

Corrigendum: The role of process analysis and expert consultation in implementing an electronic medical record solution for multidrug-resistant tuberculosis

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In the title column on page 1, the names of two contributing authors to this article have been erroneously omitted. In addition, the order of the listed authors of this article has also been rearranged. The correct order list, affiliations, and authors' contributions of the article is provided below:

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R.P. (University of KwaZulu-Natal) and H.D. (University of KwaZulu-Natal) developed the concept for the study and conducted the process analysis. H.D. conducted the Delphi study. H.D. and R.P. analysed the data from both study phases, and contributed to the writing of this manuscript. R.Q. (University of KwaZulu-Natal) and Y.S. (University of KwaZulu-Natal) guided the design and write-up of the study.

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The role of process analysis and expert consultation in implementing an electronic medical record solution for multidrug-resistant tuberculosis

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Background: Process analysis and expert consultation help streamline and optimise processes, but these are underutilised. The World Health Organisation (WHO) recommends migration to electronic data collection by 2015, partly in response to multidrug-resistant tuberculosis (MDR-TB). We explore the influence of process analysis and iterative expert consultation, on shaping health information solutions to MDR-TB programmes.

Methods: The study employs a two phase design. Phase one involves a process analysis of the South African National Tuberculosis Programme and an electronic medical records (EMR) solution and the generation of a detailed process model grounded in the fit between individual task and technology (FITT) theoretical framework using 'business process modelling notation'. Phase two involves a two round Delphi study in the clinical management of tuberculosis and implementers of EMR solutions. Expert opinion is analysed according to emergent thematic content. Analyses and graphical model representation are performed using Microsoft Excel[®] and Visio[®] software.

Results: A detailed process model is constructed which reveals 54 break points, 12 gaps, 3 risks, 5 wastes. Five participants are included in the Delphi study which support the findings of the process analysis. Thematic analysis identifies five themes: the individual, the process, technology, capacity, and collaboration. The opportunity to include synergistic relations across programmes emerges as a strong theme.

Conclusions: Overall, the findings highlight inefficiencies, risk and gaps in the current process and the need for an operational excellence intervention. The study demonstrated the value of process engineering with iterative expert consultation toward developing a meaningful EMR solution consultation in a resource constrained, developing world context.

Background

Health care is an information process which can be deconstructed as follows:

- data collection (history and physical examination)
- data recording (clinical record)
- data processing (clinical decision making)
- information transmission (clinical orders and referrals etc.) (Tierney *et al.* 2010).

The electronic medical record is fast becoming an important tool to ensure accurate and timely data collection that may be used for effective health care. There is a critical collaborative relationship between technology, people and the tasks that they perform (Elske, Carola & Mahler 2006; Tsiknakis & Kouroubali 2009a). 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 & Toussaint 2003; Ludwicka & Doucettea 2009).

Some 130 years since Robert Koch's discovery of *Mycobacterium Tuberculosis*, as the infectious agent of tuberculosis, the disease remains a near insurmountable global health concern, which claimed an estimated 1.3 million lives in 2012 alone, over 30% arising in sub-Saharan Africa (World Health Organisation 2013). As early as 1994, drug resistance was reported in nearly every country surveyed by the World Health Organisation (WHO) surveillance projects (Blondal 2007). Nearly two decades later, 'the total number of MDR-TB cases estimated to have occurred worldwide was about 450 000', comprising 3.6% of all new and 20% of all previously treated cases (WHO 2013). South Africa has the second highest burden of MDR-TB in the world (15419 notified cases

