A Quantified Cloud Base Polio Vaccination Management Information System (QCloudMIS)

Rasheed Olabisi Owolewa[1*] Pritheega A/P Magalingam[2]

Universiti Teknologi Malaysia

Razak Faculty of Technology and Informatics

roowolewa@graduate.utm.my[1], mpritheega.kl@utm.my [2]

Article history

Received:
20 Sept 2019

Received in revised form:
31 Oct 2019

Accepted:
20 Dec 2019

Published online:
30 Dec 2019

*Corresponding author
roowolewa@graduate.utm.my

Abstract

Polio Supplemental Immunization Activities (SIAs) are components of the global polio initiative set out by the world health assembly (WHA) in 1988. While the strategy has helped to interrupt the transmission of wild poliovirus in most countries. The Percentage of positive change needs to be improved upon. Polio and immunization reporting in Africa, Nigeria has traditionally been paper-based. This study assessed the existing polio immunization coverage and proposed a cloud-based framework to enhance quality of data, report and documentation including tracking rural health workers. The proposed solution is a cloud-based health information management system designed specifically for health workers in remote and challenging areas, it allows Health workers to register beneficiaries into health programs like polio vaccination, screen them for high-risk infection, submit stock reports of vaccination and report disease outbreaks as against the manual system. which delayed and lack adequate data quality. QCloudMIS technology also helps to track field exercise and reporting using offline cloud mobile cloud. While the existing technological solution depends on Standalone local server or device memory for storage, this study uncovers their limitations and proposed that cloud-based HMIS can improve health care service delivery and enhance the administration of Vaccines in rural communities.

Keywords: *Cloud technology, Mobile health technology, Health Management Information System, Polio vaccination.*

---

1. Introduction

Polio Supplemental Immunization Activities (SIAs) are part of the global polio eradication initiative strategies set out by the world health assembly (WHA) in 1988 (GEPEI, 2015). The program has engaged the usage of technology in innovative ways to map activities of polio workers and ensure that expertise and support are getting to the areas where it is most needed. While this activity has helped to interrupt polio in most countries, developing countries including Nigeria has benefited from polio intervention. Including countries like Pakistan, Afghanistan, and Somalia, yet they still have high cases of Poliovirus (GEPEI, 2015).

Nigeria has adopted a different system to kick the disease out from her boundary, this includes strong routine immunization exercise. The country has achieved close to 80%, Mop-up coverage and still maintaining active surveillance (NCDC, 2017). Against this background, the fight against Polio is a continuous

exercise in Nigeria as more birth children are birthed every day such an outbreak is very essential to curtail. Apart from maintaining close coordination with partners and civil society, etc.

---

* *Corresponding author. roowolewa@graduate.utm.my*

Basic laboratory and disease surveillance systems have been launched and this has attracted international collaboration. The intervention will make polio assignments activities easier. Notable among the technology interventions are the Open data kit (ODK) and the Vaccination Tracking System (VTS). ODK is an open-source technology innovation tool that can be easily configured for specific projects. It was launch into the Nigeria health system as a response to check disease Outbreak (Tomori, 2019).

The Vaccination Tracking System (VTS) is an android application designed to monitor vaccination exercise. The application records the GPS tracks in a database for proper monitoring. These tools are deployed to help vaccination campaigns. However, due to inaccurate and incomplete hand-drawn maps and other similar constraints, the significance of such technology has not reflected on the vaccination improvement (I. Barau, M. Zubairu, M. Mwanza, & V. Seaman, 2014). Hence the coverage and report on vaccination depend on a traditional manual system which gives the impression that there is little usage on technology on health care services

Vaccination is being done house to house visits and reported on a printed manual sheet. This can account for some children not being captured and reported. The manual system results in large work exercise for vaccinators in rural areas.
Hence, Challenges such as high workload on vaccinators, manual record management, the low caliber of people selected and sub-optimal pose challenges to Improving Polio Vaccination Coverage and documentation in Nigeria. This study observed the effect of this challenge on children and affected areas in Nigeria. The study proposed an enabling technology solution specifically mobile cloud computing polio information management system including tips for Successful Polio Vaccination Coverage and monitoring in the affected areas.

