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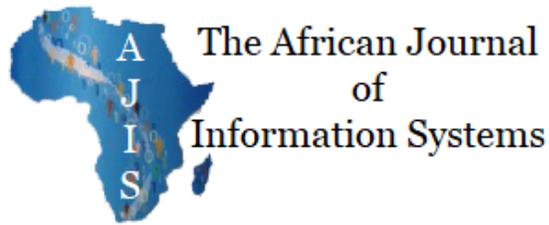


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Realist Evaluation of the Early-Stage Implementation of a Smartphone-Based Disease Surveillance Project in Two Armed-Conflict Communities in Nigeria

Research Paper

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ABSTRACT

We investigate the early-stage implementation of a smartphone-based acute flaccid paralysis (AFP) surveillance project in communities experiencing armed conflicts in Nigeria. We aim to expose factors influencing the early-stage implementation of smartphone-based AFP surveillance in two rural communities experiencing armed conflicts in Northern Nigeria. Thus, exploring “what works, for whom and under what contextual conditions?” in the early-stage implementation of a smartphone-based AFP surveillance project, given the involvement of multiple stakeholders. We adopted stakeholder theory as a lens to guide the study. We adopted a qualitative case study method, realist philosophy, semi-structured interview, participatory observation, and thematic data analysis. The findings reveal mechanisms (sense of connectedness, ownership, fear) and contextual conditions (infrastructural challenges, healthcare workforce, security constraints) influencing early-stage implementation. We postulate a model that explains the factors influencing the early-stage implementation of the smartphone-based AFP surveillance project in security-constrained communities.

Keywords

Smartphones, disease surveillance, mHealth, infectious diseases informatics, armed conflict communities, Nigeria.

INTRODUCTION

A growing body of literature focuses on challenges to providing quality primary healthcare services in communities experiencing armed conflicts (El-Khatib et al., 2018; Gele & Bjune, 2010). Unfortunately, most of the communities experiencing armed conflicts are in countries with developing economies where, under normal circumstances, the quality of primary healthcare services is adjudged to be far below the minimum standards (Mboussou et al., 2019; O'Hare & Southall, 2007). Deplorable healthcare service standards consequently characterize communities experiencing armed conflicts. The scenario makes the growing body of literature on primary healthcare and communities experiencing armed conflicts a new genre in the healthcare service delivery in developing economies extant literature. Recent studies have extended the new genre by looking at how digital technologies impact healthcare

delivery in developing economies, including those experiencing armed conflicts (Bowsher et al., 2021; El-Khatib et al., 2018). Given revelations on the successes and prospects of mobile phones in healthcare services delivery in rural communities in developing economies (Pascoe et al., 2012), the number of studies that focus on assessing the importance of mobile phones to healthcare services delivery in communities experiencing armed conflicts has increased exponentially. The new genre tries to expose the promises and the challenges stakeholders face while adopting mobile phones to surmount the challenges to healthcare delivery in communities affected by armed conflicts (Asi & Williams, 2017). The result is the growing body of literature that focuses on how mobile phones can help eradicate some of the challenges that hamper quality healthcare services in communities experiencing armed conflicts in developing economies. Some of the studies focus on adopting mobile phones to manage healthcare records (Miah et al., 2017), diagnose (Noordam et al., 2015), improve treatment (Dick et al., 2017) and drug administration and follow-up (Aranda-Jan et al., 2014; Stanton et al., 2016), and communication with healthcare delivery facilities and personnel (Chiang et al., 2018). These studies provide grounds for a novel and unique theorizing. They pose a critical question to the information systems (IS) field on the extent to which the area has contributed to developing theories that explain factors that come to bear in how mobile phones can efficiently and effectively promote healthcare delivery in communities experiencing armed conflicts.

At the centre of IS research is the need to develop good theories. The debate has been ongoing and has become more profound since Watson (2001) and Weber (2003) articulated the need for the development of good IS theories that can be used by IS scholars and practitioners to address IS-related challenges. The need for theory in IS has resulted in several debates about what theories stand for in the IS discipline. This follows Gregor's (2006) classification of IS theories into five categories and DeLone and McLean's (2003) further articulation of the role of dependent variables in IS theories, among others. Issues relating to theoretical perspectives of IS research have also been addressed (Burton-Jones et al., 2014; Markus & Robey, 1988). There are also ongoing debates on the importance of middle-range theories to the IS community (Hassan & Lowry, 2015). While all these calls are to the general IS community, specific calls are directed to IS scholars in African countries with developing economies. Scholars focusing on IS in developing economies have started to identify and underscore the importance of theory to the IS community (Avgerou, 2017; Sahay & Walsham, 1995). Avgerou (2017), for instance, argued that framing a theory for the information and communication technology for development (ICT4D) discipline requires the concatenation of multiple theoretical strands, including foundational theories on IS, contexts, and socio-economic development. This notion raises a fundamental question that IS and ICT4D scholars must answer to lay claim to theory contribution.

The number of IS and ICT4D researchers that study mobile health (mHealth) phenomena in countries with developing economies is increasing rapidly (Miah et al., 2017). It therefore suffices to say that mHealth studies have evolved and have become a core aspect of IS in developing economies and ICT4D research (Mechael, 2009; Qureshi, 2016). Therefore, developing good theories for mHealth requires (a) foundational theories on IS, addressing contexts and socio-economic and environmental development when the focus is on the impact of mHealth on development, and (b) foundational theories on IS, addressing context and healthcare outcomes, when the focus is on healthcare outcomes. Context is more unpredictable of the three factors identified as those required to develop reasonable IS-based mHealth theories. Good IS-based mHealth theories are expected to specify abstractions, generalizations, boundaries, and socio-physical and cultural contexts (Lee & Baskerville, 2012). A growing body of literature focuses on the role of contexts in IS research, specifically in developing economies (Avgerou, 2019; Thapa & Sæbø, 2014). Davison and Martinsons (2016) argue that contexts provide the basis for generalization in IS research and help to validate knowledge extensions. Insights revolving around the

role of contexts in IS research resulted in an ongoing debate that middle-range theories are more suited for understanding and solving IS-related problems in developing economies (Avgerou, 2017). It therefore follows that paying attention to contexts and middle-range theorizing for mHealth issues has become crucial. The mHealth phenomena, mainly as it unfolds in developing economies, is unique (Mechael, 2009) and its uniqueness is compounded by its role in armed conflicts communities where unpredictable socio-technical conditions characterize its implementation contexts (Asi & Williams, 2017).

