# Making the Case for Business Process Re-engineering in Health Informatics

## *Focusing on MDRTB in South Africa*

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Abstract: The potential misalignment between new technologies entering healthcare requires attention. This paper will compare the fit between an Open Source Electronic Medical Record Solution (OpenMRS) and a clinical guideline that outlines the requirements for the care of a patient. Design/methodology: A process analysis technique is used to construct and analyse the fit between the processes as stipulated by the South African clinical guidelines for Tuberculosis (TB) and that of the OpenMRS. This technique has been used to identify inefficiencies and opportunities. Lean principles are applied in the analysis to identify waste in the process. Findings: Process analysis has provided valuable insight into the working of both the system and the provision of this healthcare service. The OpenMRS solution has a good fit to the South African healthcare context with some minor gaps between the system processes and that of the clinical guidelines. In addition, wasteful tasks have been flagged within the clinical guideline processes which appear to be due to limited consideration being paid to the patient's end-to-end care process.

## 1 INTRODUCTION

The Internet revolution has resulted in exciting new information systems with the potential to improve healthcare (Haux, 2006). The challenge of an aging population and an increase of chronic illnesses like diabetes and heart disease have placed demands on healthcare service to deliver radical change. In addition, disease burdens such as HIV/AIDS have forced the health care industry to rethink their service offering. This study uses as its context the healthcare approach to Multi-Drug Resistant Tuberculosis (MDRTB) because a high rate of co-infection of Tuberculosis and HIV/AIDS has been noted in the last decade, in South Africa. There has also been an extensive drive to curb the incidence of both these communicable diseases during the same period (WHO, 2009). Unlike HIV/AIDS, TB or MDRTB is a curable disease given the correct medication and adherence to treatment guidelines by both the patient and the healthcare workers. The potential to improve diagnosis and treatment of MDRTB as a result of employing a process engineering intervention could have a meaningful impact.

There is a critical collaborative relationship between technology, people and the tasks they perform (Elske et al., 2006); (Tsiknakis and Kouroubali, 2009). This relationship has received limited research attention in the healthcare domain. This is important because merely implementing a Health Information Systems (HIS), without revisiting the business process and its context, cannot solve challenges and improve inefficiencies (Berg and Toussaint, 2003); (Ludwicka and Doucettea, 2009). This study explores the practical use of process engineering in healthcare services, thus assessing the process itself and how it can inform the development of HIS.

## 2 LITERATURE

The literature survey discusses the research conducted in Process Management in healthcare, over the last sixteen years (1994 – 2011). The discussion focuses on five areas, namely: the challenges in the implementation and adoption of HIS, the process management approach, the


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application of process management in healthcare, MDRTB as a public healthcare crisis and the origins of OpenMRS.

## 2.1 Challenge of HIS Implementations

Heeks (2006) has identified 7 gaps between what is specified in the design of a health information solution and what is actually delivered in reality. These gaps, identified as the cause for poor adoptions and implementation of HIS, are; Information, Technology, Process, Objectives and value, Staffing and skills, Management systems and Structures and other resources (Heeks, 2006). "Process" is identified as a gap because the solution often focuses on the data in isolation from the healthcare delivery process in which the data is embedded, and associated users,. The importance of addressing this gap is also stressed by Ludwicka and Doucette (2009) and Munir and Kay (2005).

## 2.2 Process Management

As technology has become ubiquitous organisations have realised that both technology and the streamlining of their businesses' processes is required to develop competitive advantage and improve performance (Trkman, 2010).

Process transformation can be seen to have occurred in four waves over the last forty years with each wave inheriting the best aspects of its predecessor. Wave one, dominated by Total Quality Management (TQM) focused more on customer facing processes and little was achieved in back office improvements (Towers, 2010). In wave two the focus shifted to Business Process Re-engineering (BPR) calling for the fundamental rethinking and redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance such as cost, quality, service and speed (Muthu et al., 1999). The third wave, triggered by the Lean management technique, saw the focus shift to customer needs, reduction of waste and value creation with the focus shifting toward simultaneously reducing cost and improving revenue and service (Towers, 2010). The fourth wave (post 2000) embraces a myriad of traditional techniques with a strong focus on successful customer outcomes (Towers, 2010).