Cloud computing is a technology that allows scalable on-demand sharing of resources among a large number of end-users from different geographical locations. It enables end-users to process, manage, and store data efficiently at very high speeds at reasonable prices. Cloud computing can be classified into private, public, community and Hybrid cloud depending on the choice of the users with different service delivery including Software as a service (SaaS), Infrastructure as a service (IaaS) and Platform as a service (PaaS) (Mell & Grance, 2012).

2. Review of existing technology in the Health Management Information System

Health data collection in Africa has traditionally been paper-based. However, recently much has been concentrated to addresses the issues of vaccination failure in some countries. The usage of Mobile health information technology has been in circulation ever since the passage of Health Information

Technology for Economic and Clinical Health Act in 2009, the use of health information technology, particularly EHRs, has dramatically increased (Xierali et al., 2013).

Electronic data collection tool using android has been used alternatively to collect field data in some African countries. Open Data Kit (ODK), has been introduced to collect data in form of survey (Hartung et al., 2010). However, the use of these tools suffered from lack of internet broadband and electricity. The like the ODK is a valuable tool to document a reliable vaccination visit in a professional manner, however, there is a lack of access to poor quality or non-availability of health facility records (GPEI, 2019).

If only there is the right existing data, populations, or health facilities based record, this technology could influence the reporting patterns of health information records. This health information records can then be integrated into the robust polio information system (POLIS). The integration will enable the system to report what was done and what was not. Hence, the use of open data kit in Nigeria only collect disease information in few states vaccination monitoring and checklist rely on the existing manual system. The effect can be seen on how children are systematically missed.

The manual operation in the primary health care department has contributed to the technology gaps and has not helped research development in the primary health care system in Nigeria. Routine manual registers and ad-hoc systems are used, such create difficulties in evaluating the performance of health information management solutions. However, the use of the Vaccination Tracking System (VTS) was introduced as a micro plan Tracking support system developed with GPS to keep track of vaccination teams and their data but did not collect and manage polio information or disease data.

The inaccurate and inconsistent hand-drawn maps create a restriction and constraints in reaching communities and health facilities, this does not eliminate data collection error and false data entries collection. Open data kit (ODK) and other mobile-based application have been introduced widely in the field of epidemiology, and some community-based household survey, but does not function optimally in some communities as a result of poor GPS coordination and network downtime. Hence, the solution could not guarantee total coverage and result in the exclusion of some important settlements. Children were missed (I. Barau, M. Zubairu, M. N. Mwanza, & V. Y. Seaman, 2014)

(Bello et al., 2013) have advocated polio information systems as a supportive supervision strategy. It allows adequate information on vaccination which makes stakeholders to concentrates on effective program management. (Jaskiewicz & Tulenko, 2012) have proposed a model to improve the health environment and increase community health workers' productivity by incorporating community-based strategies; this must include training of rural health workers on the use of modern technologies. (Davis et al., 2011) advocated mobile technology in health interventions by demonstrating that it can create a positive change in program management. This can expand the systematic

documentation and validation of data, although active surveillance and location tracking during vaccination visit is important.
Information technology approaches have been used to achieve different health information system objectives, however, much have not been concentrated on the usage of cloud-based systems in macro-planning and management of field data especially in a country with wide geographical areas like Nigeria. Cloud technology has trigged several cases of diseases surveillance and detection. Consequently, it has enhanced the case management of more deadly diseases in other countries.

For effective monitoring of polio outbreak and surveillance of vaccination, there is an urgent need for coordinative knowledge of and best practices in polio management. Experts have advocated polio information technology to enhance the effectiveness of surveillance program operations, management, and documentation processes (Initiative, 2018). The use of cloud technology will provide means to achieve global extensive monitoring of polio exercise with extensive storage management and hosting for the polio information system. Field officers while they report vaccination process can leverage on Cloud facilities to achieve the following:

Technology support reports from rural areas to be harmonized and managed through a mobile cloud system. According to (Hanen, Kechaou, & Ben Ayed, 2016), mobile cloud computing is likely to be the heart of healthcare transformations as it offers new kinds of services and facilities like mobile monitoring, patient tracking system and enables centralized vaccine distribution. This, therefore, Cloud computing can host a robust Polio Information System if available and it will assist in addressing data quality, storage, and accessibility.

