RESEARCH ARTICLE

Use of social media in a national Tuberculosis Drug Resistance Survey: lessons from the first anti-tuberculosis drug resistance survey in Ghana [version 1; peer review: 1 approved with reservations, 1 not approved]

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Abstract

Background: The widespread use of social media applications on mobile phones indicate that smart phones have become more than just a simple medium for voice calling. Several studies have shown the potential benefit of these social media applications in discussing many health conditions. We report on tracking sample transport by public and private transport providers using WhatsApp during the first nationwide drug resistance tuberculosis (TB) survey in Ghana.
Methods: The survey was conducted between February 2016 and June 2017, and involved 33 TB diagnostic sites selected on the basis of a two-stage cluster randomized sampling design on both anticipated yield and probability proportional to size method. We engaged the services of privately and publicly owned vehicles' union to transport samples to the central laboratories in Kumasi for further laboratory processing.
We created a mobile social group platform ('National TBDRS') on WhatsApp consisting of two representatives from each site as well as other stakeholders. The purpose was to notify a laboratory team in

Open Peer Review

Approval Status ✓ ?

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version 2 (revision) 18 Sep 2019	✓ view	? view
version 1 17 Jan 2019	? view	✗ view

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Any reports and responses or comments on the

Kumasi, on the following details of the sample: date and time of dispatch, driver's name, car number, estimated time of arrival, and bus terminal name.
Results: A total 3077 WhatsApp messages were received during the survey period. Of these, 2879 (93.57%) messages were related to the survey. We observed a positive correlation between the total number of messages received and the total number of well-packaged sputum samples sent (r=0.89, p=0.02). There were no major transport delays (11:44±03:50) and all samples arrived within a 3-day window from the survey sites.
Conclusions: Using WhatsApp as a platform of communication can significantly aid in improving tracking of samples, enhance accountability of for example drivers handling the samples over at a road crossing and communication across health facilities.

Keywords
WhatsApp, Tuberculosis, Ghana

article can be found at the end of the article.

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Author roles: Sylverken AA: Methodology, Project Administration, Supervision, Writing – Original Draft Preparation; **Owusu-Dabo E**: Conceptualization, Methodology, Writing – Review & Editing; **Kwarteng A**: Methodology, Writing – Original Draft Preparation, Writing – Review & Editing; **Twumasi-Ankrah S**: Methodology, Writing – Review & Editing; **Owusu M**: Methodology, Writing – Review & Editing; **Adu-Amoah L**: Methodology; **Dumevi RM**: Methodology, Writing – Review & Editing; **Arthur RA**: Methodology, Writing – Review & Editing; **Addofoh N**: Data Curation, Methodology, Writing – Review & Editing; **Dzata F**: Methodology, Project Administration, Writing – Review & Editing; **Bonsu F**: Methodology, Project Administration, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

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The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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List of Abbreviations

TB	Tuberculosis
KCCR	Kumasi Centre for Collaborative Research in Tropical Medicine
GPRTU	Ghana Private Road Transport Union
MTB	*Mycobacterium tuberculosis*
DRS	Drug Resistance Survey
WHO	World Health Organization
NTP	National Tuberculosis Control Programme
NRC	National Reference Center
KNUST	Kwame Nkrumah University of Science and Technology
CHPRE	Committee for Human, Publication, Research and Ethics
AFR/ERC	Afro Ethics Review Committee of the World Health Organization

Introduction

Availability of internet use on mobile phones has resulted in the increased use of social media applications[1]. Current examples of social media application platforms include Facebook, LinkedIn, Twitter, WhatsApp, Flickr and several others. Most of these applications are known to be inexpensive and, more often than not, completely free, and are easy to use and manage. Various studies have outlined key usefulness of these applications as social interaction, information seeking, entertainment, relaxation, communicatory utility, expression of opinion, information sharing, and knowledge about others[2,3]. While applications such as WhatsApp maybe useful in chatting and/or exchanging messages and pictures[4], its relevance in tracking infectious samples and logistics in resource-limited settings has not been fully explored. Particularly in resource limited areas, it will be important to explore the use of these applications in health care systems since there are indications that penetration of mobile phones, especially in rural areas, has increased such that there is no significant difference between rural and urban areas. On the contrary, some studies have indicated other usefulness of social media applications especially WhatsApp in discussing (exchanging messages) health-related issues[5,6] and in the conduct of surveillance surveys[7,8]. However, the usefulness of WhatsApp in particular in tracking infectious samples when they have been transported from health facilities to central laboratories for processing is yet to be fully explored. There is therefore a need to explore the usefulness of these applications especially in resource-poor countries in sub-Saharan Africa, where access to and use of mobile telephony and social media applications has increased dramatically over the past decade. We report on experiences of tracking transported samples using WhatsApp, during the conduct of the first anti-tuberculosis drug resistance survey for Ghana.