There was a pressing need to avert the reoccurrence of AFP in the contexts where this research was conducted, given the previous occurrence of AFP in communities experiencing armed conflicts in Nigeria. The AFP surveillance project became necessary to avoid AFP reoccurrence after the World Health Organization (WHO) declared Nigeria polio-free in August 2020. For instance, in 2016, two years after the wild poliovirus was reported in Nigeria, two cases were detected in the north-eastern state of Borno (Bolu et al., 2018; Nnadi et al., 2017). This reoccurrence happened after the country was declared polio-free by the WHO in 2014. The reoccurrence was mainly due to the security challenges in the local communities in Borno state (Bolu et al., 2018). Leveraging the mHealth technology became essential to ease the challenges for primary healthcare centres, governments, and other inter-governmental organizations for effective surveillance of AFP, and effective detection and reporting of the cases to avoid possible outbreaks. Therefore, engaging local community members familiar with the insecure terrains and understanding local traditions became crucial for strengthening AFP surveillance. The local community members were engaged as volunteers in the smartphone-based AFP surveillance project despite the risks and challenges. The risks included anti-western medical cultures and traditions (Amzat & Razum, 2014), mistrust (Berman et al., 2017) and lack of security (El-Khatib et al., 2018; Nnadi et al., 2017). Training was provided to local community volunteers to manage these problems and carry out AFP surveillance to detect and report cases of AFP using smartphones. The assumption that informed the engagement of local community members for the surveillance project was premised on the belief that only those with first-hand experience of the socio-technical conditions prevalent in the communities experiencing armed conflicts were engaged in the smartphone-based disease surveillance project. The consequence of this was the inclusion of new stakeholder groups in the smartphone-based AFP surveillance projects, which initially comprised the communities, primary healthcare workers, governments, and inter-governmental organizations. In this study, the stakeholder groups involved in the project comprised the communities, community health workers (CHWs), governments, inter-governmental organizations, community health informants (CHIs) and disease surveillance and notification officers (DSNOs). Studies in the IS extant literature highlight how the role of multiple and diverse stakeholders in IS implementation projects leads to critical implementation challenges (Nyemba-Mudenda & Chigona, 2013; Pouloudi & Whitley, 1997; Utulu & Ngwenyama, 2019). Existing IS studies show that differences in expectations, views, and notions exist in IS project implementations involving several stakeholders (Nyemba-Mudenda & Chigona, 2013; Utulu & Ngwenyama, 2019).

We adopted stakeholder theory as the theoretical lens to guide the study. Stakeholder theory comprises three elements, namely, the descriptive, instrumental, and normative. We adopted the instrumental element, which posits that the relationship among the stakeholders involved in an IS project impacts the set project outcomes (Donaldson & Preston, 1995). We aimed to explain how the relationship among the stakeholders involved in the smartphone-based AFP surveillance project impacted its early-stage implementation. Nyemba-Mudenda and Chigona (2013) is an exemplar of an IS study in the context of a developing economy that adopted the instrumental element of stakeholder theory to explain the impact of multiple stakeholders on IS implementation. This study, therefore, aims to explain the factors that come to bear in the early-stage implementation of a smartphone-based AFP surveillance in two

communities experiencing armed conflict in Northern Nigeria. The study was informed by the following research question: *What are the mechanisms that shape what works, for whom, and under what contextual conditions in the early-stage implementation of a smartphone-based AFP surveillance project in armed conflict communities in Nigeria, given the diversity of stakeholders involved?* This study is significant because of the current call for frameworks to guide mHealth disease surveillance project implementations (Osei & Mashamba-Thompson, 2021). There is also a dearth of IS-based research studies of the disease surveillance phenomena aside from a few notable examples such as Andersson et al. (2017).

LITERATURE REVIEW

Research studies devoted to using information and communication technology (ICT) to provide and improve healthcare access and services to communities in developing economies have increased recently. Different terminologies have evolved in the extant literature and have been adopted by scholars to describe phenomena surrounding ICT use for healthcare delivery in these communities. Interestingly, telecare, telehealth, telemedicine, electronic health and mHealth have evolved and are often used interchangeably. These terminologies, although closely related, have been defined and conceptualized in various ways by scholars (Askedal et al., 2017). For instance, mHealth refers to the use of mobile phones, patient monitoring devices, wearables, and other related mobile telecommunication technologies to provide healthcare services. According to scholars in the field, mHealth is a subset of electronic health (Aranda-Jan et al., 2014; Motamarri et al., 2014). Scholars in this domain argue that mHealth has immense potential in improving healthcare service outcomes, especially in remote and underserved rural communities. It offers a significant contribution to healthcare service delivery in ways that are supportive to the achievement of the Sustainable Development Goal 3. For instance, mHealth projects have been implemented in several developing economies to address issues of maternal and child health (Ezenwa & Brooks, 2013), training and supervision of health workers (Long et al., 2018), data collection and transfer (Lori et al., 2012), patient follow-up and medication adherence (Pop-Eleches et al., 2011), and disease surveillance (Andersson et al., 2017; Budgell et al., 2015). This paper focuses mainly on mHealth-based disease surveillance in communities experiencing armed conflict. We define disease surveillance as a continuous and systematic process of health data collection, interpretation and analysis required for effective planning, implementation and evaluation of public health practice, and involves timely dissemination of data to those expected to act on them (Adokiya et al., 2016). We take communities experiencing armed conflict as “complex emergencies”, defined by the WHO as threats to life resulting from warfare, civil unrests, and mass displacement of people such that any emergency response has to be conducted in a challenging political and security environment (Munn-Mace & Parmar, 2018).