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in 2012), and is the only country with a growing incidence of TB (currently estimated at 1 new case per 100 persons) (WHO 2013). The total cost for treating MDR-TB is approximately 30 times more than that of drug-sensitive TB, and diverts resources away from managing a national TB programme (Tupasi *et al.* 2006; Resch *et al.* 2006; Uplekar & Lonnroth 2007). The South African National TB Control Programme provides local guidelines for the management of drug resistant tuberculosis, which is based on WHO recommendations. The current cure rate for MDR-TB in most developing countries is between 30–50%, and the second line drugs used to treat MDR-TB are poorly understood, difficult to administer, and have poor side effect profiles (Pooran *et al.* 2013; Resch *et al.* 2006; Tupasi *et al.* 2006; Uplekar & Lonnroth 2007). Whilst the initial response to the MDR-TB epidemic in South Africa mirrored the World Health Organisation guidelines in the provision of centralised inpatient care, the high burden of disease in this country rapidly made centralised care unsustainable. As an alternative to centralised care, KwaZulu-Natal has moved toward a decentralised model of care, with comparable outcomes (Loveday *et al.* 2012). Whilst tuberculosis is a curable infectious disease, successful treatment outcomes require both patient adherence and a functional health system. Health system factors have been demonstrated to significantly impact treatment outcomes, and may contribute to avoidable negative clinical outcomes (Loveday *et al.* 2008). Therefore, there exists the potential to improve how multidrug-resistant tuberculosis (MDR-TB) is diagnosed and treated, as a result of employing a process engineering intervention built into an electronic medical record system could be significant (Fraser *et al.* 2006). As a key component of the global public health response to MDR-TB, the WHO has recommended a complete migration to electronic data collection by 2015 (WHO 2013). In light of decentralised care, this would require a comprehensive electronic medical record system that is able to satisfy the data recording purposes of public health authorities as well as the clinical and operational needs of patients and their health care providers. The complexity of such an electronic medical record (EMR) system will require the collaboration of a number of key stakeholders, and specifically an iterative relationship between designers of the system and the end-users (Allen *et al.* 2007; Ammenwerth, Iller & Mahler 2006; Blaya, Holt & Fraser 2008; Clifford *et al.* 2008; Elske, Carola & Mahler 2006; Fraser *et al.* 2006; Gerntholtz, Van Heerden & Vine 2007).

Little research is available for healthcare process management both in South Africa and other developing countries. South African health care processes have been described as ‘fundamentally broken’ and, thus, research in this area is much needed (Gerntholtz, Van Heerden & Vine 2007). South Africa’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, Wyatt & Garvican 2003).

Technology is a mechanism to enhance delivery; and one such technology is OpenMRS which has a specific module for management of MDR-TB programmes (Choi & Fraser n.d.; Seebregts *et al.* 2006). OpenMRS is one of the most widely used open source EMR solutions in Africa (Seebregts *et al.* 2006; Tierney *et al.* 2010). OpenMRS is designed using international standards (HL7, DICOM, and LOINC) for interfacing with other technologies and is designed for universal deployment. The OpenMRS MDR-TB module that is discussed in this study was developed to provide an intuitive ‘front end’ to support the treatment of MDR-TB for WHO sponsored projects. The module can be customised with some medium to high level computer skills for specific geographical or treatment requirements (Choi & Fraser n.d.). To date OpenMRS has been implemented in over 25 countries, these being mostly low income, and supports HIV and TB programmes. The OpenMRS MDR-TB module may be used as an electronic medical record solution, but may, in addition, provide the electronic framework for providing process engineering support to the critical MDR-TB clinical programme. The combination of a grounded process analysis tool, together with expert consultation, is a novel method for designing and optimising an EMR solution. This study aims to describe the role of process engineering and iterative consultation in shaping an EMR solution (OpenMRS) in the South African MDR-TB programme.

Methods

The study employed a qualitative two phase design. The first phase focused on the creation of process models based on the South African clinical guidelines and the OpenMRS MDR-TB module using Business Process Modelling Notation (BPMN). The procedures in the guidelines were translated into business processes (National Department of Health 2009). The tutorial from the OpenMRS MDR-TB module 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 patient’s diagnosed with and treated for MDR-TB.