Methods

Facility selection

The survey began in April 2016 and involved 33 TB diagnostic clusters/facilities located in the 10 regions of Ghana (Figure 1). These sites were selected on the basis of a two-stage cluster randomized sampling design on both anticipated yield and probability proportional to size method, as described[9]. Apart from one facility that provided 87 smear positive sputum samples, all the other facilities were expected to send 29 smear positive sputum samples to the central laboratory in Kumasi.

Transportation and training

A privately owned vehicles' union, the Ghana Private Road Transport Union (GPRTU) agreed to transport sputum samples from health facilities to laboratories. The GPRTU has transport terminals across the country. We held meetings with the regional heads of GPRTU in 10 regional capitals of Ghana as well as with the heads and representatives of drivers of all GPRTU terminals located near the selected health facilities. These meetings were conducted in the local language and where appropriate, a translator was engaged. During these meetings, the aims and objectives of the nationwide TB drug resistance survey were explained and discussed. Assurance with regards to safety in transporting infectious samples was provided. Demonstrations of packaging and sealing of samples was given together with the name and telephone number of the study coordinator and the laboratory receptionist. Training on how to fill the drivers' part of the specimen transfer form was provided. The urgency in transporting the samples and associated forms to the respective bus terminals in Kumasi was pointed out. On reaching Kumasi, drivers were asked to call the laboratory to pick up the samples. Once the contents of the cooler box were retrieved, the empty cooler boxes were returned to the sending health facility by GPRTU. At each health care facility, two laboratory technicians were to identify who was responsible for transporting the samples and forms to the GPRTU bus terminal. They were also responsible for collecting returned cooling boxes.

WhatsApp platform

A mobile social group platform ('National TBDRS') was created on WhatsApp before the start of the DRS. There were two representatives from each of the 33 selected health facilities, and other stakeholders, including the NTP Manager and assistant, the NTP laboratory focal person and a representative of the national reference laboratory, were members of the platform. At KCCR, the principal investigator, survey coordinator, two laboratory technicians in charge of receiving the samples and the laboratory receptionist were also members of the WhatsApp group. The WhatsApp group was used to inform the KCCR team that samples were sent. In addition it was used as a means to track samples and locate missing samples. The following details were shared on the WhatsApp group about each sample: date and time of sample dispatch, driver's name, car number, estimated time of arrival and arriving bus terminal name. The health facility sending the sample could opt to send pictures of the vehicle's number plate as well as the part of specimen transfer form which

Figure 1. Map of Ghana showing the study facilities (Image: Google, 2016).

indicated the driver's details. Some health facilities sent pictures of the actual package as evidence that samples were transported. The team at the receiving end (KCCR) notified the sending health facility once samples had been received and the cooling boxes returned.

Only messages related to the DRS and sample transport were meant to be posted on the WhatsApp group. Survey health facilities were asked to notify the central laboratory at KCCR about logistics such as lack of consumables via the WhatsApp group. The group was administered by the KCCR receptionist and the survey coordinator.

Ethics approval and consent to participate

We obtained ethical approval from the Afro Ethics Review Committee of the World Health Organization (AFR/ERC/2016/02.01).

We also obtained clearance from the Scientific and Ethical review Committee of the School of Medical Sciences, Kwame Nkrumah University of Science and Technology (KNUST) and the Komfo Anokye Teaching Hospital, Kumasi (CHPRE/AP/328/15). Written informed consent was also obtained from each participant at the time of recruitment through signatures and thumbprints.

Data handling and analysis

All messages on the National TBDRS WhatsApp page sent between February 2016 when the page was created and June 2017 when the survey ended were copied into a Microsoft Word document. The document was aggregated into a Microsoft Excel file and cleaned by ensuring that all messages received from the facilities have all be captured. This was then exported to STATA (version 12.0; Stata Corp LP, College Station, TX, USA) for analysis. Descriptive statistics were summarized and displayed as charts and graphs. Pearson's Correlations between number of messages and number of samples were conducted. A value of $p<0.05$ was assumed as significant.

Results

WhatsApp messages

A total of 3077 WhatsApp messages were received between February 2016 and June 2017 (525 days) (Figure 2). Of these, the majority, 2879 (93.57%), were related to the survey while 17 (0.55%) were warnings to facilities that sent messages that were not related to the survey (Figure 3). Raw data are available on OSF[10].

A total 1958 (63.63%) of all messages were from the 33 survey sites, 1075 (34.94%) from KCCR, the implementers and 44 (1.43%) from NTP who played a supervisory role. The platform consisted of 106 members, with at least three members per site, including NTP and KCCR.

Of the total 1958 messages, each health facility sent a minimum of 5.86 messages and an average of 55.59±23.37 messages during this period. When comparing the number of messages concerning the number of sputum samples received at the central laboratory, a total of 955 sputum smear positive samples were transported from the survey sites. Of this total, 2879 messages were from the survey sites, the highest number 112 (3.89%) was sent by Lawra, a facility in the Upper West region. This facility sent a total of 26 samples out of an expected 29 samples. The least number of messages (2 in total) was sent by Bawjiase and Holy Family Hospital in the Central and Eastern regions, respectively. While Bawjiase sent one sample, Holy Family Hospital sent four samples out of the total 29 samples that each cluster was expected to send. There was a positive correlation between the total number of messages received and the total number of samples sent ($r=0.89$, $p=0.02$).