Consequently, we undertake to answer the following specific research question: *How do security challenges impact the early-stage implementation of the smartphone-based AFP surveillance project in communities experiencing armed conflicts in Nigeria?*

Smartphones for disease surveillance have been increasingly adopted, especially in rural areas of resource-limited countries such as Nigeria (Angues et al., 2018; Larsen et al., 2017; Mohammed et al., 2018). Outcomes of research studies in developing economies showed that smartphones’ efficiency and effectiveness can improve and strengthen disease surveillance. Smartphone-based disease surveillance has proven to be a more cost-effective strategy than the traditional paper-based system (Brinkel et al., 2014; Rajput et al., 2012). Decreasing the cost of mobile phones and increasing mobile network coverage are highlighted as key reasons for the cost-effectiveness of mobile phone-based projects. In addition, the cost of transferring paper-based surveillance reports is more expensive than transmission

via mobile phones (Brinkel et al., 2014). The majority of the smartphone-based surveillance projects have been implemented to target specific priority diseases such as measles, rabies, polio and malaria (Birukila et al., 2016; Mohammed et al., 2018; Mtema et al., 2016; Rajvanshi et al., 2021). Smartphone-based surveillance has also been used to track maternal and child health in resource-limited countries (Diese et al., 2018). Evidence suggests that the implementation of smartphone-based surveillance has improved the timeliness, completeness, and accuracy of disease surveillance data, compared with the traditional paper-based methods (El-Khatib et al., 2018; Yugi & Buesseler, 2016). Despite the opportunities offered by smartphone-based disease surveillance, there is an essential need to recruit people to implement an effective disease surveillance project. The severe shortage of health personnel, especially in the contexts of high security challenges, threatens smartphone-based disease surveillance projects (Dussault & Franceschini, 2006; Wurie et al., 2016). However, implementing the smartphone-based disease surveillance project in armed conflict rural communities can help address unemployment rates through the local capacity building embedded within the project. Smartphone-based disease surveillance projects' potential to promote employment in armed conflict communities has not been well explored in the literature. The indication that events in armed conflict communities may render potential health personnel jobless and, as a result, increase the number of those available and willing to take up health volunteering roles has not been considered an essential factor by scholars. This despite that such a switch in conditions related to personnel availability could have a critical impact on the outcome of smartphone-based disease surveillance projects.

The scenario and its possible impact on smartphone-based disease surveillance led to the second specific research question treated in the research study: *How does the unemployment rate impact the early-stage implementation of the smartphone-based AFP surveillance project in communities experiencing armed conflicts in Nigeria?*

Furthermore, disease surveillance in developing economies is characterized by high operating costs (Brinkel et al., 2014; Maponga et al., 2014). Limited financial and infrastructural resources aggravate challenges related to high operating costs among developing economies (Quaglio et al., 2016). Despite implementing several mHealth projects in developing economies, there are very few cases of implementing smartphone-based disease surveillance. Like other mHealth initiatives, smartphone-based disease surveillance relies on the availability of good telecommunications infrastructure (network coverage) to achieve its intended objectives (Aker & Ray, 2010). However, in the context of armed conflicts where there is the partial or total destruction of both public and private infrastructure, including health facilities (Tyndall et al., 2020), this becomes a challenge for implementers and project designers. This challenge is in addition to the fact that the infrastructure in rural areas such as healthcare facilities, road networks, and power supply are often sub-standard (White et al., 2016).

The scenarios led to the third specific research question asked in the research study: *How do infrastructural challenges impact the early-stage implementation of the smartphone-based AFP surveillance project in communities experiencing armed conflicts in Nigeria?*

Another revelation deduced from the extant literature is the lack of IS based theories in the context of developing economies. Most research studies on mHealth projects, including those focused explicitly on IS-based disease surveillance, have attracted criticism (Chib et al., 2014). Most of the theories and frameworks adopted to study mHealth projects are borrowed from other disciplines, and in some cases, unable to fully capture the complexities of mHealth project implementation (Chib et al., 2014). In the IS discipline, mHealth projects have been studied using adoption theories such as the technology adoption model (Könsgen et al., 2017), the unified theory of acceptance and use of technology (Alam et al., 2019; Chandran & Aljohani, 2020; Seethamraju et al., 2018) and the diffusion of innovation theory

(Ndayizigamiye & Maharaj, 2016). The technology adoption theories used to study mHealth projects in the IS discipline mainly take a positivist approach to investigating mHealth. Other theories used to study mHealth projects in the IS discipline include the task technology fit theory (Tariq & Akter, 2011), activity theory (Wolff-Piggot & Rivet, 2016), social cognitive theory (Fallon et al., 2019) and affordance theory (Meske et al., 2020). While the positivist and interpretivist approaches have dominated the studies in mHealth projects in the IS discipline, realist understanding has only recently gained attention by scholars in the field (Wall et al., 2019).

