Definition 1: Software agent (SA)

Software agents are a set of computational entities that exists in the form of a set of programs or components that runs on a dedicated server and can interact with external components. They act with minimal intervention from humans. They can require special and punctual collaboration with other embedded agents in pursuing their goals and executing tasks.

SAs are divided into two parts: code component ζ and data component Κ. Code component can be activities, services and applications that may act both as callers and as called. Data component is a content provider. It is passive and only receives calls. Code component is a set of actions that can perform on the data component.

Software agents pursue goals or carry out tasks in order to meet their design objectives. The main objectives related to the SA which acts in the OMaT system are to provide an interaction mechanism with a healthcare practitioner (HCP) and to generate diagnosis and to suggest treatments. This is the general context of use of our SAs and their specialization.

In doing so, this is considered as a multiple objective-constrained optimization problem. The purpose, on the one hand, of the optimization problem is to evaluate a solution alternative according to multiple criteria. On the other hand, the constraint in the objective optimization problem means that if O is reachable the f(c) is supported by some proof system. Thus, we define a λ contract as our proof system.

SA is defined as the following:

$$\text{SA: } \langle \zeta, K \rangle \qquad (1.1)$$

where ζ is set of code component, K is a set of data component.

The specification of the SA is the following:

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$$SA:: = c_0 \mid c_1 \rightarrow c_2 \mid c_1 \leftrightarrow c_2 \mid c_1 © c_2 \qquad (1.2)$$

where

(i) c_0 a stand alone application.
(ii) $c_1 \rightarrow c_2$, denotes that the application c_1 calls the application c_2, in other words it means the application of c_1 followed by the application of c_2.
(iii) $c_1 \leftrightarrow c_2$ means that the application of c_1 can be run in parallel with that of c_2.
(iv) c* is the complement of the application c.
(v) $c_1 © c_2$ means that the application of c_2 is embedded to that of c_1.
(vi) | denotes the alternative states of the system.

Definition 2: Code component

A code component ζ is defined as:

$$\zeta(\varphi, \kappa, \nu) = (d_n, t_n) \qquad (2.1)$$

where ζ is a code component that performs φ actions with the set of input value *v* concerning a particular patient in a data component *K*. ζ returns information regarding disease *d* and therapy strategy *t* on the basis of following relations:

$$\Delta : 2^{(k,v)} \rightarrow D, \text{ (many-to-one relation)}, \quad (2.2)$$

$$D = \{d_1, d_2, \ldots, d_n\}, \; d \in D$$

where D is a set containing treatable diseases and/or types of malaria, *d* is the diagnosed symptom and/or species of Plasmodium; and,

$$\Gamma : D \rightarrow T \text{ (One-to-one relation)}, \qquad (2.3)$$

$$T = \{t_1, t_2, \ldots, t_n\}, \; t \in T$$

where T is a set containing different therapy strategies, t is a suggested therapy.

Definition 3: Action

Action is defined as a composition of a set of atomic tasks. Consider the following action structure:

$$A ::= \varepsilon \mid a_0 \mid a_1 a_2 \mid a_{1\rightarrow} a_2 \mid a^* \qquad (3.1)$$

where

(i) ε is the empty action or a standard alone action.
(ii) a_0 denotes a finite or countable infinite number of basic actions that needs further construction.
(iii) $a_1 a_2$, the concatenation of actions a_1 and a_2 means the action of a_1 followed by the action of a_2.
(iv) $a_1 \rightarrow a_2$ means that the action of a_1 can be replaced by that of a_2.
(v) a* is the complement of the action a.
(vi) | expresses alternative state of the system.

Definition 4: Optimization

The purpose of the optimization problem is to evaluate alternative solutions according to multiple criteria.

$$\begin{aligned} &max\{f_1(c)=o_1\} \\ &max\{f_2(c)=o_2\} \\ &\ldots \\ &max\{f_k(c)=o_k\} \end{aligned} \qquad (4.1)$$

where *f(c)* is the objective function, *o* is the highest objective function value.

Definition 5: λ contract

The achievement of the goal pursued by the agent with awareness is sustained by a proof system called a λ contract.

The idea of a contract is borrowed from those related to human activities where there are commonly two parties; a provider, which performs some task for the other, a client.

The model of the contract used is developed in [21]. Thus applying to software agents, a contract leads to the interaction between applications or functions into an application. Ideally, a contract should cover all essential functional and non-functional aspects of an application.