Mode of transportation

Of the total 955 samples received from the survey sites, facilities employed GPRTU, Courier, Metro Mass Transport, VIP and others in transporting the samples. Significantly, a higher proportion of samples were sent through GPRTU services than by any other means. There were no major delays (11:44±03:50) and all samples arrived within a 3-day window from the survey sites.

Discussion

Mycobacterium tuberculosis infection poses a major public health concern in several TB endemic countries[11]. However, despite the existence of well-structured treatment regimens against TB in most endemic countries[12], field-related challenges such as transportation/tracking of TB samples to referral hospitals and timely delivery of logistics to health centers, remain to be addressed. Even though some mobile-phone-based health application systems are currently in place, the use of mobile-phone applications to track infectious samples and logistics in a national survey is yet to be explored. In the current study, we assessed the feasibility of using WhatsApp to track samples and logistics among selected health facilities and other stakeholders in the first ever Tuberculosis Drug Resistance Survey (TBDRS) in Ghana. Results of our work on using this mobile-based application indicate the usefulness of using WhatsApp to track infectious samples from 33 survey sites to a central laboratory in Ghana for the first time.

In this study, the majority (94%) of the messages served the purpose for which they were intended and thus correlated with the

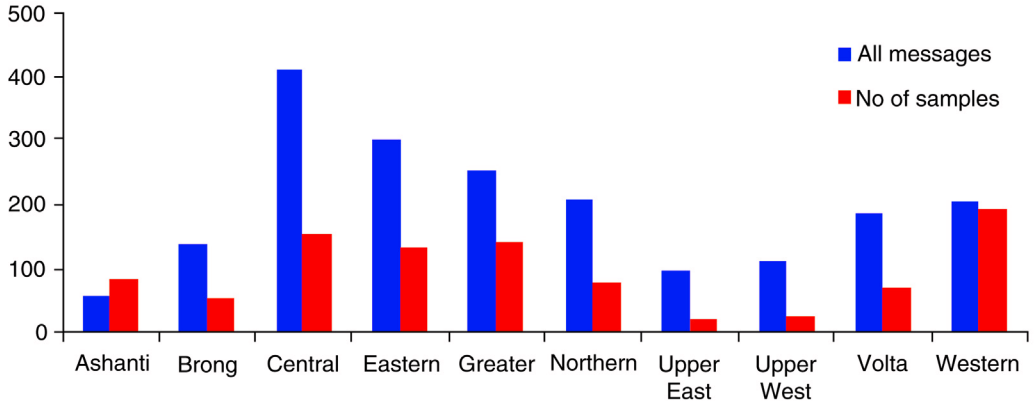

Figure 2. Total number of samples and messages sent by the clusters.

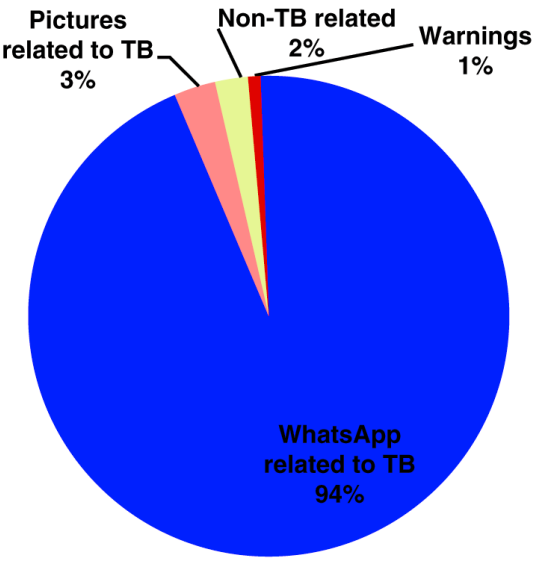

Figure 3. Categories of WhatsApp messages received during the study period.

number of samples obtained from each facility. However, a few of the messages, i.e., less than 1% were not suitable for the purpose for which the platform was created. This is not uncommon, given that WhatsApp is a social media and that the decision to send a study-related message solely relied on the user, despite several warnings from group administrators at KCCR. Our findings corroborated those of Dorwal *et al.*, who demonstrated the role of WhatsApp in laboratory management systems and improved communication amongst several partners and stakeholders in their facilities[13]. The authors highlighted some user inconveniences, such as the misdirected or irrelevant spread of information. In a similar scenario, social media has been used to facilitate communication between patients and health workers[14]. A recent study in London including an emergency surgical team and patients concluded that WhatsApp is a safe and efficient communication technology for use in clinical settings[15]. The technology has also been explored for medical consultation at hospitals where physicians were not stationed in referring health facilities[16].