THEORETICAL CONTEXT- STAKEHOLDER THEORY

Stakeholder theory first emerged from the management literature in the 1960s and 1970s and increased in popularity over the years (Eze et al., 2020). The term “stakeholder” has been contentious in the literature following its usage in various fields and contexts. However, we draw from the definition of stakeholders as proposed by Freeman et.al (2010): “A stakeholder is any group or individual who can affect or be affected by the realization of an organization’s purpose” (p. 26). Stakeholder theory comprises three interrelated elements that explicate the different assumptions inherent in the theory (Pouloudi, 1999). These three elements of stakeholder theory are categorized as descriptive, instrumental, and normative. The descriptive element of stakeholder theory provides a model of the organization and describes the ways corporations work, their impact on the external environments and how the external environment impacts them (Donaldson & Preston, 1995; Nyemba-Mudenda & Chigona, 2013). The instrumental element focuses on providing a framework for investigating the relationship between different stakeholders and how it comes to bear in achieving the organizational purpose (Donaldson & Preston, 1995; Nyemba-Mudenda & Chigona, 2013). The normative element is the core of stakeholder theory in the sense that it focuses on exploring the ethical considerations amongst all stakeholders and holds that all stakeholders and their interests are intrinsically valuable (Donaldson & Preston, 1995; Nyemba-Mudenda & Chigona, 2013). Stakeholder theory has been applied in the IS discipline. The theory provides an avenue for assessing and identifying key stakeholder groups and protecting and managing conflicting interests that impact IS adoption in ways that will positively impact the overall organizational objectives. The IS discipline has paid more attention to the instrumental concept of stakeholder theory, which is in contrast to management literature, where the attention has focused more on the normative concept (Mishra & Mishra, 2013; Pouloudi, 1999). IS researchers have applied stakeholder theory in various areas, including the implementation of a large-scale health information technology (IT) program in the United Kingdom (Pouloudi et al., 2016), government IS implementations (Ahmed, 2017) and investigating business model innovation and stakeholders (Hermes et al., 2019). Similarly, in the context of developing economies, IS researchers have applied stakeholder theory in several areas such as e-government projects in Ghana (Bibi et al., 2019), an ICT4D initiative in higher education in South Africa (Tanner & du Toit, 2015), telemedicine projects in Ethiopia (Mengesha et al., 2013) and a mHealth initiative for maternal and childcare in Malawi (Nyemba-Mudenda & Chigona, 2013).

This research study investigates a smartphone-based AFP surveillance project in two communities experiencing armed conflict in Northern Nigeria. The study aims to explain how the involvement of multiple stakeholders impacts the early-stage implementation of the project. This is important because key stakeholder groups involved in the smartphone-based surveillance project includes local community members, government officials, and expatriates working with intergovernmental organizations. These characteristics make stakeholder theory appropriate for investigating how the different stakeholder groups impact the early-stage implementation of the smartphone-based disease surveillance in the two communities studied. While stakeholder theory has proven helpful in investigating, identifying, and

managing stakeholder interests in smartphone-based disease surveillance projects, the number of studies that adopted it to evaluate the situations in communities experiencing armed conflict are almost non-existent. This despite the capability of stakeholder theory to provide grounds for assessing how the involvement of multiple stakeholders in smartphone-based diseases surveillance projects in communities experiencing armed conflict comes to bear on the early-stage implementation of the projects. Our observation in this study revealed that the stakeholder groups involved in the smartphone-based disease surveillance in the two communities under study include CHWs, CHIs, DSNOs, project facilitators and project managers. Among the CHIs, we further identified sub-groups, including traditional birth attendants (TBAs), traditional medicine vendors/herbalists, traditional bone-setters, community and religious leaders. We assume that these stakeholder groups have a critical impact on the early-stage implementation of the smartphone-based AFP surveillance project and the extent to which the project will support identifying and reporting suspected cases of AFP. Therefore, stakeholder theory is relevant for answering the question: *What are the mechanisms that shape what works, for whom, and under what contextual conditions in the early-stage implementation of a smartphone-based AFP surveillance project in armed conflict communities in Nigeria, given the diversity of stakeholders involved?*

Table 1

Stakeholder Groups in Smartphone-Based Surveillance Project

Stakeholder Groups	Sub-groups	Description	Role in mHealth Surveillance
CHWs	Surveillance focal officers	These are randomly selected CHWs usually attached to a primary healthcare centre in a LGA ward. They are usually employed by the government and receive monthly salaries for their services	Community sensitization Identifying and reporting suspected AFP cases
	DSNOs	DSNOs are categorized into LGA DSNOs and State DSNOs. LGA DSNOs oversee the activities of CHWs and CHIs in various wards in the local government. The state DSNOs oversee the activities of all LGA DSNOs within the state.	Verifying suspected AFP cases Stool sample collection Identifying and reporting suspected AFP cases Recommend recruitment of volunteers Evaluate the performance of volunteers and health workers
CHIs	TBAs	TBAs are usually women trained to attend to pregnant women within their communities. Traditional methods of pregnancy delivery are common.	Community sensitization Identifying and reporting suspected AFP cases.
	Traditional Bonesetters/Spiritual Healers	Traditional bonesetters are experts in traditional methods of curing fractures, dislocation and other related orthopaedic issues. They	Community sensitization Identifying and reporting suspected AFP cases.

Stakeholder Groups	Sub-groups	Description	Role in mHealth Surveillance
		work closely with spiritual healers. Spiritual healers offer special prayers and spiritual remedies or advice to community members who come for consultation.	
	Herbalist/traditional medicine practitioners	Herbalists/traditional medicine practitioners offer medicines prepared primarily from local herbs to cure various diseases.	Community sensitization Identifying and reporting suspected AFP cases.
	Religious leaders	Prominent religious leaders within the communities usually help in sensitizing community members about vaccines and immunization. Community members usually trust them.	Community sensitization Identifying and reporting suspected AFP cases.
	Chemist attendants	These are attendants at drugstores who possess some basic knowledge in healthcare and have some formal education. They dispense drugs based on doctors' recommendations to patients or buyers.	Community sensitization Identifying and reporting suspected AFP cases.
Project Facilitators	Project Implementers	The initial implementers and designers of the intervention provide technical support and training to CHWs and CHIs.	Training of CHWs and CHIs Provision of smartphones, incentives and supporting devices; repair and replacement of faulty smartphones/parts
	Project Managers	The team of managers who ensure the project runs accordingly.	Organize quarterly review meetings and reward best performing individuals, wards, or LGAs
Network Providers		The group of telecommunications companies operating within the country provide network services. For example, MTN, Airtel, 9Mobile and Glo are Nigeria's dominant mobile network service providers.	Provide mobile network services for smartphones to run. These services include airtime purchases, CUG subscription, voice and text message (SMS).

