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Analysis of Tuberculosis Surveillance Tools at the Ministry of Health:The Case for Computerised /Mobile Surveillance Systems

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***Abstract* – Tuberculosis (TB) is a major global health concern, causing nearly ten million new cases and over one million deaths every year. In Kenya, it remains a major cause of morbidity and mortality affecting a substantial percentage of the population. Early detection of TB through surveillance is an effective intervention measure against Tuberculosis. [The general objective of the study was to investigate how TB Surveillance is done in Kenya. The specific objectives of the study were to: establish the current challenges facing TB Surveillance system, review current state of TB surveillance systems, identify the requirements for TB surveillance system, design and develop a mobile integrated prototype system for TB surveillance Qualitative data was analysed to provide a deeper understanding of user requirements of the system which then were used to design and develop a TB surveillance system using Prometheus agent design methodology. The system was implemented on PHP, MySQL for database and Java Agent Development Framework for multi-agent platform. The designed TB surveillance system enabled the medical practitioner to interact with the patient. The tests included the use of mobile phones to capture data from the remote centres. Usability and functionality tests were performed which indicated that the application was an effective surveillance and responsive tool. Finally the study concluded by pointing out the keys areas of future improvements on the existing system and recommendations for future research.**

***Keywords* – Analysis, Tuberculoses, Surveillance, Systems, Kenya etc.**

I. INTRODUCTION

Tuberculosis, or TB, is an infectious bacterial disease caused by Mycobacterium tuberculosis, which most commonly affects the lungs. It is characterized by the coughing up of mucus and sputum, fever, weight loss, and chest pain. It is transmitted from person to person via droplets from the throat and lungs of people with the active respiratory disease WHO, (2017). It's a highly contagious chronic bacterial infection and leading killer worldwide.

Tuberculosis remains one of the world's most deadly infectious diseases, second only to HIV/AIDS. If not diagnosed and treated promptly, tuberculosis may be spread via an airborne route to family and community members. Untreated, someone with active tuberculosis will infect an estimated 10 to 15 people per year UNAIDS, (2013). Africa has the highest per capital incidence of TB in the world (28%), with most of the worst affected countries located in sub-Saharan Africa. Those most at risk include the urban poor, migrants and refugees, who are forced to live in overcrowded conditions WHO, (2013).

II.PROBLEM STATEMENT

In Kenya, Tuberculosis remains one of the leading causes of morbidity and mortality. Tuberculosis (TB), a disease that, despite being curable, continues to kill many people each year. Most tuberculosis is curable, if diagnosed early and patients with the disease put on medication. There are well known interventions for detecting, controlling and preventing TB. Early detection and effective rapid response to Tuberculosis is critical to reduce morbidity, mortality when they occur.

In the recent past, the World Health Organization, Kenya Ministry of Health and its partners have put a lot of emphasis on development of infectious disease surveillance systems. In Kenya, the major contributing factor responsible for the increase TB cases is the current HIV pandemic affecting over 1 million people. Additionally there have been increasing concerns about the emergence of drug resistant TB, a threat that would pose major challenges in the fight against TB in this resource limited country.

The early detection of TB through surveillance is an effective intervention measure against Tuberculosis. However, existing surveillance approaches, have been criticised from only concentrating on collecting TB related data and ignoring the critical need to notify the patient on their treatment feedback. In addition, they are not effective in collecting and analysing of data in a timely basis.

In order to address the above drawbacks, the study developed a TB surveillance system using Multi-agent System Engineering (MaSE) methodology to cater for the needs of both the medical practitioner and the patient. This system will be expected to improve timely data transmission and multi-level communication for TB surveillance in order to facilitate timely reporting and prompt response to TB incidences.

In addition, by catering the needs of the patient, by giving feedback, we will be contributing to addressing the problem of Drug-resistant TB which is currently on the rise to ensure patient compliance with treatment. This will help in follow up diagnostic tests, and proper documentation of treatment outcomes

III.OBJECTIVE OF THE STUDY

Analysis of tuberculosis surveillance with a view of enhancing current systems in Kenya

1. Theoretical Review

According to Kumar (2005) a theoretical framework is a structure that can hold or support a theory of a research work and provide a general framework for data analysis. The synthesis of existing theories and related concepts and empirical research, would help to develop a foundation for new theory development. This study utilized the theory of multi-agent systems in the design and development of the prototype of surveillance system.