While the issues of internet and broadband connection have been poor in some rural terrains, the mobile cloud can consolidate, by reporting offline data, however, mobile cloud demand a central repository that houses record of every person eligible for clinical intervention. In some priority countries, they have documentation of every child and pregnant women and their data have been integrated into the existing clinical information systems. In a nutshell., most developing countries have a system in place for monitoring and validating active surveillance visits and value data for action (Initiative, 2018)

In Polio and disease surveillance exercise in Nigeria and other developing countries, field officers are kitted with thousands of IDSR reporting booklets to communicate feedback to the health agencies (NCDC, 2017). The reporting booklet is not sufficient to provide adequate technical feedback that will improve the quality of service.

2.1. Current Vaccination method and documentation

Vaccination reporting is an important aspect to consider in program management, this collection has remained traditional paper-based (King et al., 2014; King et al., 2013). Manual tally cards are used to collect data on polio vaccination and then entered or typed on data processing machines. The requirement checklist is also typed with multiple copies printed and photocopied, then administered to vaccinators based on the sample size. Information collected

from the field are documented in datasheets and are manually entered into data processing software and analyzed.

This strategy is fraught with several shortcomings spanning from all stages of the activities, a miss population is advised to be left blank and revisit. Vaccinators administer drops of OPV into the mouth of the eligible child and then immediately tally each child vaccinated in a sheet of paper while the vaccinator marks the child's left little fingernail with a pen marker.

Theoretically, this approach is fraught with unavoidable documentation error considering the growing population of the community. This is an encounter with different cancellation of the information filled in the datasheets. There is no administrative database to work with. Intuitively, children in some sparsely situated areas may be missed and excluded from immunization. There is no clear system that reports the total number of children missed, however, the tally card is used to report the total number of children vaccinated. There is no system that reports any coverage bias and false data entries. Thee revisit plans are not adequately followed and thus result in a large number of children being missed. However in the case of missing households, vaccinators are encouraged to do documentation on the "re-do form" at the back of the tally sheet and inform the Group supervisor or the community leader. These necessitate a great deal of person-hours and such some supervisors do not comply.

2.1.1. Limitation of the Current method

The tally sheet is used to capture and record a number of OPV and children vaccinated before it is eventually transferred into Microsoft Excel for analysis. During the course of this transfer, more hours and painstaking manpower are spent in *data entry and cleaning*, yet removing incorrect data, duplicates are not guaranteed. Below are the characteristics of the existing manual system:

1. The manual tally card is used to document the number of OPV received for the day and at the completion of the day's workload.
2. It is also used to write the name of the settlement in which vaccinators are working on. This immediately indicates a number of children immunized on the tally sheet and give the child 'plus' sign.
3. It is believed the tally sheet will support the vaccinator in resolving non-compliance if any.
4. There is a recorder who marks houses vaccinated in a very conspicuous place after completion of immunization in each household. The houses are marked.

2.2 Mobile-based technology

Mobile-based technology has been introduced to resolve these complications According to NCDC, the 2017 NIPDs' report, introduced a Basic Laboratory Information System (BLIS). A freeware web-based system that records, manages, and stores data for laboratories. The scope of the BLIS is to ensure that zonal laboratories report is connected to the National Public Health Laboratory Response Network coordinated at the NCDC headquarter. It is also expected to accurately harmonize surveillance and laboratory data during outbreaks.

Similarly, a Vaccination Tracking System (VTS) was developed with GPS to keep tracks of all vaccination teams and uploaded their data to a laptop available at the

Local Government Area (LGA) level or the Emergency Operations Center (EOC) (Novel-t, 2019). Technological advancement has the potential to eliminate such structural exercise, notably, the health information system can yield viable methods for the collection and presentation of field data even in a disperse geographical location (DeVoe et al., 2016).