The use of internet-based resources has the potential to maximize distribution of logistics and information especially in resource-limited settings and therefore crucial to curtailing most infectious diseases. In this study, we observed that the ease of transmission of information via WhatsApp significantly facilitated the transport of TB samples from the 33 survey sites in the country despite obvious transportation network challenges by improving communication among several study teams. We show that the highest number of samples and logistics in the current study were sent via GPRTU (72%) compared to other transport services. Interestingly, the highest number of messages 112 (3.89%) and samples (26/29, 89.65%) were received from Lawra Government Hospital, a facility in the Upper West region. Lawra is approximately 530.6 kilometers from Kumasi, which is the farthest among the study facilities from KCCR. What could have accounted for the highest number of messages from Lawra is the type of transportation used to and from this facility. In contrast to many other facilities, where GPRTU was the main means of transport, Opoku Agyemang (OA) transport was the only recognized transport service to Lawra from Kumasi and there was constant communication between KCCR and the facility to ensure timely delivery of samples and logistics. The least number of messages (2 in total) were sent by Bawjiase and Holy Family Hospitals in the Central and Eastern regions, respectively. While Bawjiase Hospital sent one sample, Holy Family Hospital sent four samples out of the total 29 expected samples. This could be due to the fact that there was no direct means of transport from these sites to Kumasi, KCCR, therefore, accounting for the poor performance of these sites during the entire study.

While relatively few studies have used WhatsApp to track infectious samples and logistics, we have demonstrated in the current study that such an approach is innovative and can enhance existing tools and control strategies not only against *M. tuberculosis* infection, but also other infectious diseases as well as in natural disasters. Our findings are consistent with a recent study, where health workers used WhatsApp to coordinate specific medical resources (such as supplies, equipment and personnel) for affected people during the 2015 Nepal earthquake[17]. Elsewhere, WhatsApp improved information sharing among doctors and patients in real-time during an influenza outbreak in Gujarat, India[18]. Although the authors supported the use of social media for disease surveillance and outbreak management, privacy of patients' data was a major concern and thus the need to broaden ethical frameworks before integrating social media into public health surveillance programs.

A major limitation of WhatsApp is the security and privacy issues. Given that WhatsApp can replace paper or email for the rapid transfer of information and logistics, serious considerations will be needed to address privacy of patients' information[19]. Currently, the content of any delivered messages reside directly on the sender's and recipient's mobile devices. The Terms of Service of WhatsApp clearly states: "You shall be solely responsible for your own status submissions and the consequences of posting or publishing them." While WhatsApp is free and can be embedded with multimedia files compared to traditional SMS (messaging) platforms, it can be seen as a time-consuming and inconvenient medium, especially when one has to transcribe all patients' clinical data by typing.

Although the use of WhatsApp remains to be comprehensively explored in the health sector, data from this study suggest that, the application has enormous potential to significantly revolutionize information transmission/communication among health workers, patients and stake-holders, especially in resource-limited settings. Given that the global strategy to eliminate TB emphasizes the need for country adaptation and prioritization in accordance with the local epidemiology and the healthcare systems, we anticipate that the findings from this study may contribute significantly to bringing this objective much closer to reality in Ghana.

Conclusion

The present study shows that the prudent use of WhatsApp, a social media application, can significantly aid in improving

communication across health facilities and tracking potentially infectious samples from remote areas. The application of the platform ensured timely intervention/action, and supported information-sharing amongst partners and stakeholders, which ultimately translated in improved samples transport during the TBDRS study in Ghana for the first time.

Data availability

The data underlying this study is available on OSF. DOI: https://doi.org/10.17605/OSF.IO/58X62[10].

Author information

Dr. Augustina Angelina Sylverken is a Lecturer at the Department of Theoretical and Applied Biology, KNUST, Ghana. She is interested in the characterization of novel viruses and public health related issues.

Grant information

This work was supported by the Global Fund Round 6. The content is solely the responsibility of the authors and does not necessarily represent the official views of Global Fund. Augustina Angelina Sylverken is an affiliate of the African Academy of Sciences.

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Acknowledgements

We appreciate the effort of all the 33 TB diagnostic sites involved in the first ever TB DRS work for Ghana. We also thank the WHO country office and the National TB control program for supporting this work. We are grateful to the entire KCCR team for giving us the platform to conduct this study.

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PubMed Abstract | Publisher Full Text

Open Peer Review

Current Peer Review Status: ? ✗

Version 1

Reviewer Report 20 May 2019

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✗ **Rashmi Rodrigues**
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[2] Department of Public Health Sciences, Karolinska Instituet, Stockholm, Sweden

Dear Authors,
First of all, I congratulate your efforts towards the development of the manuscript, including, the research work involved. The efforts to eliminate Tuberculosis (TB) have gained fervor in the recent years and any effort towards TB prevention and control will go a long way in achieving this goal.

I have read your manuscript and am of the opinion that it will do well with a few corrections and clarifications. Please find below my comments which I hope will enable a better understanding of your work when addressed.

Introduction:
While the researchers have addressed the use of Information Communication Technology (ICT) in healthcare it would be good to have an idea of the burden of TB and drug resistant TB in Ghana.