2.Theory of Agents and MAS Systems

According to Wooldridge (2000) a software agent is an encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives.By ‘encapsulated computer system’is meant that there is a clear distinction between the agent and its environment. Moreover, the definition implies that there is a well-defined boundary and concrete interface between the agent and its environment.

The key aspect of the definition is autonomy, which refers to the principle that agents can operate on their own; without the need for human guidance. An autonomous agent has the control over its own actions and internal state, that is, an agent can decide whether to perform a requested action. The definition implies that agents are problem solving entities, with well-defined boundaries and interfaces, designed to fulfill a specific purpose that is, having particular goals to achieve, and exhibiting flexible and pro-active behaviour (Wooldridge, 2000).

IV.EMPIRICAL REVIEW

Burdakov, A et al, (2013) developed a mobile based surveillance system called Click Clinica. The application identifies major infectious diseases. It demonstrates how health surveillance can be improved with Electronic Integrated Disease Surveillance System using an example from Kazakhstan. Research shows that Smartphone applications have the potential to generate real-time disease surveillance data that may augment current methods.

Asif, M et al(2013) developed a real time GIS based public health surveillance systems based on web technology that uses maps and charts. It has proven useful to decision makers and public health officials for analysis and taking preventive actions against infectious diseases.According to the World Health Organization WHO, (2010), the incidence of tuberculosis in African countries more than doubled between 1990 and 2005 and is taking an upward trend (WHO, 2007).

According to Chaisson and Martinson (2008), Africa carries 29% of the world’s disease burden and 34% of the world’s total death rate. Kenya is ranked 15th among the world’s 22 countries with a high tuberculosis burden; with an estimated incidence of 355 cases per 100,000 people per year and mortality of 84 deaths per 100,000 people per year WHO, (2007), Centre for Disease Control CDC, (2005).

Jajosky and Groseclose 2004, in their research emphasised the importance of timeliness as a key performance measure of public health surveillance system. The sequence of events in reporting of information may delay the relaying of the information to the National level for decision making. The Figure below shows the steps in reporting of health incidents to the National Public Health System.

Koopmans, M. (2013) researched innovations in disease surveillance aimed at early detection of diseases of populations across the globe through international travel and trade. Chandrasekar, K (2013) did a comparative study of the existing disease surveillance systems of Sri Lanka and the UK.

They explored the possibilities of developing an information system suitable for the surveillance of diseases in Sri Lanka and proposed that the system be modelled for receiving notifications from various sources, and involving laboratories in disease

surveillance activities, and computerizing the existing surveillance system for notification to enhance the completeness and timeliness of reporting.

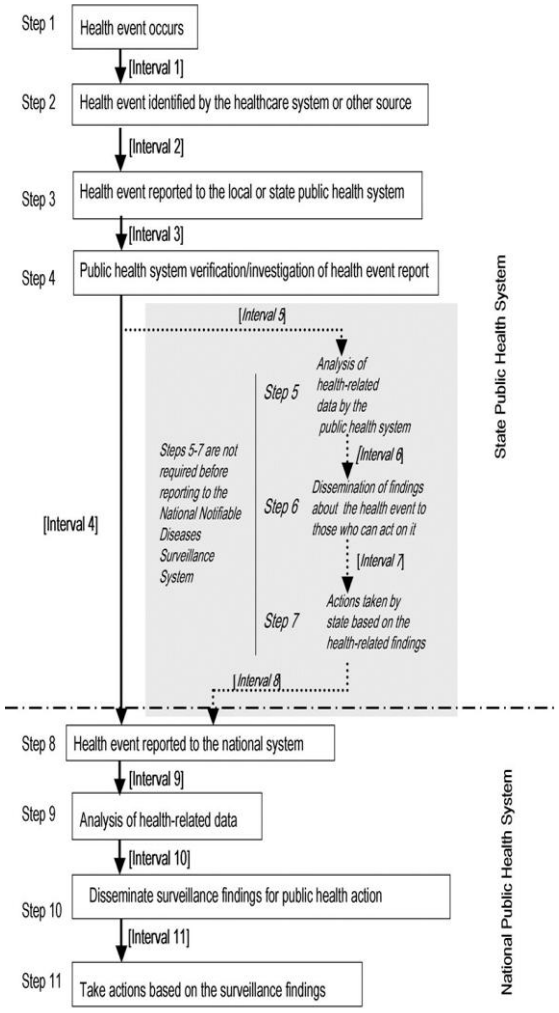

Fig.1 Health System Reporting Structure Model, Source: Jajosky and Groseclose, 2004.