Figure 1. Medical data integrate with ODK mobile capturing (Medic, 2015)

2.1.2. Limitation of the existing Mobile-based Technology

ODK -based Collect Android apps by connecting to the ODK-based platform's server. The server is browser dependents which often has some connection issues. During filed exercise, ODk is not exempted from error while generating beneficiaries form from the server. ODK is a free and open-source set of tools that provides an out-of-the-box solution for users to build a data collection form or survey on a mobile device, this survey is downloaded and uploaded to and from a web-based server (Hartung et al., 2010). ODK has been proved to be fragile and occasional crash during filling and form submission. The most common cause is over-dependent on the device memory or external memory cards. The device memory get used up when the device collects lots of submissions offline. Beside ODK. Also, the tools are not adequately available in all health care locations.

The application of geographic information system technology has been used to track vaccination members. It monitors settlement coverage, and prove to reduce the number of missed settlements. However, owing to the technical capacity requirements of tracking vaccination teams, also tracking was limited to few local Governments for one round. In a study conducted by (Touray et al., 2016), only 40 LGAs were tracked in each round using a mobile phone with VTS monitoring, it later covers 60 LGAs and subsequently increased to up to 80. The technical functioning of the VTS and the ODK is that data gathered from the survey are temporarily stored on the device memory and later uploaded to a local server (Laptop) at the LGA Improving immunization coverage requires better use of technology like the immunization information system (IIS) and cloud computing (Patel et al., 2015).

The study revealed the lapses in the existing solution and vaccination reporting process. Our solution proposed an enhanced mobile cloud system that meets new and existing requirements. The study also review the disease surveillance process in challenging situations like (hard-to-reach or security-compromised areas).

3. Methodology

We collected data on Polio health information and routine immunization exercise in Nigeria and plot a performance monitor chart with Excel Pivot chart. 2016 MICS/NICS routine immunization exercise was analyzed to reveal the national polio immunization index. This led to the review of the key strategic and operational tactics that were used in the previous vaccination exercise. The limitation in the tools was uncovered which include the use of Manual registry for data collection, the intervention of the third party electronic system including VTS and the ODK were evaluated.

4. Findings and Discussion

Figure 2 shows data on immunization coverage across 36 states in Nigeria which evidenced that more could still be done. It is observed that the national coverage of immunization stood at 33%. While Lagos, Kwara, and Sokoto have immunization coverage of 80%, 48%, and 3% respectively. This chart has also positioned Nigeria to be declared a polio-free country according to BBC News (Soy, 2019). However, there is still room for continuous improvement of the existing eradication methods. One would observe that coverage rate declined immediately after Kwara, reducing coverage rate from Borno down to Sokoto state.

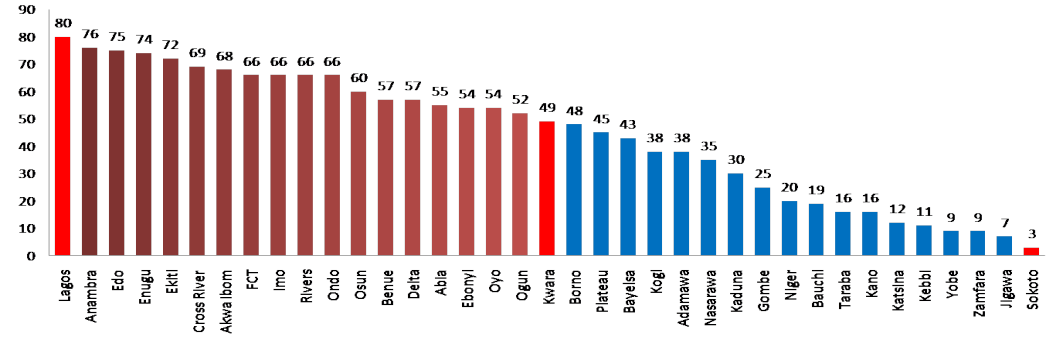

Figure 2. Immunization Coverage across Nigerian states

One would observe there is a decline in immunization coverage in the Northern part of Nigeria starting from Kwara. The national immunization coverage stood at 33% less than average. After, Kwara, most of the states highlighted in "blue" falls under the northern region were the population is even increasing every day. Births are given every day, yet there is a decline in immunization coverage. The effect of this is that Children are systematically missed and excluded from vaccination due to one reason or the other. It is believed that the manual system of collections and reporting could have an effect on the quality of data, hence create an information gap. It is frequently delayed and duplication in reporting system and inaccurate estimates of children vaccinated might be given. In the process of computing this information on a database, transcription errors at each health system level might occur with paper-based systems collection. In some SIAs, reports are often inflated due to short time for recording, and vaccinators unable to vaccinate persons outside the target group.