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 a detailed view of processes a process is divided into sub-processes. Each sub-process is then reconfigured 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 or not each task in the process is contributing to the process goal. The process model and analysis was grounded in the

FITT (fit between individual task and technology) theoretical framework (Elske, Carola & Mahler 2006). This model explicitly looks at three dimensions and the relationship between each:

1. user and technology
2. task and technology
3. user and task.

Whilst the focus of the methodology is on the task and the technology fit, it aims to also consider the implications for users in terms of their fulfilment of tasks and use of technology.

The second phase of the study involved a two round Delphi study where experts in the clinical management of MDR-TB in South Africa, or the implementation of OpenMRS modules, were surveyed to assess the process analysis findings and to offer insights for the future design of EMR solutions in MDR-TB management. 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 MDR-TB from a South African perspective in the past five years.
4. Currently or previously a clinician.
5. Availability of an email address.

An invitation was sent to 28 participants (11 Clinicians and 16 OpenMRS implementers) identified to participate in the study, requesting their participation. Seven participants responded, confirming their participation in the study within a two-week period (three clinicians and four OpenMRS implementers). Five of the seven participants who responded within two weeks of the request provided responses to the first and second rounds of the Delphi study. With the objectives of the study in mind, the collated responses from the first round were used to create questions for the second round. As no new responses arose in round two there was no need to conduct a third round. The opinions from the experts were analysed according to emergent themes. Thematic content analysis was used to determine the points of contention and consensus with regard to the value of process engineering when using OpenMRS to manage patient medical data. All analyses were collated and graphically presented using Microsoft Excel® and Microsoft Visio® respectively. Ethical approval was obtained from the University of KwaZulu-Natal Biomedical Research Ethics Committee (Ref: BE036/11).