Disease surveillance system's goal is to provide epidemiological data that is essential to control, prevent and respond to diseases (CDC, 2013).

In Kenya, epidemiologic surveillance is usually led by the Ministry of Health (MOH,2013), and they often still use traditional pen and paper methods of disease reporting. However, in the past decade, there has been a proliferation of electronic surveillance systems.

Table 1 Demographic Information.

Paper Based Surveillance Systems	Electronic Surveillance Systems
Well-established, standardized system of data collection and reporting	Time-saving (record reviews, patient follow-up)
Relatively low technology threshold required for implementation	Real-time report generation capability (standardized and ad hoc)
Can be easily implemented at all levels of health care	Allows for complex analyses
Low costs to implement and maintain	Increased accuracy and confidentiality controls
Difficult to rapidly detect variation in the quality of reporting between quarters and among administrative levels	Safer data maintenance (i.e., patient confidentiality and integrity)
Time-consuming manual entry, compilation, transfer and analysis of TB data	Dependent on a well-established paper-based system
Restricted' real-time 'quality control and validation of data for supervision	Increased infrastructure needs (e.g., computers, regular electricity supply)
Limited options for securing data to maintain patient confidentiality and prevent data loss	Specialized human resource requirements
	Specialized training and support requirements
	Higher implementation and maintenance costs

V.METHODOLOGY

This research employed an explanatory survey research design and used simple random sampling to conduct a survey within the Ministry of Health to identify and specify functional and non-functional requirements of the current system in use.

The study generated both quantitative and qualitative data which was collected using observation, document review and analysis of the questionnaires. The data was analysed descriptively using measures of central tendency and inferentially using regression model.

1.SamplingTechnique

The study was limited to Tuberculosis Surveillance Centre where the data collection and analysis is done. The Division has a staff population of 450 permanent employed. A sample size of 17 staff was targeted using systematic form as defined by Kothari, (2004) who recommends that a small proportion of targeted population can be selected.

2.Demographic Information

The survey setting was carried out at Ministry of Health staff (National Tuberculosis surveillance centre) composed of a number of different professions. The professions are indicated in Table 4below.

Table2 Comparison of the advantages and disadvantages of paper vs. electronic surveillance.

Profession	Total population	Number of Response	%
ICT officer	5	3	60%
Clinical officer	8	5	63%
Nurses	12	4	33%
Data clerks	8	2	25%
Registry officers	7	2	29%
Monitoring and Evaluation Officer	5	1	20%

The survey sample was selected on the basis of their organizations, profession disease surveillance roles in the National Tuberculosis monitoring unit. As such the respondents were better placed to have knowledge and access to accurate information that would be valuable in this research. Their distributions are indicated in Table 4.

3. Frequency of Data Collection

On the Frequency of receiving data by the TB surveillance unit, the response showed that most data is received quarterly. This indicates that the no instant reporting, the time taken to react to a new infection is so long that it allows for multiple infections before the cases are reported. The unit should therefore reduce the time taken to receive the cumulative reports from the various community health centers.

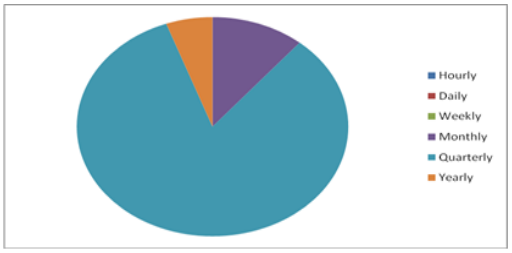

Fig.2 Frequency of Data Collection.

4.Validation

The validation process for the TB surveillance System provided a high degree of assurance that specific processes consistently provide products which met predetermined specifications and quality attributes. This factors were considered in relation to the existing system and operating environment. Various compliance procedures were conducted throughout the life cycle in view of user requirements and functional specification. The actors were designed as depicted in the figure below.

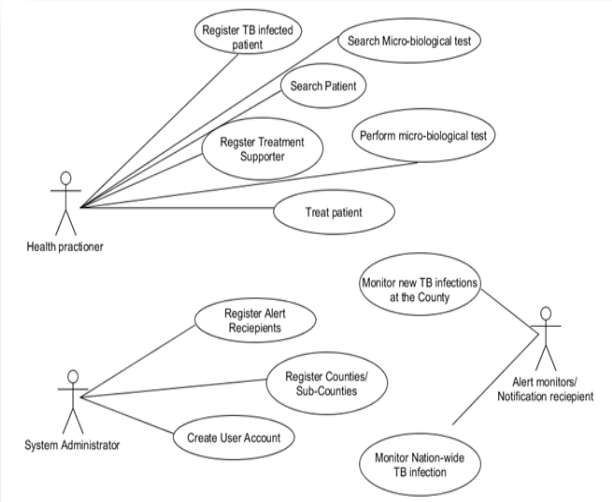

Fig.3 Actors Interactions.