Stakeholder Groups	Sub-groups	Description	Role in mHealth Surveillance
Ministry of Health		Government officials and agencies are responsible for overseeing the affairs of the health systems at all levels (LGA, state and federal level).	<p>Selection of target LGAs and states for project implementation.</p> <p>MoH provides the health workforce to be trained on detecting and reporting suspected AFP cases.</p> <p>Partner with NGOs and international organizations/donors to provide funding.</p>

Note. AFP = acute flaccid paralysis; DSNO = Disease surveillance and notification officers; LGA = Local government area; TBA = Traditional birth attendant; CUG = Closed user group; CHW = Community health worker; CHI = Community health informant; NGO = Non-governmental organization; MoH = Ministry of health; MTN = Mobile telecommunication company; SMS = Short message service.

RESEARCH CONTEXT

The smartphone-based surveillance project was initiated in Nigeria to increase the sensitivity of AFP. AFP is a significant indicator of the existence of the wild poliovirus. Polio has been endemic in Nigeria, and the fight has lasted for over three decades. The smartphone-based surveillance project is a short message service (SMS)-based innovation developed to detect and report suspected cases of AFP within local communities. CHWs and CHIs are trained to report suspected AFP cases through the smartphone-based surveillance application installed on the android phone. CHWs and CHIs conduct a house-to-house search within their communities. A 30-second video clip is embedded in the smartphone-based surveillance application, which prompts the informants as a weekly reminder to submit their report. If they have not encountered any suspected AFP case, the informant submits a zero report on Mondays at 10 am. Therefore, when the application asks if they have seen a suspected case, they choose “No” and submit. However, if a suspected case has been identified but yet to be reported, the informant selects the “Yes” option. The informant proceeds to enter the details of the suspected case using the smartphone application. The details include the name of the child, the name of parent or guardian, location and phone number of the parent or guardian. When the informant captures the relevant details, they submit the report through the smartphone-based surveillance app.

When the informant reports a suspected AFP case, the DSNO responsible for that ward receives an SMS alert as a notification for a new suspected case. The DSNO follows up to further investigate the child to confirm whether it is an actual case. The DSNO is a trained government health professional who is more knowledgeable than the informants and able to ascertain the status of the suspected case. If the DSNO verifies the possibility of an actual case, more details are obtained, and a unique identification number is assigned to the case through an open data kit form, especially for DSNOs via the smartphone-based surveillance app. A stool sample is collected from the suspected case and sent to the laboratory for further investigation. The DSNO also conducts contact tracing around the index case to control a possible outbreak of the virus. Once the laboratory results confirm a true case, the index child is isolated, treated and given medication free of charge. We outline three primary objectives of implementing this smartphone-based AFP surveillance project. First, to enhance the quality and sensitivity of AFP surveillance by equipping CHWs and CHIs with smartphones and the necessary incentives required to carry out the task. Secondly, to improve the timeliness, completeness and overall investigation rate by

prompt detection and reporting of suspected AFP cases. Thirdly, to improve AFP detection rate, especially in hard-to-reach settlements where such communicable diseases could be spread and hardly detected.

METHODOLOGICAL ASSUMPTIONS

Realist Evaluation

Realist evaluation in IS research is a theory-driven evaluation approach that aims to produce a detailed explanation to the questions of why an IS initiative works, for whom and in what circumstances (Carlsson, 2003). Realist evaluation has its roots in the realist philosophy, in which different theoretical approaches can be found and can have different meanings. Additionally, from an epistemological perspective, the logic of inquiry in realist evaluation “has no particular preference for either quantitative or qualitative methods” (Pawson & Tilley, 2004, p. 10). Therefore, it promotes mixed methods (qualitative and quantitative) to allow adequate investigation of both the programme processes and their impact. The nature of the hypothesis and the available data determines the balance of methods to be used. Thus, the epistemological stance of realist evaluation sits between positivism and constructivism (Hoerner & Stephenson, 2012). However, the distinguishing feature of realism is its particular understanding of how causation works. It revolves around the idea that things we experience and observe are caused by deeper, usually non-observable processes (Wong et al., 2016).

Realist evaluation provides a framework to understand how and why an IS initiative can produce desired changes in a given context. The use of theory is essential in conducting a realist evaluation at every stage. It begins by identifying the initial programme theory of the IS initiative under evaluation. The programme theory explains what works for whom and under what conditions, and it is assumed to be implicit within the IS initiative. Thus, the programme theory is exhumed through several methods such as reviewing documentation of the initiative, interviewing the people involved or experts in the area, adopting a theory from existing literature, and adding some hunches based on pre-existing knowledge (Wong et al., 2016). An essential notion of realist evaluation in IS research is that IS initiatives do not simply “work”. Instead, the stakeholders' actions make them work, and the causal tendencies of the IS initiative provide reasons and resources to enable the various stakeholders to make changes (Carlsson, 2003). That is to say, understanding the action mechanisms is essential in revealing why the IS initiative works.

Moreover, the changes in the contextual conditions are also crucial in understanding for whom and under what circumstances (context) the IS initiative works (produce outcomes). Therefore, to link this interrelationship, the context-mechanism-outcome configuration analysis tool is adopted. The findings of an IS realist evaluation is a refined context-mechanism-outcome configuration that offers propositions explaining what it is about the IS initiative that works, for whom and under what circumstances. In this research, we refer to context as “material resources, social structures, including conventions, rules and systems of meaning in terms of which reasons are formulated” (Sayer, 2010, p. 75). Therefore, these systems of meanings, rules and interrelationships shape the reasoning and behavior of the stakeholders in response to the implementation of the IS initiative, thereby influencing the outcomes (Utulu & Ngwenyama, 2017). The concept of “mechanism” revolves around the idea that the things we see and observe are caused by a deeper, usually non-observable process. In realist evaluation, program mechanisms refer to the interaction between the program resources and how the different stakeholders interpret and act upon them. Different stakeholders may respond to the IS initiative in multiple ways. Therefore, the mechanisms through which the program may work are also multiple. However, these responses by stakeholders may be constrained or supported by the implementation context of the IS

initiative. Thus, mechanisms are essential in realist explanations to give an account of how and why the program produces the outcomes (intended or unintended) that can be observed.