It has been frequently reported that Vaccinators don't conduct a revisit strategy to make up for the missed population, and tracking becomes difficult. Hence, the low level of OPV in some affected areas can result in high-risk migration or isolated populations. The endpoint is that Polio may resuscitate.

Arguably, it has been reported that some northern parts of Nigeria are being terrorized by the insurgency. However, coupled with threats, there are still some lots of difficult or hard to reach terrain which have the tendency to witness poor data reporting, absent of vaccinators, communication failure and, poor geographical coverage.

Our (QCloudMIS) based solution can help to convert this limitation to opportunity. However, there are lots to cover as the existing gaps have been under-researched, or previous recommendations have been poorly implemented. There is a need to improve the quality and sensitivity of existing networks, increase or create efficient Polio Information Systems to cover the whole state, map and manage human resources. This will enhance Polio Management and Oversight activities. For the sake of this study, we concentrated on how to enhance poor quality of data reporting and make health facility records available on cloud storage, enhance the performance of field officers and help to track the implementation process. Hence the database will be segregated and analysis state by state to ensure surveillance coverage. The implementation must start with appropriate aggressive data collection across the whole state.

4.1. Proposed (QCloudMIS) Framework and Implementation Details.

The research proposed **QCloudMIS** to enhance the quality of health information systems with Cloud storage and Mobile Web Application. The uses of Cloud storage and web app is to negate zero reporting and increase timely collection of data. The framework uses GIS digital elevation Map (DEM) to navigate directions in challenging situations (hard-to-reach or security-compromised areas). The following are the functional component of the proposed solution.

Table 1. QCloudPolioMIS Component and Description

Components	Sevice Description
Mobile web applications	The mobile web app will collect Healthdata from the field and will be documented on Polio Management Database. It will be used to collect investigation information rather than the conentional form
GIS mapping	Digital elevation maps (DEM) will be collected instead of the manual inconsistent maps. This will be used to locate the best site for environmental surveillance. The use of GIS and satellite imagery will map out surveillance network and AFP cases to ensure that all population is covered by the surveillance team
Offline SMS-gateway for reporting and	In the case of network deficient areas, offline SMS and Unstructured Supplementary Service Data (USSD) will be used for reporting AFP cases

surveillance	

It is envisaged that reaching some location for data collcetion and immunization exercise will still be challenging due to inconsistent mapping and population estimates, the framework presents some recommendations to be considered in Figure 4. However, offline SMS and Unstructured Supplementary Service Data (USSD) will be used for reporting case management. Figure 3 depicts the QCloudMIS implementation framework.