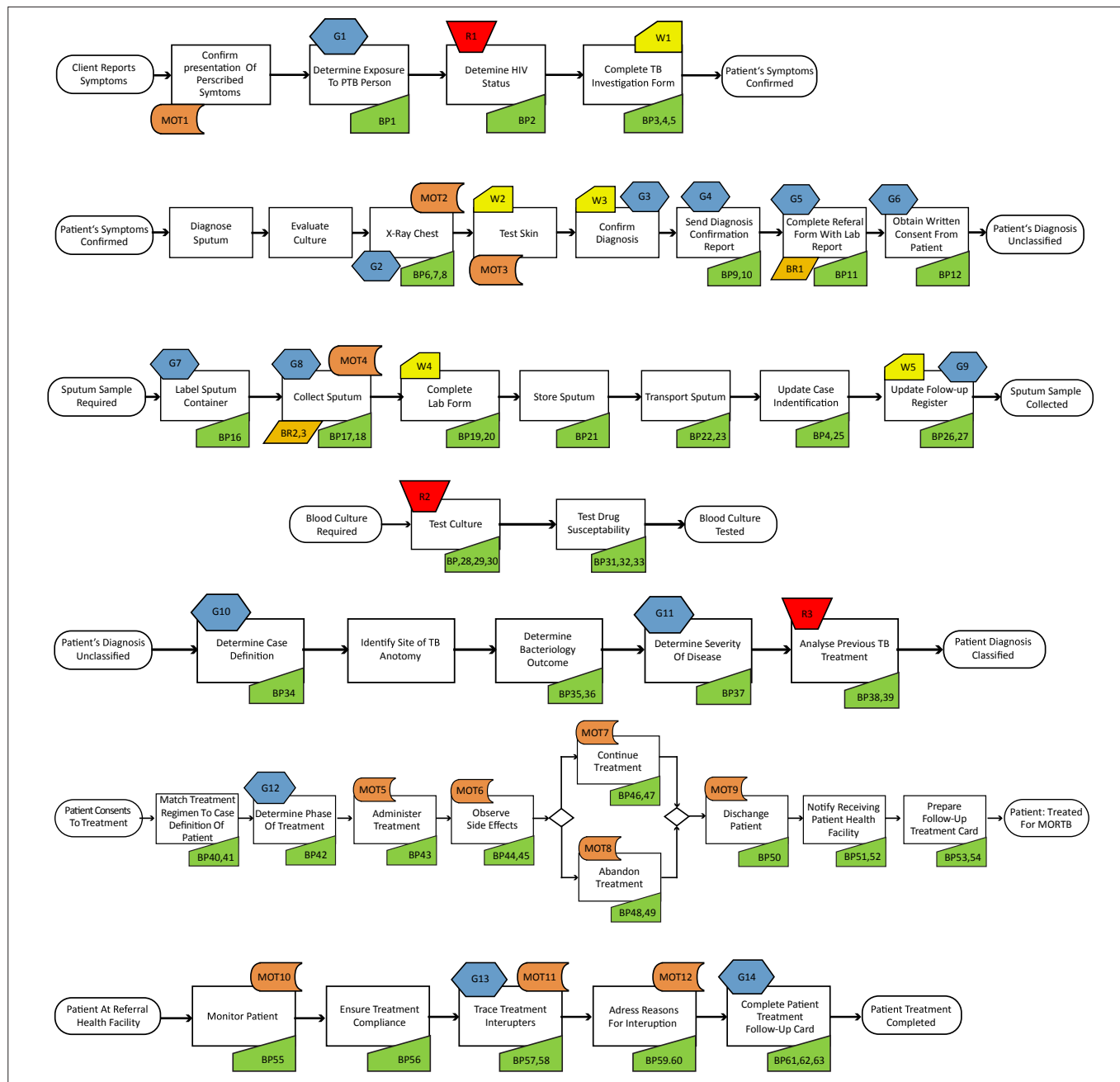
Results

A detailed process model for the South African National Tuberculosis Control Programme reflects five core activities enclosed between the start and end points (Figure 1). The results of a detailed process analysis by core activity highlight various inefficiencies and gaps (Table 1). Some of these problems are related to the lack of integration of upstream processes with downstream processes. Break points refer to an activity with hand-offs between departments, people, systems or 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 second 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 means that some customisation will be required. The Risks identified highlight potential weaknesses in the process. Finally the waste identified in the process highlighted the potential opportunities to streamline the process.

In the Delphi study five participants responded to both rounds in the study, and profiled themselves as spending their time doing research, implementing EMR solutions and performing clinical activities. All three clinicians in the group had knowledge of the South African clinical guidelines. Only one participant refrained from indicating their level of experience with EMR solutions, whilst 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. The majority (four out of five) of the participants regarded the alignment of process, technology and individual as 'important'. The participants' responses affirm the underlying principle of the FITT framework that has been used as a theoretical framework for the study (Chan & Kaufman 2010; Elske, Carola & Mahler 2006; Tsiknakis & Kouroubali 2009a; Tsiknakis & Kouroubali 2009b). On reviewing the participants' statements, a pattern emerged, that 80% of statements were related to either 'Process', 'Individual', or 'Technology'. The participants tended to use the terms from the FITT framework that were used in the questions. The remaining statements were then

TABLE 1: Summary of a process model of OpenMRS and the National tuberculosis guidelines.

Process analytics	Total instances of analytics identified
Break points: Errors that can occur during hand-offs between departments, people, systems and functions.	54
Business rules: Directions for healthcare workers or machines which are ambiguous or unnecessary.	2
Gaps: Functions or steps required by the clinical guideline but which cannot be captured or supported by OpenMRS.	12
Moments of truth: The interaction between the patient and the health care facility.	9
Risks: Errors that may occur that could prevent the flow of the process from successfully reaching its objective.	3
Wastes: The aversion of activities in the process that results in avoidable inefficiencies.	5



G, Gap; BP, Break point; MOT, Moment of truths; R, Risk; W, Waste; BR, Business Rule

FIGURE 1: Detailed process model for diagnosis and treatment of TB with process analytics at points of disjunction between the clinical guideline and OpenMRS.