## 2.3 Applications of Process Engineering in Healthcare

Bergman (1994) suggested the introduction of re-engineering in healthcare and within a decade some traction in this idea is evident: A study by Anderson et al. uses the design of processes to determine the best way to develop HIS to meet user requirements (Andersson et al., 2003); Berg and Touisant(2003) realised the mapping of processes allowed the "fluid" nature of medical knowledge to be easily expressed; and Lenz and Khun (2004) aim to align HIS and healthcare processes, by defining a layered approach that allows for quick deployments using an integrated "generator tool", used extensively at the university hospital at Marburg Germany. A similar approach was proposed by researchers in Finland in an effort to design web services for a generic HIS using a service orientated architecture approach (Mykka¨nen et al., 2007).

In a systematic review of evidence based re-engineering in healthcare 87 articles from 1989 to 2003 were analysed (Elkhuizen et al., 2006). They identify two main weaknesses in this research field: Firstly, there are few studies focusing on negative results of process management and, secondly, a large number of health improvement projects are being performed by private companies who do not have a vested interest in publishing this work(Elkhuizen et al., 2006). However, this is beginning to change as private companies are publishing results of the process re-engineering work they have done (Hartung and Biglin, 2010).

TQM is seen as inadequate to address the challenges experienced due to the inherent complexity of healthcare (Patwardhan and Patwardhan, 2008). On the other hand, process engineering is being seen as an appropriate technique as it provides an understanding of the impact and influence of the process on people and technology (Lenz and Kuhn, 2004, Elkhuizen et al., 2006, Boston-Fleischhauer, 2008b, Patwardhan and Patwardhan, 2008, Trkman, 2010).

Little research is available for healthcare process management both in SA and other developing countries. Vine (2007) suggests the South African health care processes are "fundamentally broken" (Gerntholtz et al., 2007) and thus research in this area is much needed. SA's boldest attempt to implement an EMR solution across all government hospitals in Limpopo, failed in 1998. Healthcare workers were inadequately prepared and a lack of attention to the intent of processes and their unique application in South Africa appear to have played a role in this failure (Littlejohns et al., 2003). However, by first improving the process before automating it , led to a successful Electronic Medical Record implementation in the renal department of

Chris Hani Baragwanath Hospital (May 2005) (Gerntholtz et al.,2007). Thus process re-engineering does seem to suggest one possible way forward.

### 2.4 Patient Centred Process Management

It is however necessary to consider where the focus of such process reengineering needs to be placed. There are two "user" groups who will benefit from a HIS; the staff of the medical facility and the patients. As the patient is in fact the "customer" in these systems, the focus on patient centred care is becoming a trend in the healthcare industry (Tsiknakis and Kouroubali, 2009). By understanding that the patient is the focal point in the healthcare system, it becomes evident applications of process engineering should be patient centred (see for example Francis and Alley (1996) and Pickles et al. (2008)

### 2.5 Open MRS Origins

One of the most widely used Open source EMR solutions in Africa is OpenMRS (Seerbregts et al., 2009); (Tierney et al., 2010). OpenMRS is designed using international standards (HL7, DICOM, and LOINC) for interfacing and development to support portability and interoperability of the solution and universal deployment. The OpenMRS MDRTB module that is being reviewed in this study was developed to provide an intuitive "front end" to support the treatment of MDRTB for World Health Organisation (WHO) sponsored projects (Thomas, 2008). The module can be customised with some medium to high level computer skills for specific geographical or treatment requirements (Choi and Fraser, undated). OpenMRS positions itself as a means to enable and empower developing countries to improve the healthcare administration and thereby the standard of care of patients. To date OpenMRS has been deployed in Kenya (2001), Tanzania (2008) Rwanda (2008), South Africa (2006), and Uganda (2007) (Seebregts et al., 2006); (Frasier et al., 2008); (Tierneya et al., 2010).

### 2.6 MDRTB

MDRTB is a strain of tuberculosis where the bacteria are resistant to two or more of the drugs used to treat TB, in particular isoniazid and rifampicin (WHO, 2010). MDRTB has developed as a result of patients' poor compliance to their tuberculosis treatment regimens. There have been attempts to address the improvement of the treatment of TB patients with the Direct Observation Treatment Short-course (DOTS). DOTS aims to provide a patient centred care framework, whereby the patient is provided with the necessary support such as; travel arrangements to the clinic and active participation of community care workers, to ensure adherence with the treatment regimen (2009).