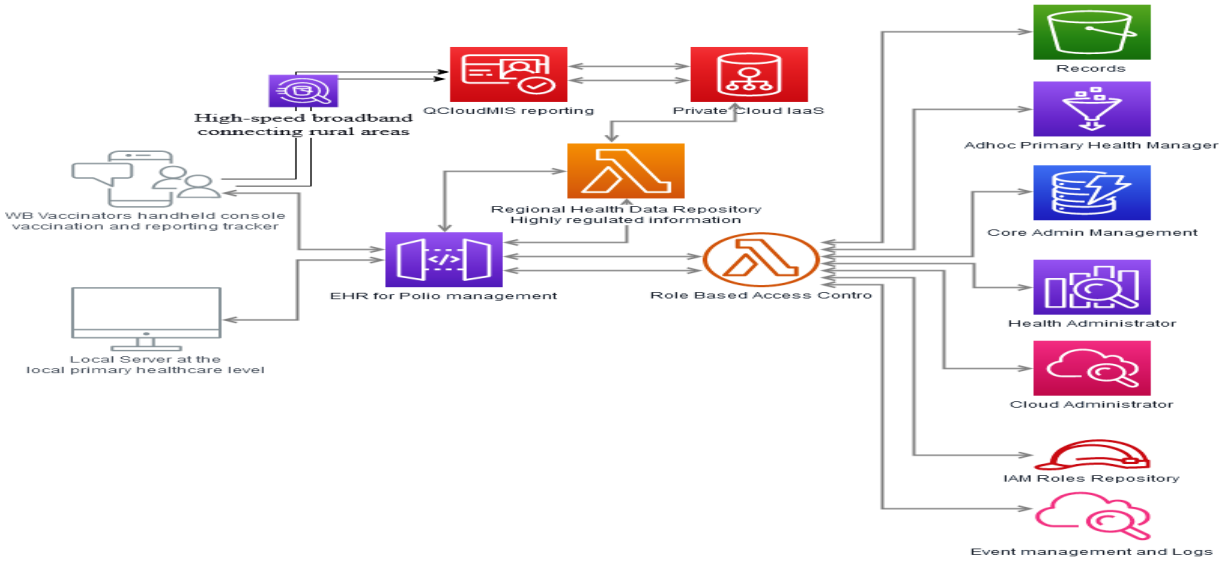

Figure 3. QCloudMIS implementation Components

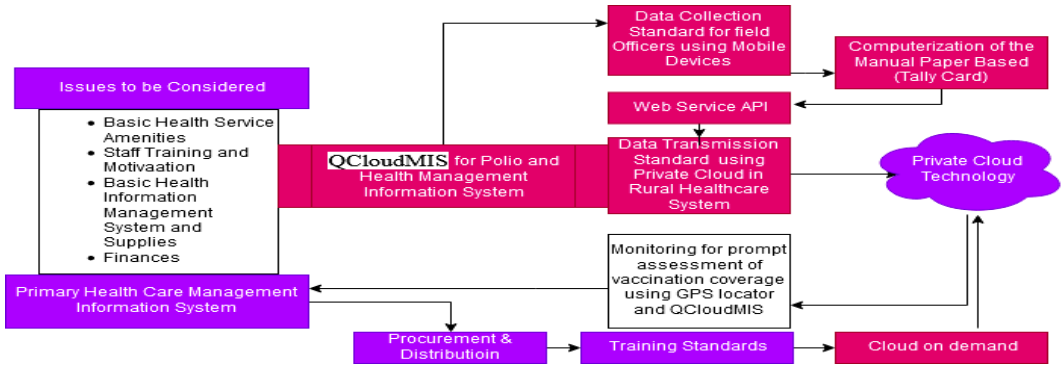

Figure 4. QCloudMIS Checklist

5. Conclusion

The QCloudMIS present a framework for Polio health data management using cloud-based technology to enhance data quality, reduce costs and improve access to more local areas. Although the framework presents a shift away from the paper-based method of collecting Polio and other health-related information. The solution maintains a digital repository of communities and household including children that would be vaccinated. Thus, it will enhance quality and reliable performance in data collection and reporting. Meanwhile, there is a lack of standard in collecting and managing health-related data especially from the rural

areas, the usage of cloud management information systems will give assurance of data quality that will have a great impact on the overall effectiveness of similar system. However, our innovation is not a one-size-fits-all, there is still some daring issue to be addressed in the usage of cloud health management systems such as security, and appropriateness of use. The proposed solution enables that record collected is stored and exchanged securely and accessible by different levels of authorized users.

Considering storage, availability, cost, and accessibility, the proposed cloud solution can guarantee a positive reaction to that and ensures all beneficiaries or households are covered during the vaccination, thereby given comprehensive, clean and reliable data as it cannot be achieved with the existing manual system. Therefore, the key achievement of this solution will be to support the continuity of polio vaccination in affected areas using cloud-based technology to allow fast exchange and integration of the proposed system into personal Health Record (PHR), Electronic Medical Record (EMR) and Electronic Health Record (EHR).