TABLE 2: Contributions of process analytics by process analysis and by Delphi technique.

Contributions	Process analysis	Delphi study		
		Total	Clinical respondents	Medical informatics
Gaps	12	5	4	1
Process improvements	4	5	4	1
Synergies	-	11	-	-
Risks	7	3	2	1

reviewed to identify common themes, and two additional themes, namely ‘collaboration’ and ‘capacity’, were added. This illustrated that participants contributed new ideas to the process analysis as opposed to simply validating what they were presented with. Overall, the Delphi study demonstrated support for and affirmation of the process analysis findings (Table 2).

A summary of gaps identified in the process analysis is shown in Table 3. Delphi participants identified five unique gaps after final coding which were not identified in the process analysis phase (displayed in bold). This finding demonstrates the synergistic potential of process analysis, with an iterative consultation process, with stakeholders.

Wastes were stated as improvements, gaps or risks in the second round of the Delphi study and tested for agreement 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 (Clifford *et al.* 2008; Blaya, Holt & Fraser 2008; Gertholtz *et al.* 2007; Vine 2007). As noted by a participant, it is important for an EMR solution to be customisable, 'The reality of the operational set up is that the care process is highly fluid'. 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 hospital information system (HIS) implementation is completed. The gap analysis indicates there is a high concentration of gaps between the process and the technology.

A participant, who is an international OpenMRS implementer, highlighted that nine of the thirteen gaps between task and technology could be addressed by customisations. OpenMRS has been customised and integrated with other applications such as Chasqui in Peru, FrontlineSMS in Ghana and AMPATH in clinics in sub-Saharan Africa, and Google maps in Pakistan (Tierney *et al.* 2010; Staccini *et al.* 2000; Seebregts *et al.* 2009; Seebregts *et al.* 2006; Frasier, May & Wanchoo 2008; Choi & Fraser n.d.; Blaya *et al.* 2007; Allen *et al.* 2007). Of the nine improvements proposed by participants, five of these

related to technology improvements (Figure 2). The figure further illustrates that the majority of the respondents agreed with the need for technology related improvements, with the exception of increased access to GeneXpert diagnostic technology. This was possibly because the South African Department of Health had announced its plans for a national roll-out of the technology just prior to this study, making such an improvement unnecessary. The technology has since been widely rolled out and enjoys the growing support of the medical and scientific community (Theron *et al.* 2013).