Qualitative Case Study

As this research aims to study mHealth for disease surveillance in security-constrained settings, an emerging issue that cannot be investigated outside its occurring research context, the case study approach becomes the most appropriate for investigating this phenomenon (Walsham, 1995; Wynn & Williams, 2012). The case study approach from a realist perspective seeks to provide in-depth explanations about the mechanisms responsible for generating the outcomes of the mHealth disease surveillance project under investigation rather than seeking understanding or making predictions (Wynn & Williams, 2012). Thus, the case study approach has been advocated as a practical and suitable approach to investigate events occurring in an open system or real-life setting without the researcher's external influence or control (Benbasat et al., 1987; Tsang, 2014). A multiple case study design was adopted in this research as it is suitable for providing a detailed description of the phenomenon, theory building or theory testing (Benbasat et al., 1987). The case study approach employs multiple data collection methods to offer an opportunity for triangulation and support of the conclusions drawn from the study (Benbasat et al., 1987). These data collection methods include semi-structured interviews, direct observation, project documentation and reports, and physical artefacts (smartphones).

A purposeful sampling technique was adopted in this research to enable the researchers' unrestricted access to key participants directly involved in the project to help identify information-rich cases across the various stakeholder groups (Harsh, 2011). The researcher was introduced to the DSNOs and project assistants at the state level through the focal person at the National Primary Healthcare Development Agency. The DSNOs and project assistants further assisted the researcher in identifying and selecting relevant and willing participants among the CHWs and CHIs who are directly involved with the project.

This technique has allowed the researchers to gain deep insights from different viewpoints. The main groups of participants involved in this study include the following:

1. CHWs – these are trained health officials employed by the government to provide healthcare services at primary health care centres in different wards. Among the CHWs are surveillance officers whose responsibilities are mainly to report priority diseases among their immediate local communities.
2. CHIs –in this study CHIs refer to a group of individuals who may or may not be serving in the healthcare line but are prominent in their community. These groups of individuals include TBAs, traditional medicine vendors (or herbalists), traditional/spiritual healers, community/youth leaders and chemist owners.
3. DSNOs – these are government officials who oversee and supervise all disease surveillance activities of CHWs and CHIs. The local government DSNO oversees all CHWs and CHIs involved in surveillance across multiple wards within the local government area (LGA). The state DSNO, however, oversees surveillance activities from all LGAs within the state. Therefore, the local government DSNOs report to the state DSNO. All DSNOs are skilled and trained to investigate whether the suspected cases are likely to be true or not before taking the samples to the laboratory for further investigation.

Data was collected mainly through semi-structured interviews. However, multiple data collection sources were explored, including document analysis and observation. The case study approach adopted in this study supports multiple data collection sources. We collected data from two communities in two northern states in Nigeria. We conducted a thematic analysis of the data to identify the response patterns

through which several themes emerged. Semi-structured interviews with 33 research participants served as the primary source of data in this study. Face-to-face interviews were conducted with all the participants across the two cases under investigation. The interviews allowed us to observe changes in emotions or perceptions displayed by the research participants. The semi-structured approach also allowed the interviewer to probe further discussions around the topic as more insights unfolded. This aided in obtaining a more detailed understanding of the experiences of the research participants. Documents relating to the project were obtained and analyzed. We retrieved some of the project report documents from the website to serve as a secondary data source. We gained permission to obtain specific project reports from the project implementers for this study. The documents and reports allowed us to compare and analyze our interview findings with the published project reports. This enabled us to maintain some level of objectivity where the reports support or contradict our interview findings.

Thematic Data Analysis

A thematic analysis was conducted based on the data collected from semi-structured interviews and observations. We used thematic analysis for this study due to its flexibility and straightforwardness. We followed the six phases outlined in Braun and Clarke (2006, 2012) to generate the themes for this study. We developed the themes to fit into the patterns of contexts, mechanisms and outcomes. The steps for generating the themes, according to Braun and Clarke (2006), are outlined in Table 2.

Table 2

Phases of Thematic Analysis

Phase	Description
1	Familiarization with the research data This process involves transcribing and translating the audio data collected from interviews and re-reading them several times over. This also includes secondary data on the periodic project reports being part of the dataset.
2	Generating initial codes The second step involves highlighting and coding the segments of interest which align with our theoretical and methodological concepts.
3	Searching for themes The emergence of several codes from the data set to generate potential themes.
4	Reviewing themes Checking and verifying the themes resonate with the coded extracts and their relationships. This may include generating a thematic 'map' of the analysis to ensure no overlaps in the themes generated.
5	Defining and naming themes Generating clear definitions and names of specific themes and the overall story the analysis tells.
6	Producing the report Producing the final report of the analysis involves the selection of clear and compelling extract examples to support the story in each theme. It also involves an iterative process to align with the study's research questions and the literature investigated.

Note. Adapted from Braun and Clarke, 2006.

Ethical Considerations

Ethical approval was obtained from the state ministry of health in each of the two states and the Institutional Review Board approval from the American University of Nigeria. These approvals were necessary to proceed with data collection. Each of the interview participants had consented to participate

in the research by signing the consent form. For participants who were unable to read, the researcher explained the contents of the consent form to them and obtained their consent after that.

RESEARCH FINDINGS

Impact of Security Challenge on the Early-Stage Implementation of Smartphone-Based AFP Surveillance Project

From a security perspective, the context of sub-Saharan Africa (SSA) is often volatile due to prevalent civil unrest and acts of terrorism, which usually emanates from political instability. For example, South Sudan had to endure a series of ethnic violence, massacres, and civil war after gaining independence from Sudan in 2011. Similarly, the Boko Haram terrorist group operate and attack communities spanning from north-eastern Nigeria to neighbouring countries across Cameroun, Chad, and Niger Republic. In addition, frequent communal clashes exist primarily between farmers and herders in Nigeria. More recently, however, kidnappings have been prevalent in the northern part of Nigeria, such that individuals are abducted on major highways or even inside their homes. The existence of these security threats and vulnerabilities have rendered some remote communities even more difficult to access. This challenge, in turn, hinders the efforts of CHWs and CHIs to perform adequate surveillance operations due to these instabilities raising fear among the health workers. Thus, the decreasing scope of surveillance coverage leads to possibilities of a future outbreaks in these communities.