In South Africa many patients die before an MDRTB case is confirmed, as a result of the turnaround time in conducting these diagnostic tests(O'Donnell et al., 2009). It is often more beneficial in suspected cases to begin MDRTB treatment, while a diagnosis is being conducted. While MDRTB patients require hospital based treatment they are often turned away due to the limited capacity at the hospitals and the high prevalence rate, this often creates a risk of the disease spreading more widely in the community(Seung et al., 2009). In addition there is a high rate of co-infection of MDRTB and HIV(WHO, 2010). Once again one of the major drivers for the escalations of death among HIV positive patients is the time to confirm the MDRTB diagnosis of the patient(Seung et al., 2009). Another concern in treating an MDRTB patient who is co-infected with HIV is the potential drug interaction conflict (Cohen and Maarstens, 2004).

In summary: Once the technology becomes accessible and reliable, the challenge lies in the fit between the two dimensions of adoption: Firstly, the task to be performed and the technology being employed to achieve it and secondly, the user performing the technology-enabled task and the task to be performed (Elske et al., 2006). As highlighted earlier by process transformation waves, greater attention is being given to the individual who derives value from the execution of the process.

## 3 METHODOLOGY

There has been little research on process analysis in the developing world context (Harrison, 2009). A qualitative methodology was thus adopted in order to "raise awareness and increase insight" (Hancock, 2002). The research study is grounded in the FITT theoretical framework (Elske et al., 2006). This model explicitly looks at three dimensions and the relationship between each: (1) User and Technology, (2) Task and Technology and (3) User and Task. While the focus of the methodology is on the task and the technology fit, it aims to do so while also considering implications for users in terms of their

fulfilment of tasks and use of technology.

The study was conducted in four phases. This is illustrated in figure 1. The first phase focused on the creation of process models based on the SA clinical guidelines and the OpenMRS MDRTB module using Business Process Modelling Notation (BPMN) (White, 2004). The procedures in the guidelines (2009d) were translated into business processes. The tutorial from the OpenMRS MDRTB module (Thomas, 2008) together with an out-of-the-box installation were used to create process models that represent how the health information system should be used to manage the data of patients diagnosed with and treated for MDRTB.

A business process model visually illustrates the sequence of tasks completed to achieve the organisations objective. Each task is detailed in a rectangular shape starting with a verb to focus on the action taken. In order to achieve both a big picture and finer grained view of processes; a process is sub-divided into sub-processes. Each Sub-process is then decomposed into a process map. The process rules are represented by "gateways" (a diamond shape symbol). The process is contained by a start point and end point marked by circle shapes at either end of the process. The starting point indicates the trigger that sets off the process and the end points indicates the attainment of the organisation's objective. BPMN is a well-used technique for illustrating process models in a simple and easily understandable manner. The process goal for each process is determined based on the understanding of the objective of the guideline. The process goal is used to evaluate whether each task in the process is contributing to the process goal.

During the second phase the analysis of the process models provided insight into inefficiencies, and the alignment of the process as prescribed by the clinical guidelines and the technology solution as provided by OpenMRS.

In the third phase of the study, experts were engaged in a discussion on the analysis derived in phase 2. These experts were identified by creating a list of authors from the literature review conducted and assessing their potential involvement based on the following criteria: (1) Published research related to OpenMRS deployment in Africa or South Africa in the past five years, (2) Member of the OpenMRS Implementers' Community for the past three years, (3) Published research related to TB or MDRTB from a South African perspective in the past five years, (4) Currently or previously a clinician, and (5) availability of an email address.

The participants group consisted of 28 experts; 15 individuals responsible for implementing EMR solutions and 13 clinicians practicing or researching in the field of TB and MDRTB. These experts were consulted to provide judgment on the process analysis provided using the Delphi technique. An email was sent to 28 participants (11 Clinician & 16 OpenMRS implementers) identified to participate in the study, requesting them to participate. The email explained the objectives of the study and their role in the study. 7 Participants responded confirming their participation in the study within a two week period (4 clinicians and 4 OpenMRS implementers). As the timelines for data collection had already been agreed with those who had agreed to participate, it was not possible to delay the study further in order to attempt to secure additional participants. Of the original 28 experts approached to participate in the Delphi study; Only 5 of the 7 participants who responded within two weeks of the request, provided responses to the first round of the study. These 5 participants formed the Delphi group. The participant's responses were then collated. The objectives of the study together with the responses from the first round were used to create questions for the second round. The aim of the second round of questions was to determine the degree of agreement with a statement or the frequency with which a particular risk or gap is experienced. The experts' comment on the perceived usefulness of the process analysis was also requested. The feedback from round two was collated with Excel and analysed. As no new responses arose in round 2 there was no need to conduct a third round (Syed et al., 2009).