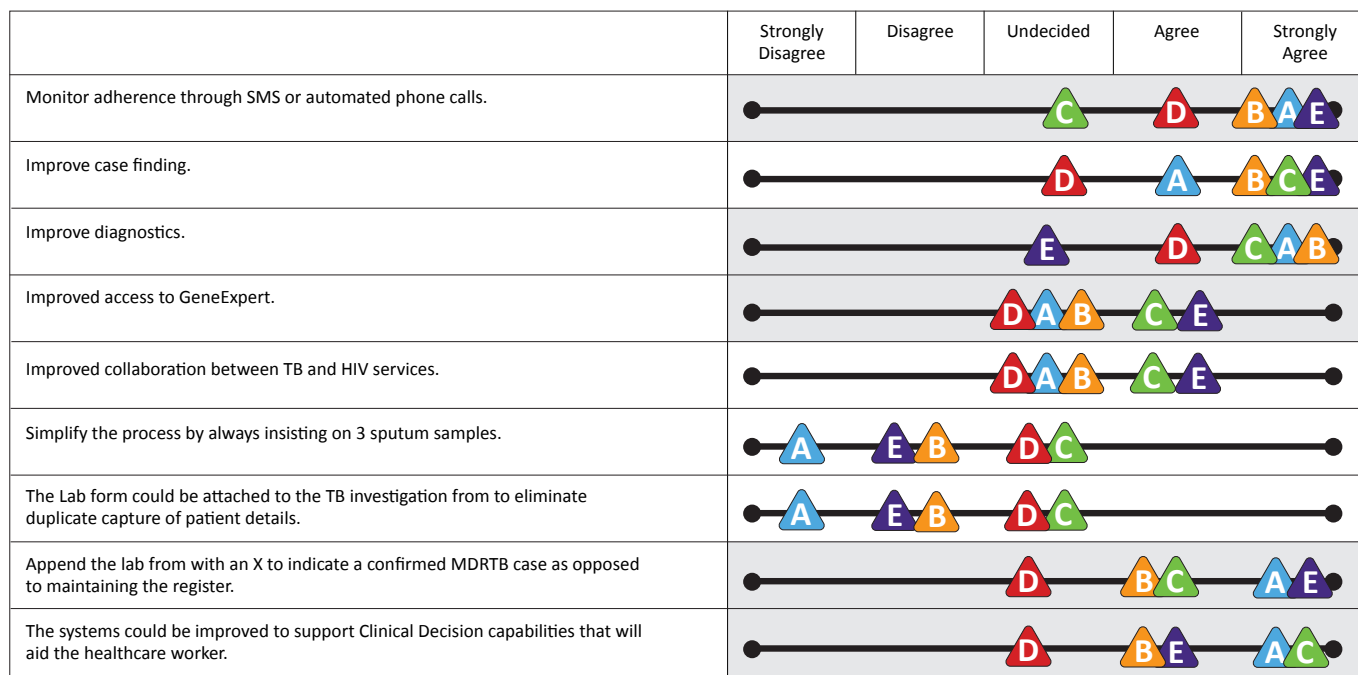
Given the growing use of technologies to support clinical decision making, it was not surprising that participants, particularly clinicians, made recommendations with regard to the need to integrate specialised technologies (Andersson, Hallberg & Timpka 2003; Isern & Moreno 2008; Terazzi *et al.* 1998). This is reinforced by the outcome in which the majority of participants responded positively to the technology improvement in OpenMRS regarding clinical decision making support to aid healthcare workers.

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 amongst healthcare workers during the clinical care process, to support care co-ordination (Boston-Fleischhauer

TABLE 3: List of Gaps clustered according to themes.

Themes	Gap Identified
Gap between individual & technology	<ul style="list-style-type: none"> • The limited ability of healthcare workers to use computer technology to support clinical tasks.
Gap between capacity demand and capacity supply	<ul style="list-style-type: none"> • There are insufficient human resources available to support the clinical care of MDR-TB patients.
Gap between Technology & Process (based on out of the box OpenMRS MDR-TB module implementation)	<ul style="list-style-type: none"> • OpenMRS does not support the ability to track a sample group of patients. • There is limited integration of specialist technologies like Gene Expert to support the diagnosis process. • There is limited access to rapid and accurate diagnostic technologies. • OpenMRS does not support the ability to capture details about the exposure to TB unless taken in an unstructured textbox. • X-ray results can only be captured as part of a patient encounter and not as part of the MDR-TB diagnosis form within OpenMRS. • Lab results can only be captured once the diagnosis has been completed. This forces the healthcare worker to bridge the connection between the point at which the patient requires a test and when it is completed. • A disconnect occurs between the point at which the patient requires a test, and the test completion point, results in a record of the test that is only captured in OpenMRS after the test is completed. This results in the inability to capture the turn-around time of the lab results. • The system does not have the ability to send confirmation of the diagnosis to healthcare workers. This limits the speed at which healthcare workers can begin preparing the patient for treatment. • OpenMRS does not provide clinical protocols to instruct the healthcare worker on the procedure to collect sputum. This assumes that the healthcare worker has previous knowledge of the process. • OpenMRS does not allow the time the sputum sample is collected to be recorded. • OpenMRS does not have the ability to track patients' status through the diagnosis process and, therefore, no report can be created listing all patients who are still awaiting confirmation of diagnosis. This also results in delays in responding to queries on a patient's diagnosis status. • OpenMRS does not have the ability to capture the standardised case definition and allow healthcare providers to select the relevant option. • OpenMRS does not have the ability to capture the severity of the disease. This is important for informing treatment dosage. • OpenMRS does not allow for the phase of the treatment to be captured. • OpenMRS does not support the capturing of treatment compliance or treatment interruption on the part of the patient.