The specification of a contract can contain in general the following pieces of information:

a. Operation semantics describe each operation using: - Informal text, - pre/post condition, - invariant

b. Interface protocol provides the constraints on the order in which operations may be called.

c. Service level covers guarantees regarding the qualities or non-functional requirements such as: timing constraints, network availability, data safety for persistent state, capacity, security and performance. This information can be introduced in one of the following basic element of the contract:

Request-response protocol

Data-field
Execution-information
Message
Message-client
Message-provider

Context
Results

The request-response protocol is transactions divided into two parts, contracted and contractor, one for requests and the other for responses. Transaction data-fields are used for performing two kinds of data-fields: the execution information that controls the execution of the transaction, and the message addressed to the contracted or the contractor. Furthermore, the request-response protocol, in the SA, facilitates easier integration of non-functional requirements with functional requirements. The context determines actions performed by the agent. The result is the achievement of the goal pursued by the agent.

3 Results

We had the objectives to formalize the design of software agents and to demonstrate their applicability to a web-based medical decision support system. This was possible by the prototype that we designed and implemented under the name “OMaT” [22].

The prototype was developed using PHP, XML, HTML, JavaScript and CSS as front end and raw files, MySQL and NoSql data base as the backend. The proposed solution in the form of web applications includes a generic medical decision support system and is expected to assist healthcare professionals at medical consultation and decision of the patients with the malaria disease. It contains five basic components that constitute the main menu: newCase Agent, openCase Agent, iLaboratory Agent, GIS Agent and Knowledge Repository (KR) Agent.

We describe only the component newCase to point out the use of our model, specifically the contract. The component newCase is a succession of sub-components namely: newCase1, newCase2, newCase3, and newCase4. The newCase1 sub-component allows the HCP to supply first information on the clinical examination. The newCase2 sub-component generates a report of clinical diagnosis and allows the HCP to supply secondly information on the laboratory test. The newCase3 sub-component generates the report of diagnosis, the symptomatic report and the report of therapy strategies. It also allows the HCP to write his own medical prescription based on the reported information. The newCase4 sub-component allows the HCP to download a file in the form of an electronic medical record (csv format), to print the medical decision report, and to receive it in an email.

In the following, we emphasise the use of the contract by pseudo code-based PHP to illustrate the implementation of different agents acting for the medical decision support.

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3.1 Usage scenario of the λ contract by the software agents

The specification of the OMAT system is:
OMAT ::= Login → Menu
Menu ::= newCase | openCase | iLab | GIS | KR
newCase ::= newCase1 → newCase2 → newCase3 → newCase4
newCase1 ::= newCase1 | GIS | KR
newCase2 ::= newCase2 | iLab | KR
newCase3 ::= newCase3 | KR
newCase4 ::= storage | print | sendEmail
where GIS is a Geographic Information System, KR is a Knowledge Repository and iLab is a Remote

1° Contract to guarantee action of calling another Agent
newCase1 Agent side:

```
1. <?
2. # OMAT SYSTEM
3. # newCase1 AGENT
4. ## Request-response protocol
   5. session_start();   //Set a self control of the system
6. while(($userNameSystem=$userNameInput) and
7.   ($passWordSystem=$passWordInput))
8.   {
9.      count++; // Try again
10.     if ( count>5)
11.       {
12.           echo "Login Failed!";
13.           echo "<script>window.close();</script>";
14.           exit;
15.       }
16.  } endwhile
17. ## Context
    18.  Input Values in newCase1 form
19. // Enter Patient Profile Data: Sex, Age, Weight,
      Country, …,
20.  // Enter Signs/ Symptoms Data
21.    ...
22. ## Results
23.    // Submit data value to newCase2
24.   Submit();
25.       ...
26  ?>
```