In the fourth phase, the opinions from the experts were analysed according to emergent themes. The emergent themes were used to determine the points of contention and consensus with regard to the value of process engineering when using OpenMRS to manage patient's medical data. When a content analysis statements was performed analysing word concentration to identify themes, there was a poor result therefore statements were further analysed to interpret the actual meaning of the statement (Thorne, 2000). This culminated in a final review with experts.

# 4 RESULTS

The results of the study are presented to highlight three key aspects, namely: First, the insights gained from the process analysis of two perspectives of the MDRTB guidelines; second, the synergies relating to the co-treatment of MDRTB and HIV/AIDS; and

third, and the value of process re-engineering as an analytical and design tool.

## 4.1 Process Analysis Insights

### 4.1.1 Process Models

The results from the process analysis highlight various inefficiencies and waste. Some of these problems are related to the lack of integration of upstream processes with downstream processes. Table 1 provides an overview of the key metrics evaluated in Phase 2 of the study: Break points referred to an activity with hand-offs between departments, people, systems and functions. With the 54 break points that were identified, steps need to be put in place to ensure that the transition at the break points are smooth to support optimal flow of the process. The 2nd metric, Business Rules directs an individual or machine through a different path depending on the condition that is met. During the analysis the applicability of the business rules were questioned and found to be relevant. The Gaps identified focused on identifying where the out-of-the-box instance of OpenMRS did not meet specific requirements in the South African context. This meant that some customisation will be required. The Risks identified highlight potential weaknesses in the process. During phase 3 of the methodology, when the risks were put to the Delphi Group, these were identified as "not significant". Finally the Waste identified in the process highlighted the potential opportunities to streamline the process.

### 4.1.2 Expert Commentary on Process Models

The Delphi study was conducted over one month (15 November 2011 – 15 December 2011). Using a questionnaire, participants profiled themselves as spending their time doing research, implementing EMR solutions and performing clinical activities. Four, out of five, participants has experience in overcoming challenges of diagnosis and treatment of MDRTB patients and experience in healthcare quality improvement projects. All three clinicians in the group have knowledge of the South African clinical guidelines. Only one participant refrained from indicating their level of experience with EMR solutions, two of the participants expressed "some experience" and another two expressed a "great deal of experience". With the exception of the one participant who practices process analysis on a daily basis, all other participants had limited exposure to process analysis. One of the clinicians expressed an interest to learn process analysis.

In support of existing literature all participants agreed that the alignment of process, technology and the individual is very important (Elske et al., 2006); (Ludwicka and Doucettea, 2009); (Tsiknakis and Kouroubali, 2009). Participants also indicated that operational efficiency, quality improvement and innovation in service delivery of healthcare are poorly explored subjects in healthcare research (Elkhuizen et al., 2006). They also identified that these subjects are becoming more relevant as the burden on the healthcare system grows (Nathanson et al., 2006); (Singh and Padayatchi, 2007); (Keshavjee et al., 2008; 2009), (WHO, 2009); (WHO, 2010). In the literature reviewed it is evident that much of the in these subjects is concentrated in the developed world (Boston-Fleischhauer, 2008a); (Pickles et al., 2008); (Chan and Kaufman, 2010).

In this study participants raised issues potentially related to developing countries; issues of poor capacity development and inefficient turn-around times as gaps and risks, respectively. Participants refer to poor capacity both in terms of the infrastructure; such as diagnostic equipment, integration of specialized technologies, and in terms of skilled human resources to execute procedures. Laboratory results that are used for diagnosis are conducted by a third party in South Africa, creating a further disconnect. Turn-around times of processes thus need to be more tightly managed to support the efficiency of the diagnostic process. As highlighted by Seung et al. (2009), there are several cases where a delayed diagnosis results in treatment being delayed resulting in a patient's delayed recovery or even death. All participants agreed with these and other wastes identified in the process analysis.

Wastes were stated as improvements, gaps or risk in the second round of the Delphi study and tested with the participants. In agreement with existing research, their responses show that two of the greatest inefficiencies in current non-EMR settings are the redundant capture of information and laborious data analysis (Gerntholtz et al., 2007); (Vine, 2007); (Blaya et al., 2008); (Clifford et al., 2008).