Unique gaps identified by the Delphi study shown in bold.
MDR-TB, multidrug-resistant tuberculosis.



Note: Technology improvements indicated by grey shading.

FIGURE 2: Improvements identified and rated by participants.

2008; Taneva *et al.* 2010). Not all participants responded 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.

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; Choi & Fraser n.d.).

Whilst there are numerous gaps highlighted in the out-of-the-box installation of the OpenMRS MDR-TB module, it does help to mitigate various identified risks and eliminate waste, making the diagnosis and treatment process of MDR-TB more efficient (see Table 1). However, it would be better if the gaps identified in the study were closed before an implementation is carried out. This might have been possible if the implementation was preceded by a process analysis with iterative consultation, as described in this study.

Five improvement opportunities were identified by participants, four of which were from a clinical perspective. One of the suggested process improvements (Simplify the process by always insisting on 3 sputum samples) to address the perceived waste in the system was not supported by the experts, possibly because new modalities of diagnosis, such as GeneXpert, no longer require multiple first contact sputum specimens.

According to the second round of the Delphi study the most frequently experienced risks were:

- Paper records that are more likely to be lost or corrupted than electronic records
- Long laboratory turn-around times that result in delayed treatment
- Unclear timing of integration of antiretroviral therapy
- Dependency on the patient providing the correct information
- The limited linkage of health records between health facilities
- Suboptimal patient adherence.

All of these risks may have a negative impact on clinical decisions made by providers.

Ten synergies were identified by four participants, three of whom are MDR-TB clinicians. One of the main themes that were stressed by participants is the collaboration of treatment facilities for HIV positive and MDR-TB patients. Some of the synergies that participants disagreed on were: electronic monitoring systems that do not require specialised data capturers, and separate clinic notes and registers and provision of isoniazid prophylaxis for all immune-compromised individuals, especially post-TB treatment. In contrast to the fact that most participants disagreed with the synergy to provide isoniazid prophylaxis to all immune-compromised individuals, especially post-TB treatment, all participants agreed with the comprehensive treatment of other opportunistic infections, including the provision of co-trimoxazole prophylaxis. The synergies that received the most agreement from participants were:

- Identification of delays, and the reasons for the delay, in initiating HIV treatment of MDR-TB patients. This is especially significant as recent data suggests that delayed initiation of treatment is a major challenge to the health system and is a significant contributor to morbidity and mortality in patients with MDR-TB (O'Donnell *et al.* 2009; Padayatchi *et al.* 2014).

- The provision of support to HIV and MDR-TB patients to adhere to their treatment programmes.
- One service provider focusing on treatment of both conditions.
- Ensuring that all TB facility attendees are offered an HIV test.

The synergies that received the most agreement from participants are supported by the growing support for the integration of TB and HIV programmes (Loveday & Zweigenthal 2011; Perumal, Padayatchi & Stiefvater 2009; Van Rie *et al.* 2013). Participants went so far as to suggest one service provider to support co-treatment, in keeping with the integration of TB and HIV care as a current major health systems priority (Loveday & Zweigenthal 2011; O'Donnell *et al.* 2009; Padayatchi *et al.* 2014; Perumal *et al.* 2009).