Acknowledgments

This work appreciates the UTM IDF Fellowship grant support for my PhD studies: UTM.J.10.01/13.14/1/128 (201902M10117).

6. References

[1] GEPEI. (2015). Introduction of inactivated poliovirus vaccine and switch from trivalent to bivalent oral poliovirus vaccine—worldwide, 2013–2016. *Morbidity and Mortality Weekly Report, 64*(25), 699-702.

[2] Tomori, O. (2019). Disease Outbreaks in Africa and the Response of African Governments. In *Socio-cultural Dimensions of Emerging Infectious Diseases in Africa* (pp. 143-160): Springer..

[3] NCDC. (2017). *First Annual Report of the Nigeria Centre for Disease Control (August 2016 – July 2017)*. Nigeria Retrieved from https://ncdc.gov.ng/themes/common/files/annualreports/07b45389d14275a12c916883fa65933c.pdf.

[4] Al-Roomi, M., Al-Ebrahim, S., Buqrais, S., & Ahmad, I. (2013). Cloud computing pricing models: a survey. *International Journal of Grid and Distributed Computing, 6*(5), 93-106

[5] Singh, P., & Kathuria, R. (2016). Infrastructure and Connectivity in India: Getting the basics right. *Asian Economic Policy Review, 11*(2), 266-285

[6] Bello, D. A., Hassan, Z. I., Afolaranmi, T. O., Tagurum, Y. O., Chirdan, O. O., & Zoakah, A. I. (2013). Supportive supervision: an effective intervention in achieving high quality malaria case management at primary health care level in Jos, Nigeria. *Annals of African medicine, 12*(4), 243.

[7] Jaskiewicz, W., & Tulenko, K. (2012). Increasing community health worker productivity and effectiveness: a review of the influence of the work environment. *Human resources for health, 10*(1), 38.

[8] Davis, R. G., Kamanga, A., Castillo-Salgado, C., Chime, N., Mharakurwa, S., & Shiff, C. (2011). Early detection of malaria foci for targeted interventions in endemic southern Zambia. *Malaria journal, 10*(1), 260.

[9] Aysha, Z., Kashif, S., Saleem, I., & Shagufta, P. (2016). Strengthening health systems: using mobile phones for co-ordinated community case management of childhood diarrhea and pneumonia in district Badin. *Pakistan Health Syst Policy Res, 3*, 2.

[10] NPHCDA. (2017). *16th Independent Monitoring Board Meeting1 November 2017London*. Retrieved from London: http://polioeradication.org/wp-content/uploads/2017/11/NigeriaUpdate_IMB2017.pdf.

[11] Xierali, I. M., Hsiao, C.-J., Puffer, J. C., Green, L. A., Rinaldo, J. C., Bazemore, A. W., . . . Phillips, R. L. (2013). The rise of electronic health record adoption among family physicians. *The Annals of Family Medicine, 11*(1), 14-19.

[12] Lemeshow, S., & Robinson, D. (1985). Surveys to measure programme coverage and impact: a review of the methodology used by the expanded programme on immunization. *World Health Stat Q, 38*(1), 65-75.

[13] Novel-t. (2019). *About the Vaccination Tracking System (VTS)* Retrieved from Nigeria: http://vts.eocng.org/Home/About?campaignId=0#contactus

[14] DeVoe, J. E., Bazemore, A. W., Cottrell, E. K., Likumahuwa-Ackman, S., Grandmont, J., Spach, N., & Gold, R. (2016). Perspectives in primary care: a conceptual framework and path for integrating social determinants of health into primary care practice. In: Annals Family Med

[15] Hartung, C., Lerer, A., Anokwa, Y., Tseng, C., Brunette, W., & Borriello, G. (2010). *Open data kit: tools to build information services for developing regions.* Paper presented at the Proceedings of the 4th ACM/IEEE international conference on information and communication technologies and development.