Security challenges are more prevalent in the rural settlement in Adamawa state than in Kano state. This arises from the historical context of the Boko Haram insurgency and its proximity to bordering countries. Some remote settlements were utterly inaccessible during the peak of the insurgency. However, the project seems to have thrived against these odds. Reports of suspected cases were still being received even from remote settlements affected by the insurgency. Once communication is established with the CHI, the informant brings the suspected case to a safer location in that settlement. The CHIs are more familiar with the terrain and routes to avoid a likely confrontation with insurgents. In addition, there has been a growing concern about local bandits who are known to physically assault individuals and rob them of their mobile phones and other valuable possessions. Our findings suggest that the challenge of local bandits is prevalent in Adamawa state, affecting the cost of maintenance and performance of CHIs and CHWs. One of the research participants noted that “it affects our performance because the *yan shila* cause us to fear, they [*yan shila*] take away our phones, but there is nothing we can do. It is in the hands of law enforcement agency.”

In addition, one of the project managers narrated that “we give priority to security compromised settlements as we’ve been discussing from the onset of this interview. We give priority to international border communities.”

Sense of Connectedness

Armed conflict has caused massive displacement of people, especially in rural communities, and access to communities overtaken by the insurgents was impossible. Till the period of data collection of this research, access to some rural communities worst hit by armed conflict requires caution. Nevertheless, smartphones offer opportunities to bridge the gap between community members and trigger an improved sense of connectedness. In the smartphone-based surveillance project, the deployment of smartphones, free monthly airtime and closed user group (CUG) services increased communication and connectedness among informants. The use of smartphones also reduced the cost of transportation to remote and sometimes hard to reach communities. The DSNO at the state and local government level became more familiar with the informants in local settlements. Smartphone usage also led to new social ties and

strengthened existing ties among community members involved in the smartphone-based surveillance project. This mechanism has built trust, social ties, and cooperation among informants. Cooperation among the CHWs and CHIs was observed through the voluntary sensitization campaigns organized within local communities. Before implementing the project, lack of airtime impeded communication between CHWs and their respective DSNOs. However, the CUG service offered through the various network operators has been a significant contributor to the increased level of communication since users on the same network can talk for long periods with very little or no charges on the part of the users. However, good network coverage is essential to experience these benefits. A participant stated:

This smartphone has really helped us especially because we receive some credit every month to send our reports and also, with that, *InshaAllah ta'ala*; it grants us the opportunity to call our friends and family to maintain kinship and social ties.

Another interview participant responded on how they use the smartphones besides sending weekly reports, which elicited the following response: “There is a WhatsApp group we created, and we also call our relatives because of that monthly credit we usually receive, and that keeps us happy indeed.”

Additionally, one of the TBAs interviewed highlighted how they used the smartphones to mobilize in their various communities as follows: “There is a WhatsApp group created for our different wards and LGAs. In the WhatsApp group, we usually share ideas, information and how to improve our surveillance work but only related to this project.”

Community Engagement and Mobilization

The smartphone-based surveillance project has reinforced the commitment of informants, especially among health workers doing surveillance and reporting. They feel that they have the necessary tools and support in carrying out their jobs. It has also improved confidence among informants, strengthening the level of community sensitization. Community sensitization involves active case search within communities to find and report suspected AFP cases and create awareness among community members. Community sensitization is usually organized by the CHWs and CHIs periodically as part of their voluntary endeavour. It has also created an opportunity for the informants to build and maintain relationships, primarily through meetings. They also share knowledge and ideas, as well as discuss and address some prevailing challenges they face. Informants themselves become more aware of prevailing diseases as they are being discussed in the meetings. The translation of the surveillance application into different local languages has been an essential driver for improved community sensitization. The video playback embedded in the application showing a child with AFP symptoms has helped informants create awareness and educate community members about the effects of AFP. The video is translated into different local languages, including Hausa, Yoruba, Igbo, Kanuri, Fulfulde, French, and Arabic. Thus, community members become more receptive to the project and health workers. This is further substantiated from the response of one of the interviewees as follows:

For us, rural dwellers, I believe that the video playback is the most important because you can show people how the disease looks like. You can also play the video in their language for them to understand what you are looking for.

The implementation of the project has also improved the level of communication and supervision among health workers. With the free monthly airtime and CUG service, which cuts down call rates, communication has greatly improved among CHWs and CHIs. Before implementing the smartphone-based surveillance project, adequate communication and supervision used to be a severe challenge. Sometimes health workers would not have sufficient airtime to call and make swift decisions, causing

delays in following up suspected cases for several days. With the implementation of the smartphone-based surveillance project, there has been a timelier response to suspected cases and more efforts to follow up on each case until the end. This has resulted in a reduction in the number of “inadequate” cases. Inadequate cases occur due to a delay in taking stool samples from a suspected case, making the virus weaker and more challenging to identify at the laboratory facilities. Therefore, one of the CHWs narrated in respect to motivation, supervision, and follow-up, as highlighted in the excerpt below:

Well, to be honest, our superiors always do their best because they visit us from time to time and they ask us if we have any challenges. If we have none, we tell them, likewise if we do. Their follow-up really gives us motivation and encouragement to do more in the surveillance work.

Another participant also highlighted the importance of communication with supervisors, formerly a challenge before implementing the project:

Initially, you will not get access to your DSNO; maybe by that time, you don't have credit in your phone because we were not using any CUG or whatever. But when this project came, we don't have that challenge anymore.

Healthcare Workforce

Nigeria is the most populated country in SSA with a severe unequal allocation of limited resources. The unemployment rate is forecasted to reach 32.5% in 2021 (Varrella, 2021). While there is availability of a potential workforce, many individuals, especially the youth, are unemployed or underemployed. The high unemployment rate provides grounds for increased criminal activities and other social vices in rural and urban settlements, resulting in high poverty rates. Accordingly, there is evidence to suggest that high rates of poverty often lead to poor health outcomes. While CHIs are involved in the project as volunteer members, some are also open to opportunities to gain full-time employment. Thus, the implementation of the project brings hope to ambitious community members.