Also, some information of the extent of use of ICT, especially mobile phones, used would be useful along with costs of communication via such technology.

Methods:

Information regarding the existing TB diagnostic guidelines and the relevance of testing for drug resistant TB would set the stage for the methods applied in the manuscript.

As I understand, this work is within the survey to assess the prevalence of DR TB in Ghana, that used cluster sampling, please note the use of terminology- ‘randomized’ is used when the study is a randomised controlled trial- i.e., cluster randomized controlled trial, what you mean is probably ‘2 stage cluster random sampling’ a variation of cluster sampling where probability proportional to size may also be used.

Transport: What were the kindly of vehicles involved? Were they buses or cars or a lorry or all?

Please describe the flow of the sample from the point of origin to the point of testing. Who was responsible for collecting the samples? Who was responsible for packing the samples? How were the samples packed - it would be good to understand the packaging? Were there any special requirements for sample transport such as cold storage? What was the ambient temperature in the vehicles and outside during sample transport?

Please state the optimal temperature and time that a sample can be stored once collected.

What were the kinds of samples collected - was it only sputum or were there samples of any other body fluids or tissues? If it was only sputum, was there any specific reason why the drug resistance survey restricted to only sputum samples?

What were the contents/components of the packages (other than samples) and how were both the samples and the packages labeled?

What was the reason for explaining the packaging procedure to the drivers involved? What were the instructions given to the drivers if the packaging was damaged in transit? What did the drivers actually do when this happened? How many such instances were there? What were the instructions if the driver accidentally came in contact with sample contents? Was there a protocol and was it followed?

You mention the cooling box at the end of the paragraph on transport and training - it would be good to describe the packaging and equipment in a separate paragraph.

What were the contents of the form the drivers had to fill?- please provide this as an annexure and refer to it in the methods.

Whatsapp platform:

My understanding is that there were 33 sites from which the samples were being sent, which means there were >66 individuals that included other stakeholders on the whatsapp group. Were the people included using their personal mobile phones for this? If yes, how did each site identify itself while messaging? What were the protocols followed if the messaging site did not get a response to their message? How did the receiving laboratory keep track of the messages received and link the messages to the package received. Was a response provided on the platform when a sample was received? How often did the receiving site check the messages on the whatsapp group- were alerts created when a message came in, if yes what kind of alerts were they?

How were the samples tracked through the group especially as the drivers responsible for transport were not in the group?

Were there additional phone calls involved in tracking. Were phone calls also made from site to laboratory in addition to whatsapp messaging? If yes, do you have a record of these?

Data handling and analysis: It would be good to know the following - the mean/median time taken

for sample delivery, the number of delays, the number of samples lost, if any, the number of packages damaged in receipt. Please list the variables you are presenting including outcome variables in this section.

Results:

How many messages were received per day, maximum and minimum? How many messages were received per sample received?

You mention other modes of transport in addition to GPRTU, however this has not been described in the methods. The impression from the methods is that only one transport provider was involved in transporting samples. Please clarify.

Discussion:

The discussion should involve the issues faced in implementing the ICT intervention and how they were addressed and overcome.

If additional phone calls were made would it be possible for you to say that the success of the intervention in terms of the number of samples successfully delivered was because of only the Wahtsapp platform?

Please discuss the limitations of your study - for example biases involved, issues with methods.

Conclusions:

This states that social media significantly aids improving communication and tracking - how did you assess a 'significant improvement'? To make this statement the study design should have involved a comparison - either of the number of samples delivered and time taken for the delivery of the samples before and with the intervention or a comparison of two groups one which did not involve the ICT intervention that you used and the other that did. Hence, it would be best to rephrase the sentence.

Referencing:

Uniformity of citations in the text is necessary based on the Journals requirements- e.x., Dorwal *et al* is mentioned in the discussion for one of the citations.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: mHealth, tuberculosis, health systems, infectious disease epidemiology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 04 Sep 2019

AUGUSTINA ANGELINA SYLVERKEN, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Dear Authors,
First of all, I congratulate your efforts towards the development of the manuscript, including, the research work involved. The efforts to eliminate Tuberculosis (TB) have gained fervor in the recent years and any effort towards TB prevention and control will go a long way in achieving this goal.

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While the researchers have addressed the use of Information Communication Technology (ICT) in healthcare it would be good to have an idea of the burden of TB and drug resistant TB in Ghana.

Also, some information of the extent of use of ICT, especially mobile phones, used would be useful along with costs of communication via such technology.

Response: We thank the Reviewer for this recommendation. Unfortunately, before this study, there was no information on the nationwide burden of drug resistant TB in Ghana. Indeed individuals have conducted studies in country but not on a national scale.

Methods:

Information regarding the existing TB diagnostic guidelines and the relevance of testing for drug resistant TB would set the stage for the methods applied in the manuscript.

Response: We thank the Reviewer for this comment. However, we are of the opinion that since the focus of the paper is not TB diagnostics, including information on existing TB diagnostic guidelines would change the focus of the paper.