5.Findings

The general objective of the study was to assess the status of the current TB surveillance system in Kenya. The findings is that TB surveillance in Kenya is functional but not effectively and efficiently to the advantage of the patients in the village level. While Tuberculosis pandemic continues to be a big problem of economic and social development of most developing countries, the researchers are convinced that the adoption of effective TB surveillance systems can greatly enhance emergency response and reporting and consequently the precision on the course of treatment.

The integration of short text messages (SMS) as part of surveillance system was assessed and this was found to improve patient's adherence to treatment schedules. Patients who received SMS reminders had significantly better compliance toattendance and response to medication improved than those who did not. The study sought to identify the challenges in TB surveillance in Kenya. The study established that in Kenya, TB surveillance systems were ineffective and health authorities would rather use manual surveillance

techniques to cover the entire country. This caused delay in relay of the data for analysis and hence inaccuracy and delay in taking a counter action to an occurrence. To address this the designed system was able to generate reports of new infections per county as shown in figure 2 below.

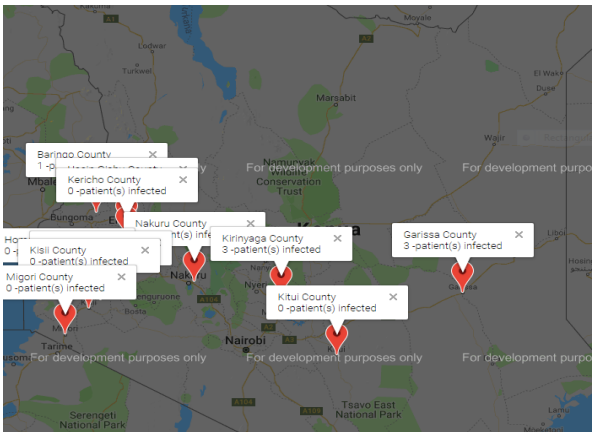

Fig.4 Geographical representation of the reported cases of infections per county.

VI.CONCLUSION

This study was able to establish that there is still room for improvement in the current system used for TB surveillance by the Ministry of Health. Timely reporting of new TB cases is the main challengein the current system and therefore the integration of Mobile technology with the surveillance system would help to increase the accuracy and effective decision making. Patients notification would reduce the drug resistance Tb has most patients are likely to adhere to the dosage schedules.The identificationof the patient's locations and use of reminders in form of both emails and short message services has the potential to improve patient's compliance to the treatment regimens that require repeat clinic visits or administration of treatments. Surveillance systems provides a snapshot of all the areas that have reported cases and this provides for an effective and efficient response measures to taken on time.

1.Recommendation

Based on the results of this study, there is need for improvement in the component of technology advancement to the system in the Ministry of Health to include mobile technology to link the patient and the medical practitioner. This would enhance the quality of medical services and accuracy of information held in the systems and hence quality decision making, resulting in timely mitigation and corrective measure against TB infections Thus an urgent intervention is needed to integrate the existing system with a patient notifying module in order to ensure that the effectiveness and accuracy in the TB treatment process is enhanced. The system should implement proper documentation methods for all the data collected mainly for the urgent notification of TB diseases and outbreaks data as well as for zero reporting. In addition, the TB surveillance system needs to develop a standard, regular and effective feedback system. The challenge is to respond quickly and properly to epidemics, thus formulation of standard rapid response team at all levels is the very first step in building effective epidemic preparedness in Kenya.

Further, strengthening of TB Surveillance support functions in Ministry of Health, Division of communicable diseases is inevitable for quality decision making. Adequate human resources at lower levels of the surveillance system as well as creation of incentive system, which would maintain committed personnel in the TB Surveillance Systems, are needed. Provision of supported, documented supervisory visits to the different levels and timely feedback might create additional support to sustain an effective TB Surveillance System that guides the public health decision making in Kenya**.**

2.Areas of Further Research.

It is therefore recommended from this research that for effective monitoring of the patients there is need to analyze the possibility of adopting the microchip implant technology, in the tracking and monitoring of the patients.

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