[16] Ven, K., Verelst, J., & Mannaert, H. (2008). Should You Adopt Open Source Software? *IEEE Software, 25*(3), 54-59. doi:10.1109/MS.2008.73

[17] Touray, K., Mkanda, P., Tegegn, S. G., Nsubuga, P., Erbeto, T. B., Banda, R., Vaz, R. G. (2016). Tracking vaccination teams during polio campaigns in Northern Nigeria by use of geographic information system technology: 2013–2015. *The Journal of infectious diseases, 213*(suppl_3), S67-S72.

[18] Patel, M., Pabst, L., Chattopadhyay, S., Hopkins, D., Groom, H., Myerburg, S., Force, C. P. S. T. (2015). Economic review of immunization information systems to increase vaccination rates: a Community Guide systematic review. *Journal of Public Health Management and Practice, 21*(3), 253-262.

[19] Buyya, R., Yeo, C. S., Venugopal, S., Broberg, J., & Brandic, I. (2009). Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. *Future generation computer systems, 25*(6), 599-616.

[20] Shankar, S. K., & Tomar, A. S. (2016). *A survey on wireless body area network and electronic-healthcare.* Paper presented at the 2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT).

[21] Chauhan, R., & Kumar, A. (2013). *Cloud computing for improved healthcare: Techniques, potential and challenges.* Paper presented at the 2013 E-Health and Bioengineering Conference (EHB)

[22] EngenderHealth, C. (2003). Handbook: A Process for Improving Quality in Health Services. *New York: EngenderHealth*

[23] Greenland, K., Rondy, M., Chevez, A., Sadozai, N., Gasasira, A., Abanida, E., . . . Pedalino, B. (2011). Clustered lot quality assurance sampling: a pragmatic tool for timely assessment of vaccination coverage. *Tropical medicine & international health, 16*(7), 863-868

[24] Mwendwa, P., McAuliffe, E., Uduma, O., Masanja, H., & Mollel, H. (2017). The impact of supportive supervision on the implementation of HRM processes; A mixed-methods study in Tanzania. *Health Systems and Policy Research, 4*(1)

[25] Raghavendra Ganiga, R. M. P., Manohara Pai M M, Rajesh Kumar Sinha. (2018). Private cloud solution for Securing and Managing Patient Data in Rural Healthcare System. *Procedia computer science, 135*, 688–699. doi:10.1016/j.procs.2018.08.217

[26] Soy, A. (2019). *Nigeria goes three years without a case of polio*. Retrieved from https://www.bbc.com/news/world-africa-49426886

[27] Barau, I., Zubairu, M., Mwanza, M. N., & Seaman, V. Y. (2014). Improving polio vaccination coverage in Nigeria through the use of geographic information system technology. The Journal of infectious diseases, 210(suppl_1), S102-S110.

[28] GPEI. (2019). Polio this week in Nigeria. Stopping polio in Nigeria. Retrieved from http://polioeradication.org/where-we-work/nigeria/

[29] Hanen, J., Kechaou, Z., & Ben Ayed, M. (2016). An enhanced healthcare system in mobile cloud computing environment. Vietnam Journal of Computer Science, 3. doi:10.1007/s40595-016-0076-y

[30] Initiative, G. P. E. (2018). Global polio surveillance action plan, 2018–2020. Geneva, Switzerland: Global Polio Eradication Initiative; 2019. In.

[31] King, C., Hall, J., Banda, M., Beard, J., Bird, J., Kazembe, P., & Fottrell, E. (2014). Electronic data capture in a rural African setting: evaluating experiences with different systems in Malawi. Global health action, 7(1), 25878.

[32] King, C., Hall, J., Beard, J., Fottrell, E., Bird, J., & Banda, M. (2013). Electronic Data Capture in a Rural African Setting: Evaluating Experiences with Different Systems. Journal of Health Informatics in Africa, 1(1).

[33] Medic. (2015). Medic Mobile integrates ODK to make a powerful new android app. Retrieved from https://medicmobile.org/blog/medic-mobile-has-an-android-app-1

[34] NCDC. (2017). First Annual Report of the Nigeria Centre for Disease Control (August 2016 – July 2017). Nigeria Retrieved from https://ncdc.gov.ng/themes/common/files/annualreports/07b45389d14275a12c916883fa65933c.pdf.