2° Contract to guarantee action of calling another Agent and to express optimization problem
newCase2 Agent side:

```
1. <?
2. # OMAT SYSTEM
3. # newCase2 AGENT
4. ## Request-response protocol
5. session_start();   //Set a self control of the system
6. while(($userNameSystem=$userNameInput) and
7. ($passWordSystem=$passWordInput))
8. {count++; // Try again
9.   if ( count>5)
10. { echo "Login Failed!";
11.   echo "<script>window.close();</script>";
12.   exit;}
13.} endwhile
14. // verify required information posted by newCase1
15. if(empty($_POST['listOfInputValue']))
16. { // Missing some information
18.   $errors = "These values are required:".$listOfValuePost;
19.   setcookie('$errors ', $Errors);
20.   // Return to newCase1
21.  echo "<script>window.location='../newCase1.php'</script>";
22.   exit;
23. }
24. ...
25.   $patientStatus; $signSymptoms;
26. ## Context
27. function checkTestSymptom($hypothese) {
28.   switch($signSymptoms)
29.    {
30.      case 1: $hypothese="Uncomplicated Malararia"
31.      case 2: $hypothese="Complicated Malararia"
32.      case 3: $hypothese="Others diseases"
33.    }
34.   }
35. function checkTreatSymptom() {
36.   switch($patientStatus)
37.   { ///Following symptoms/signs
39.   case 1: $treatSymptom= typeofTreatSymptom1;
38.          ...
39.   case m: $treatSymptom= typeofTreatSymptomm;
40.   }
41. }
42. ...
43. // Input Values in newCase2 form
44.      ...
45. // Laboratory test
46. // Possiblity to call iLab
47. ## Results
48. // Generates a Clinical Diagnosis Report
49. // Submit data value to newCase3
50. Submit();
51. ...
52. ?>
```

4 Discussion

The software agent system is adopted to cope with a complex and dynamic domain such as medicine and particularly the web-based medical decision support system for malaria diagnosis and therapy of the OMaT system.

Our clinical decision support system for the treatment of malaria is based on consensus guidelines and protocols for the management of malaria. Thus, our system only deals with information theory and medical practice identified in advance, limited and structured so for its efficiency and completeness. This constitutes the knowledge base of the software agent.

The proposed functional model facilitated the implementation of the SA. Specifically, the λ contract ensures the consistency and the credibility of the reasoning of the software agent.

Experiments on a set of test cases were performed. The results observed in our experiments were satisfactory. The system can generate diagnosis based on signs/symptoms and can advise treatment automatically in real time.

To demonstrate and to illustrate the application of our functional model, we presented two agents: the newCase1 agent and the newCase2 agent. The newCase1agent allows the HCP to supply the first information on the clinical examination. Based on the information supplied by the newCase1 agent, the newCase2 agent can analyse it and can generate a clinical diagnosis report. This will allow the HCP to supply other information for the purpose of the laboratory test.

The “Contract 1° expresses on line 24 the definition 1 where the newCase1 agent calls the newCase2 agent. The “Contract 2° expresses on lines 6 to 23 the definition 1 where the called newCase2 agent reacts to the call of the newCase1 agent. Also, the “Contract 2° expresses on lines 27 to 40 the definition 2 where the newCase2 agent acts and generates a clinical diagnosis.

Our system uses a request/response protocol in which it can receive information from the user or other agents and can respond or react.

The quality of the system depends on the reliability of the information entered, protection against handling errors and lack of dangerous results. Therefore, the human - machine interface that we have proposed is quite responsive and easy to use to facilitate the work. A click allows the user to enter data.

References

[1] Zvarova J, Heroutova H, Grünfeldova H, Zvara H. Empowering clinicians by eHealth technologies in decision-making tasks. In: Adlassnig K-P, editors. Medical Informatics in a United and Health Europe. MIE; 2009 August 30 - September 2; Sarajevo, Bosnia and Herzegovina. IOS Press; 2009. p. 683-687. Available from: http://www.researchgate.net/publication/26803658_Empowering_Clinicians_by_eHealth_Technologies_in_Decision-Making_Tasks

[2] Tribus M. Rational Descriptions: Decisions and Designs. New York: Pergamon Press; 1969.

[3] White DJ. Fundamentals of Decision Theory. New York: North-Holland; 1976.

[4] Karni E. Decision Making under Uncertainty: The Case of State-Dependent Preferences. Cambridge (MA): Harvard University Press; 1985.

[5] Akter S., Ray P. mHealth - an Ultimate Platform to Serve the Unserved. Yearb Med Inform. 2010; 94-100.