The benefit of developing a new guideline was deemed questionable as expert comments highlighted that all healthcare workers do not follow the current prescribed guidelines and suggested any revisions may remain unimplemented. However, given the various improvements that have been recommended by participants in this study and those noted in recent literature (Seung et al., 2009)

Table 1: Process analysis summary.

| Process analytics | Total instances of analytics identified |
|---|---|
| Break Points: An activity with hand-offs between departments, people, systems and functions | 54 |
| Business Rules: Determine behaviour. It directs a person or machine with regard to; what to do and when. | 2 |
| Gap: A particular function or step that the clinical guideline requires but OpenMRS does not support. | 13 |
| Moment of truth: The interaction between patient and the health care facility | 9 |
| Risk: An unforeseen error that could impact the flow of the process from successfully reaching its objective. | 3 |
| Waste: Activities in the process that result in inefficiencies that can be avoided. | 5 |

(Albert et al., 2010); (Cegielski, 2010); (O'Donnell et al., 2010); a new guideline could allow for the incorporation of best practices. Understanding the gap between the technology and the process is a critical exercise that must be conducted to ensure that there are limited work-a-rounds once the HIS implementation is completed. The gap analysis indicates there is a high concentration of gaps between the process and the technology (14).

As noted by a participant, it is important for a HIS to be customizable, *"The reality of the operational set up is that the care process is highly fluid"*. A participant, who is an international OpenMRS implementer, highlighted how nine of the thirteen gaps between task and technology could be closed by customisations. OpenMRS has been customised and integrated with other applications like Chasqui in Peru (Blaya et al., 2007), FrontlineSMS in Ghana & AMPATH in clinics in sub-Saharan Africa (Anokwa, 2010); (Kumar et al., 2010); (Wei-Chih et al., 2010), and integration with Google maps in Pakistan (Ford, 2009). Thus illustrating OpenMRS can be customised for different contexts; including developing countries.

Given the growing use of technologies to support clinical decision making (Terazzi et al., 1998); (Andersson et al., 2003); (Marc Mitchell et al., 2007); (Isern and Moreno, 2008); (Anokwa, 2010), it was not surprising that participants, particularly clinicians, made recommendations with regard to the need to integrate specialised technologies. This is further supported by the fact that the majority of participants responded positively to the technology improvement in OpenMRS regarding clinical decision making support to aid healthcare workers. While there are numerous gaps highlighted in the out-of-the-box installation of OpenMRS MDRTB module, it does help to mitigate various identified risks and eliminate waste; making the diagnosis and treatment process of MDRTB more efficient. However it would be better if the gaps identified in the study were closed before an implementation is done.

Two process improvements were presented to participants: Firstly, always taking 3 sputum samples and secondly, replacing the MDRTB register with the investigation form. The clinical guideline specifies that three sputum samples be collected based on a specified decision tree and the recommendation was to simplify the process and always collect 3 sputum samples. Participants "disagreed" and "strongly disagreed" with the process modification suggested, although no reason was provided by participants when this was queried. The majority of the participants were "undecided" whether replacing the register with the investigation form would yield value. Thus, based on the experts' experience in the field, these interventions appear likely to have an insignificant impact.

One of the greatest opportunities to enhance the OpenMRS system is to ensure that the processes that are supported by the system adequately provide relevant communication to stakeholders involved in the process. Quality improvement research highlights the need for effective communication among healthcare workers during the clinical care process to support care co-ordination (Boston-Fleischhauer, 2008a); (Tanevaa et al., 2010). All participants did not respond to statements relating to the need for the system to support communication, and responses varied widely. An individual's perspective on this issue may be dependent on the environment in which the participant operates. This form of context dependent analysis did not form part of this research however it does suggest an area for future research.

## 4.2 Synergies for Co-treatment of MDRTB & HIV

One of the greatest challenges in the developing world is the dual infection of HIV and MDRTB

(Cohen and Maarstens, 2004); (O'Donnell et al., 2009); (Seung et al., 2009). This was supported by the findings in this study as all participants agreed that there is a need for the co-treatment of HIV and MDRTB patients.