As I understand, this work is within the survey to assess the prevalence of DR TB in Ghana, that used cluster sampling, please note the use of terminology- 'randomized' is used when the study is a randomised controlled trial- i.e., cluster randomized controlled trial, what you mean is probably '2 stage cluster random sampling' a variation of cluster sampling where probability proportional to size may also be used.

Response:
We mean a two-stage cluster sampling design. We have revised this in the manuscript.

Transport: What were the kindly of vehicles involved? Were they buses or cars or a lorry or all?

Response: The vehicles used were buses and lorries. We have included the type of vehicles used during the study in the manuscript.

Please describe the flow of the sample from the point of origin to the point of testing. Who was responsible for collecting the samples? Who was responsible for packing the samples? How were the samples packed - it would be good to understand the packaging? Were there any special requirements for sample transport such as cold storage? What was the ambient temperature in the vehicles and outside during sample transport?

Response: The Technicians at the respective TB diagnostic sites were responsible for collecting and packaging the samples into cold boxes. The samples in a TB container were parafilmed and double-packed into a zip lock bag. This pack was put in a cold box with ice packs and transported to KCCR laboratories.

Please state the optimal temperature and time that a sample can be stored once collected.

Response: At the TB diagnostic site, laboratory technicians could store the samples received at 2-8^{o}C for at least one day. However, they were urged to transport the samples as soon as they had been collected from the patients.

What were the kinds of samples collected - was it only sputum or were there samples of any other body fluids or tissues? If it was only sputum, was there any specific reason why the drug resistance survey restricted to only sputum samples?

Response: For the purposes of this study, we restricted ourselves to only sputum. This is because at the diagnostic centres, only sputum is collected and tested for TB.

What were the contents/components of the packages (other than samples) and how were both the samples and the packages labeled?

Response: The sample containers were labelled with codes generated and sent to all diagnostic sites. The same code was also placed on the ziplocked bags which contained the questionnaire. The cold box was labelled with the name of the diagnostic site and phone numbers of the Technicians on the platform. The other package was the questionnaire which was put in a zip lock bag and sealed.

What was the reason for explaining the packaging procedure to the drivers involved? What were the instructions given to the drivers if the packaging was damaged in transit? What did the drivers actually do when this happened? How many such instances were there? What were the instructions if the driver accidentally came in contact with sample contents? Was there a protocol and was it followed?

Response: The Technicians who took the samples from the patients were to ensure that sample containers with samples were well-closed and parafilmed. This was to prevent any leakage before taking them to the drivers. The drivers were only transporting the sample and were not allowed to open the cold box. However the drivers were informed about the contents of the box which included the sealed sample, questionnaire and cooling elements.

You mention the cooling box at the end of the paragraph on transport and training - it would be good to describe the packaging and equipment in a separate paragraph.

Response: We thank the reviewer for this. We have included a paragraph which spells out the packaging of the samples.

What were the contents of the form the drivers had to fill?- please provide this as an annexure and refer to it in the methods.

Response: The contents of the form the drivers had to fill included; indicate whether specimen was kept on ice, the mode of transport, name of driver, vehicle's registration number, driver's contact and signature. We have included this as an annexure as

recommended.

Whatsapp platform:

My understanding is that there were 33 sites from which the samples were being sent, which means there were >66 individuals that included other stakeholders on the whatsapp group. Were the people included using their personal mobile phones for this? If yes, how did each site identify itself while messaging? What were the protocols followed if the messaging site did not get a response to their message? How did the receiving laboratory keep track of the messages received and link the messages to the package received. Was a response provided on the platform when a sample was received? How often did the receiving site check the messages on the whatsapp group- were alerts created when a message came in, if yes what kind of alerts were they?

Response: Those on the whatsapp group used their personal mobile phones. The phone numbers for the Two Technicians per facility had an identifier. In saving their names, the Administrator added a unique identifier such as Name of the Technician_facility name_1 and Name of the Technician_facility name_2. As such, in identifying themselves during messaging, these identifiers popped up.
It was almost impossible for the messaging site not to get response. The more reason why at the sample receiving laboratory, there was the Principal Investigator, the Survey Coordinator, Receptionist and two laboratory technicians in charge of receiving the samples who were members of the WhatsApp group.
The transport boxes were labelled with the NAMES of the TB diagnostic sites which synchronized with how the Administrator of the page had also saved or stored their names on the platform. All these were used as identifiers in linking the messages to the package received.
As described in detail under the 'WhatApp platform, notifications where provided in the platform when a sample was sent as well as when it was received. At the receiving site, the Receptionist and the Survey Coordinator had to check constantly on the 'National TBDRS' whatsapp platform for messages.
Notifications in the form of sounds were received when a message was sent to the WhatsApp page. These were in the form of an audible alert plays.

How were the samples tracked through the group especially as the drivers responsible for transport were not in the group?