[6] Guevara-Masis V, Afsarmanesh H, Hertzberger LO. An agent-based federate information system for telecare environments. In: Proceedings of the International Special Topic Conference on Information Technology Applications in Biomedicine (ITAB); 2006 October 26-28; Ioannina, Greece. IEEE Engineering in Medicine and Biology Society; 2006. Available from: http://www.vl-e.nl/Publications/SP2.4_c.pdf

[7] Imène B, Noria T. A multi-agent framework for a web-based decision support system applied to manufacturing system. In: Amine A, Aït Mohamed O, Elberrichi Z, editors. CIIA'09. Proceedings of the 2nd Conférence Internationale sur l'Informatique et ses Applications; 2009 May 3-4; Saida, Algeria. Available from: http://ceur-ws.org/Vol-547/86.pdf

[8] Iantovics B. Intelligent agent-based medical systems. Scientific Studies and Research. Series Mathematics and Informatics. 2009;19(2):289-300. Available from: http://pubs.ub.ro/dwnl.php?id=SSRSMI200902V19S01A0023

[9] Bellifemine F, Poggi A, Rimassa G. JADE – A FIPA-compliant agent framework. In: Proceedings of Practical Applications of Intelligent Agents and Multi-Agents; 1999; London, UK. p. 97-108. Available from: http://sharon.cselt.it/projects/jade/papers/PAAM.pdf

[10] IEEE Computer Society. IEEE Recommended Practice for Software Requirements Specifications. IEEE Xplore: 830-1998 - 1998;1-40. Available from: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=720574

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[11] Hall K. Developing medical device software to IEC 62304. European Medical Device Technology. 2010;(1(6). Available from: http://www.emdt.co.uk/article/developing-medical-device-software-iso-62304
[12] Nealon J, Moreno A. Agent-based application in health care. In: Moreno A, Nealon JL, editors. Applications of Software Agent Technology in the Health Care Domain. Basel: Birkhäuser; 2003. p. 3-18.
[13] Fox J, Glasspool D, Modgil S, Tolchinksy P, Black L. Towards a canonical framework for designing agents to support healthcare organizations. In: 4th Workshop on Agents Applied in Health Care in conjunction with the 17th European Conference on Artificial Intelligence, ECAI 2006; Riva del Garda, Italy; 2006 August 29 – September 1. Available from: http://www.lsi.upc.edu/~tolchinsky/publications/fox-glasspool-et-al.pdf
[14] Chang L, Ding J, He X, Shatz SM. A formal approach for modeling software agents coordination. In: 4th International Workshop on Agent-Oriented Software Development Methodology (AOSDM); 2008 July 22-24; Glasgow, UK. Available from: http://www.cs.uic.edu/~shatz/papers/aosdm08.pdf
[15] Hermans B. Intelligent software agents on the Internet: An inventory of currently offered functionality in the information society & a prediction of (near-) future developments. First Monday 1997;2(3). Available from: http://firstmonday.org/ojs/index.php/fm/article/view/514/435
[16] Yu H, Shen Z, Miao C. Intelligent software agent design tool using goal net methodology. In: Lin TY, Bradshaw JM, Klusch M, Zhang C, Broder A, Ho H, editors. Proceedings of the 2007 IEEE/WIC/ACM International Conference on Intelligent Agent Technology; 2007 Nov 2-5; Fremont, Canada. IEEE; 2007. p. 43-46.
[17] Foster D, McGregor C, El-Masri S. A survey of agent-based intelligent decision support systems to support clinical management and research. In: Proceedings of the Fourth International Joint Conference on Autonomous Agents and Multiagent Systems; 2005 July 25-29; Utrecht, Netherlands. New York, NY: ACM; 2005. p. 16-34. Available from: http://www.diee.unica.it/biomed05/pdf/W22-102.pdf
[18] Muteba Ayumba E. Towards networked eHealth: OMaT project (phase I). J Health Inform Afr. 2014;2(1):18-29. Available from: http://dx.doi.org/10.12856/JHIA-2014-v2-i1
[19] World Health Organization. Guidelines for the Treatment of Malaria, Second edition. Available from: http://whqlibdoc.who.int/publications/2010/9789241547925_eng.pdf
[20] Muteba Ayumba E. Optimization of medical decision: An approach of medical decision analysis. Eur J Biomed Inform. 2014;10(1):2-5. Available from: http://www.ejbi.org/img/ejbi/2014/1/Muteba_en.pdf
[21] Muteba Ayumba E. Contractual specification of component using virtual interface. In: Proceedings of the 1st International Technology, Education and Environment Conference; 2011 September 5-8; Omoku, Nigeria. Bahawalpur, Pakistan: Human Resource Management Academic Research Society (HRMARS) and Accra: Ghana: African Society for Scientific Research (ASSR); 2011. p. 293-300. Available from: http://hrmars.com/index.php/pages/detail/Proceeding2
[22] OMAT Project [Internet]. Kinshasa, DR Congo: MAESOFT; [cited October 2015]. Available from: http://www.maesoft1.co/services.html

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