Participants highlighted several factors that could offer synergies for the co-treatment such as; identifying the reasons for the delay in initiating HIV treatment of MDRTB patients and the provision of support to HIV and MDRTB patients to adhere to their treatment programmes. These are supported by World Health Organisation (2009) research and by Perumal et al., (2009). Participants suggested, and strongly agreed, that it would be preferable to have one service provider to support the treatment of patients suffering both conditions. This has not been explored in any previous study and should be further explored from both an operational and clinical perspective.

A participant noted the lack of existing literature detailing the advantages and disadvantages of a decentralized model of care (a.k.a community care or mobile care). As with previous studies, participants also highlighted the need for MDRTB patients attending facilities to be tested for HIV (O'Donnell et al., 2010). The synergies that were raised, but which participants disagreed on were; electronic monitoring systems that do not require specialised data capturers, separate clinic notes and registers and the provision of isoniazid prophylaxis for all immune-compromised individuals, especially post TB treatment.

The participants with a clinical background also highlighted the need for more synergies in terms of drug treatments to effectively support the consequences of drug interaction; as highlighted by Cohen and Maastens (2004), Calver et al., (2010) and Cegielski, (2010). Participants reiterated the point made in previous studies that there is a need for early treatment of ARV in dually infected patients (O'Donnell et al., 2009); (Seung et al., 2009).

The participants with OpenMRS implementation experience also contributed to the synergies identified, indicating that electronic monitoring systems could support patient treatment adherence. This is not surprising, as OpenMRS implementations in other African countries have already encountered such challenges and have worked on solutions such as SMS reminders (Allen et al., 2007); (Noormohammad et al., 2010); (Choi and Fraser, undated).

### 4.3 Value of Process Engineering

Participants had no substantive disagreement with the findings presented as a result of the process analysis. In addition, participants expressed the value that they had seen in terms of the advantages noted in the first round of the Delphi review. Thus the exercise promoted the appreciation of the value of process analysis. Four out of five participants agreed that conducting the process analysis was a time consuming activity. Given that participants themselves did not conduct the process analysis, their perception of the time consuming nature of the activity may be biased.

While there are a few studies that highlight the value of process models as a medium to teach healthcare workers (Stausberga et al., 2003), this potential benefit was ranked lower than most other advantages noted by participants. The use of process analysis in the development of clinical protocols has been noted by Taneva et al., (2010). Participants in this study both identified this advantage and ranked it very high. It is a growing trend in healthcare quality improvement programmes and research to encourage healthcare workers to initiate improvement opportunities (Needleman and Hassmiller, 2009); (Chassin et al., 2010). Participants identified process analysis as a technique to realise this advantage and ranked it very highly.

One of the participants highlighted that there is a need to measure improvement in clinical outcomes with the implementation of a HIS and research indicates that evidence based medicine is strongly supported by implementations of HIS (Paulus et al., 2008).

## 5 CONCLUSIONS

This study has presented an opportunity to understand how healthcare can be delivered with operational excellence. Even in the developing world context, simple process improvement can go a long way to improving service.

Firstly modelling the process that healthcare workers are expected to follow in the diagnosis and treatment of MDRTB (based on the SA clinical guidelines) and the electronic HIS processes (based on OpenMRS documentation) it became easier to understand the main objectives of the diagnosis and treatment process.

Secondly the process models allowed for the analysis of wastes, opportunities for improvement

and the alignment between the SA clinical guidelines and the functions of OpenMRS. The process analysis highlighted that there are inefficiencies in the process related to poor data management and break-points in the process. There are also various opportunities to provide value add to the patient, with reminders for follow-ups and better reporting requirements to improve assessment of the processes. There are numerous areas where the out-of the box OpenMRS MDRTB installation does not fit the South African context but has the ability to reduce the inefficiencies that currently exist.

Thirdly, the process analysis findings were validated with experts in the field. The experts confirmed that the findings were valid in terms of outlining the relevant steps to be followed by healthcare workers, the need for technology to enable the process where appropriate and risks and wastes that make the process inefficient. Participants disagreed with the need to adjust the sputum collection tasks and synergies of co-treatment such as a single service provider and provision of isoniazid prophylaxis for all immune-compromised individuals.

The study assists in providing evidence to illustrate the value of process engineering in the developing world. The findings support current trends in quality improvement such as evidence based medicine. This will help the focus in the developing world to include operational excellence to improve the quality of care delivery, clinical outcomes and the use of technology where applicable to support these initiatives.

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