Discussion

The management of any medical condition is complex, and reflects the fluid interaction between the patient, healthcare provider, and the healthcare system. In the context of MDR-TB, an 'emerging' infectious disease entity, any attempt at introducing a meaningful electronic record solution must be mindful of the rapidly changing clinical practices. As new evidence emerges, clinical practices change to accrue the advantages of this new knowledge. An important example of this was the shift in the method of diagnosis of MDR-TB from a sputum culture based diagnosis, to a newer rapid diagnosis by nucleic acid amplification technology (Xpert technology).

In addition, new evidence which has demonstrated the substantial survival benefit, of integrating antiretroviral therapy early within MDR-TB treatment, would need rapid incorporation into an MDR-TB EMR solution that contributes to the 'process' of MDR-TB management (Loveday *et al.* 2012; O'Donnell *et al.* 2009; Padayatchi *et al.* 2014). The benefit of using an open-source EMR solution such as OpenMRS lies in the ability of a wide community of developers to be called upon to deal with gaps and the need for revising the existing version, as has been performed with the MDR-TB module in this setting. Whilst EMR implementers might attempt to remain abreast of clinical developments, regular iterative input from clinical experts may serve as a more pragmatic response to keeping an EMR both useful and relevant. The move from centralised care for MDR-TB patients to growing support for a decentralised model of care will further challenge an EMR solution for MDR-TB. Central services are well documented to be easier for the implementation of EMR solutions, whilst decentralised care, especially in rural, resource-constrained settings, presents significant challenges to the implementation of an EMR solution (Heeks 2006; Lapao *et al.* 2009; Littlejohns, Wyatt & Garvican 2003; Seebregts *et al.* 2006; Seebregts *et al.* 2009; Tierney *et al.* 2010; Tsiknakis & Kouroubali 2009a). The responsiveness of a health informatics solution to such programmatic changes will be crucial for its sustainability, and will make iterative feedback (through methods such as the Delphi technique) essential to understand unique challenges that may emerge only once a programme is shifted to more rural and outlying settings. Clinical support for any EMR solution will only be possible

if clinicians are in agreement that the EMR adds value to the process of MDR-TB management, and that the value added, in terms of existing advantages, matches its accuracy and relevance when placed in the context of prevailing clinical guidelines. This is the major potential benefit of including a process analysis approach to EMR design and development. Including stakeholders, particularly healthcare workers in an EMR system selection and design, may improve their openness to the technology and reduce resistance to change (Tierney *et al.* 2010).

In keeping with evidence from other settings, participants in this study identified the use of process analysis, in the development of clinical protocols, as the highest ranked advantage (Taneva *et al.* 2010). The second and third ranked advantages (The ability of healthcare workers to personally identify problems in the healthcare system, and the ability to identify operational health system factors which may negatively impact on clinical outcomes.) attested to the use of process engineering as a quality improvement tool. There is a growing trend in healthcare quality improvement programmes and research to promote healthcare workers to initiate improvement identification opportunities (Chassin *et al.* 2010; Martikainen, Korpela & Tiihonen 2014).

Conclusions

Process analysis and expert consultation may serve as important tools in the future design, implementation and monitoring of EMR solutions in a dynamic health care setting. Process analysis and expert consultation demonstrate good compatibility for providing insights to EMR implementation, and are complementary in their generation of information. The opportunity to utilise EMR solutions as a vehicle for enhancing programmatic function, by supporting clinical decision making and guiding processes, should be harnessed. This can be achieved through customisation in an expanding open development environment. Overall, the findings highlight the inefficiencies, risk and gaps in the current process and the need for an operational excellence intervention. The study demonstrated the value of process engineering with iterative expert consultation, toward developing a meaningful EMR solution consultation in a resource constrained, developing world context.

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Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

R.P. (University of KwaZulu-Natal) and H.D. (University of KwaZulu-Natal) developed the concept for the study and conducted the process analysis. H.D. conducted the Delphi study. H.D. and R.P. analysed the data from both study phases, and contributed to the writing of this manuscript.

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