Response: Indeed, the drivers were not in the group but their phone numbers were put on the platform. In the course of their journeys, the Receptionist and or the Coordinator could call them to know where they had reached in the journey. This gave the receiving lab an idea about when the package was likely to get to the transport terminal.

Were there additional phone calls involved in tracking. Were phone calls also made from

site to laboratory in addition to whatsapp messaging? If yes, do you have a record of these?

Response: Yes, there were additional phone calls but only to some drivers. This was because they were not part of the whatsapp group. These calls were mainly during the initial stages of the study. We do not have a record of these calls.

Data handling and analysis: It would be good to know the following - the mean/median time taken for sample delivery, the number of delays, the number of samples lost, if any, the number of packages damaged in receipt. Please list the variables you are presenting including outcome variables in this section.

Response: We thank the reviewer for this. This has been incorporated as suggested.

Results:

How many messages were received per day, maximum and minimum? How many messages were received per sample received?

Response: We did not segregate the messages vis a vis samples received per day. However, altogether, a total 2879 messages accompanied 955 sputum smear positive samples from the survey sites.

You mention other modes of transport in addition to GPRTU, however this has not been described in the methods. The impression from the methods is that only one transport provider was involved in transporting samples. Please clarify.

Response: We apologise for this omission in the methods though we have captured it in the results and discussion. We have described this in the methods under the section 'Transportation and Training'.

Discussion:

The discussion should involve the issues faced in implementing the ICT intervention and how they were addressed and overcome.

If additional phone calls were made would it be possible for you to say that the success of the intervention in terms of the number of samples successfully delivered was because of only the Wahtsapp platform?

Response: We thank the Reviewer for this. Indeed, the additional calls were made only to some of the drivers. This study aimed at exploring how this ICT and a social media application could be used between labs and how useful they can be applied in low and

middle income countries settings. We are careful in saying that only the WhatsApp played a role but the fact that we utilized this application in our settings is worthy.

Please discuss the limitations of your study - for example biases involved, issues with methods.

Response: These have been discussed under the discussion section.

Conclusions:

This states that social media significantly aids improving communication and tracking - how did you assess a 'significant improvement'? To make this statement the study design should have involved a comparison - either of the number of samples delivered and time taken for the delivery of the samples before and with the intervention or a comparison of two groups one which did not involve the ICT intervention that you used and the other that did. Hence, it would be best to rephrase the sentence.

Response: We thank the Reviewer for this observation and we totally agree with him. We have revised this statement since there was no comparison in this case.

Referencing:

Uniformity of citations in the text is necessary based on the Journals requirements- e.x., Dorwal *et al* is mentioned in the discussion for one of the citations.

Response: We stuck to the referencing style of this journal. Dorwal et al has the citation given in full (12).
Dorwal P, Sachdev R, Gautam D, Jain D, Sharma P, Tiwari AK, et al. Role of WhatsApp Messenger in the Laboratory Management System: A Boon to Communication. Journal of medical systems. 2016 Jan;40(1):14.

End of response

Competing Interests: No competing interests were disclosed.

Reviewer Report 08 April 2019

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Review Comments

- Can authors further enlighten on how WhatsApp was used in tracking the samples and logistics? Was any tracking done in-between travel points? Was Estimated Time of Arrival (ETA) a factor in tracking? Authors should analyse and show data on ETA and how relevant the app was in tracking, preparation to pick up and delivery of the samples to the central lab was.

Methods/Results

1. Materials used for packaging the samples must be indicated since they are infectious.
2. Authors should be consistent with dates the study began. In the methods section it is stated as April 2016 while elsewhere it is February 2016. This should be clarified.
3. Can authors provide details of distances travelled by the samples and delivery times? These will help evaluate the timing of delivery and whether samples arrived intact.
4. Under “Transport and training” authors said samples were transported to “laboratories”. Can this be verified as to the number of labs that samples were transported to?
5. Contact and discussion was held with only GPRTU but results indicate otherwise. Can authors explain how the other transport services were engaged and whether they had similar training for drivers as they did with the GPRTU drivers.
6. How many laboratory technicians were identified and enrolled unto the platform? This information is conflicting under the last paragraph on “Transport and training”.
7. Was there any time during the study participants were made to evaluate and share their experiences (satisfaction or otherwise) about the process? Was there any assessment of their challenges to the arrangements?
8. Data on ETA is lacking. These would be very important to understand how promptly samples were delivered with the right containment ensured.
9. Data on the number of samples from each of the survey sites should be indicated.

Discussion

1. Authors in the 3rd paragraph indicated that WhatsApp significantly facilitated the transport of TB samples. This conclusion is a bit worrying since there is no data to show how this significance was arrived at.
2. Meanwhile the facilities that delivered less samples, was it the case that they had the samples but due to transport difficulties could not send them or the samples they sent were the only ones they had within the period? Were these communicated via the app as well?

Conclusion

- Emphasis has been on the use of WhatsApp to track infectious samples from remote areas. The survey areas used, were they all remote areas? Authors should please justify.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
No

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: 1. Mechanisms of Antitumor Immunity of Natural & Synthetic Products. 2. Differentiation and Proliferation of T-Cells in Microbial Infections. 3. Mechanisms of Immunity and Infection of Microorganisms. 4. Clinical Ethical Practices and Jurisprudence. 5. Role of Mitochondria in Immune Response to Infections

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 04 Sep 2019

AUGUSTINA ANGELINA SYLVERKEN, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

· Can authors further enlighten on how WhatsApp was used in tracking the samples and logistics? Was any tracking done in-between travel points? Was Estimated Time of Arrival (ETA) a factor in tracking? Authors should analyse and show data on ETA and how relevant the app was in tracking, preparation to pick up and delivery of the samples to the central lab was.
Response: We thank the reviewer for these comments. In using WhatsApp to track the samples and logistics, information on samples sent by the TB diagnostic facility was put on the platform as soon as the sample was dispatched from the facility.
There was no tracking done in-between travel points since the drivers who transported the samples were not on the WhatsApp platform. However, since their phone numbers were put on the platform, staff at the receiving laboratory could call them to check where they had gotten to in the travel.

Methods/Results
1. Materials used for packaging the samples must be indicated since they are infectious.
Response: We thank the reviewer for this comment. We have captured a section under

'Packaging of samples' under 'Methods' and in the manuscript.

2. Authors should be consistent with dates the study began. In the methods section it is stated as April 2016 while elsewhere it is February 2016. This should be clarified.
Response: We thank the reviewer for taking notice of this. The survey began in February 2016. We have revised this in the manuscript.

3. Can authors provide details of distances travelled by the samples and delivery times? These will help evaluate the timing of delivery and whether samples arrived intact.
Response: We have provided the map of Ghana with facilities included in the study highlighted. Moreover, we have indicated the average delivery times samples were received. The issue about samples arriving intact is debatable. We did not create a criteria for sample intactness since intactness can span from sample packaging to test result. We have carefully omitted the sample testing in this manuscript so we stick to only the transportation/tracking of infectious samples.

4. Under "Transport and training" authors said samples were transported to "laboratories". Can this be verified as to the number of labs that samples were transported to?
Response: We thank the reviewer for this. The samples were sent to only one laboratory but the laboratory has several sections. We have revised the sentence to 'samples were transported to the bacteriology department of the Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR) laboratories'. We hope this clarifies the confusion.

5. Contact and discussion was held with only GPRTU but results indicate otherwise. Can authors explain how the other transport services were engaged and whether they had similar training for drivers as they did with the GPRTU drivers.
Response: The other transport services were not engaged since majority of the diagnostic sites used GPRTU services.

6. How many laboratory technicians were identified and enrolled unto the platform? This information is conflicting under the last paragraph on "Transport and training".
Response: Two laboratory representatives were added to the platform as explained under the section 'WhatsApp platform'.

7. Was there any time during the study participants were made to evaluate and share their experiences (satisfaction or otherwise) about the process? Was there any assessment of their challenges to the arrangements?
Response: Participants shared challenges on the platform. This included the unwillingness of few drivers within the GPRTU to transport the samples. This was expected since not every single driver had received information about the study. However, as soon as theheads and or representatives of drivers of such GPRTU terminals were notified, they contacted the

driver and the issue/s was/were resolved.

8. Data on ETA is lacking. These would be very important to understand how promptly samples were delivered with the right containment ensured.
Response: We indicated an average of 11:44±03:50 as actual transport time. ETA would have been difficult to estimate since this depends on several factors. One key factor is the condition of the road. If the road is in a bad shape, it will mean an increased ETA. This is one key reason we did not provide data on ETA but provided information on the actual transport time samples were received.

9. Data on the number of samples from each of the survey sites should be indicated.
Response: This has been indicated in Figure 2. 'Total number of samples and messages sent by the clusters'.

Discussion
1. Authors in the 3rd paragraph indicated that WhatsApp significantly facilitated the transport of TB samples. This conclusion is a bit worrying since there is no data to show how this significance was arrived at.
Response: We agree that the use of 'significantly' may sound worrisome. The word significantly has been removed from the sentence.

Meanwhile the facilities that delivered less samples, was it the case that they had the samples but due to transport difficulties could not send them or the samples they sent were the only ones they had within the period? Were these communicated via the app as well?
Response: As indicated in the manuscript, for the two facilities; Bawjiase and Holy Family Hospitals, there was no direct means of transport from these sites to Kumasi where the laboratory is located. At the end of the study, cross checks made by National Tuberculosis Control Programme indicated these sites had samples alright but the challenge was transportation. Indeed these two facilities presented a real case scenario for the study and even for NTP.

Conclusion
· Emphasis has been on the use of WhatsApp to track infectious samples from remote areas. The survey areas used, were they all remote areas? Authors should please justify.
Response: We thank the reviewer for this. Not all the study sites are located in remote areas. A combination of 'distant and remote' areas may seem appropriate in this case. This has been revised in the manuscript.

Competing Interests: No competing interests were disclosed.