In Nigeria and many developing economies in the SSA region, there is a common challenge of insufficient health workers to provide adequate healthcare services for the growing population. This shortage is more evident in rural areas with poor health care services and infrastructure than in the major cities. Despite several efforts to increase the availability of health workers through retention programs, training, and task-shifting, concerns remain around health workers' performance. The smartphone-based surveillance project was designed to incorporate key stakeholders within the traditional health system, including community leaders, TBAs, and community member volunteers. This community-based participatory approach has effectively expanded the surveillance scope and strengthened the health workforce within local communities, thereby identifying more cases of the AFP disease.

Employment Opportunity

The smartphone-based AFP surveillance project in rural communities provided an additional source of income to health workers and volunteers in the selected communities. We also find that opportunities exist for well-performing volunteers to be employed by the government as CHWs. Despite the high unemployment rate, the project implementation provides idle youth opportunities to volunteer and receive cash, smartphone, and airtime incentives. This is supported by the response from one of the volunteers involved in the project:

Among us, there are those who have received formal education while others have not. But we plead that we should be involved in future projects because it could be an opportunity for some to further their education or get employment.

Additionally, another volunteer also shared that:

I have a family. I have a wife and three children. So if you look at it, it will be unfair to just go to work without getting any pay. But with this project, since I know that I benefit from the incentives, I have taken the work very seriously because I do not have any other source of income better than this, for now.

The provision of smartphones to health workers resulted in a sense of fulfilment and belonging. The initiative made the health workers develop a positive perception about themselves and their communities. This is because they viewed the smartphone-based AFP surveillance project to improve and bring the standards of healthcare services in local communities to similar standards in urban centres (cities). Additionally, the CHIs, in particular, have reported a sense of increased prestige in their respective communities based on their involvement in the surveillance project. Community members have developed trust in the selected CHIs in the communities, and they become the “go-to” persons for health emergencies or health-related information. This is supported by the response of one of the interview respondents in this research as follows:

For one to be selected from among a thousand other people to do some work shows that one has been honoured. You understand? For example, if the people here feel that I deserve to be selected as the councillor or any important post in my locality, they have honoured me because it means they feel I am better than ten or a hundred people around my locality. This [being involved as a community informant] is an achievement.

On a similar note, another interview respondent also highlighted that:

This project has actually brought us into the centre stage in our community. Because before, people did not know us, and they did not bother to know us. But now as soon as we go out, people start asking who we are and what we do.

Sense of Ownership

CHIs and CHWs who are given free smartphones to carry out surveillance activities exhibit some form of accountability in handling the phones. Even though mobile phones may be relatively cheap, they take it upon themselves to ensure continuous usage. Some of the informants consider it very valuable and make efforts to handle it with care. The continuous usage of the smartphone is essential to them to keep being part of the smartphone-based surveillance project. As a result, informants may go to some length, including paying for minor repairs or parts replacement even if they are not sure of reimbursement from the project manager. Also, a policy in place requires that informants pay for lost or damaged smartphones resulting from negligence.

Additionally, some informants perceive the project as a source of income due to their incentives after every quarter. Therefore, they could be tagged as inactive and not eligible for the incentives without a functioning smartphone to send reports. One of the interview respondents from the rural community describes how they, as CHIs, took ownership of the project driven by their initiative:

We came together as a group and thought to ourselves that we need to do something that will make our superiors happy and encouraged because of how they have involved and treated us well. Therefore, we came together and contributed some money among ourselves to sew uniforms.

Health Workers' Workload Reduction

CHWs have expressed a high level of satisfaction with the smartphone-based surveillance project, especially with the ease it has brought to them in discharging their duties. Disease surveillance of AFP cases used to be predominantly paper-based, which is characterized by numerous logistical challenges. These challenges include plying through dilapidated roads leading to hard-to-reach communities and spending excessive time to follow-up and investigate a single suspected case. Sometimes, the health workers do not have sufficient transport fare to visit and investigate the suspected cases. All these challenges have contributed to missing some suspected cases of AFP, which might have been true cases. However, implementing the project helped address most of these challenges because of the involvement of CHIs assisting CHWs in identifying and reporting suspected AFP cases. The adoption of the smartphone technology to alleviate this process has resulted in more timely data reporting with relative ease on the CHWs. For instance, one of the CHWs who has been the surveillance focal person for eight years, when asked how the project has influenced their surveillance work, responded as follows:

It has brought ease to my work. Before [the implementation of this project], we have to enter the data in hard copies and send it to the DSNO, but with the smartphone project, we can easily notify the DSNO, and everyone involved, including the headquarters at the national level in Abuja and they, will be aware in real-time. If not for the mobile phones, we would have had to write down all the details on a card with some long follow-through processes. However, now, it has reduced the timeframe required to complete a task.

The interview participant also added that:

This is something that has eased my work burden. For instance, now I would have been talking [to create awareness] in front of these women, but now I would just play the video for them... as you can see... they would be able to see everything about the disease.

Infrastructural Challenges

Network quality plays a vital role, especially in mHealth projects. It serves as the backbone for all types of telecommunications using the smartphone. Rural areas are more prone to have a poor quality of network due to the limited resources and infrastructure often allocated to rural areas. This limitation is common in most rural areas in Nigeria. Network challenges could be traced either to network service providers or the destruction of infrastructure due to armed conflict or terrorism. Therefore, places with good network reception often enjoy the full benefits of the project more than places with poor network reception. Poor network reception or downtime results in delayed reporting of suspected cases using the smartphone disease surveillance application. Since reporting is through SMS, the message is queued on the network when the service is unavailable and delivered when the service is restored. Frequent network service disruptions negatively impact the performance and motivation of CHWs and CHIs. One of the project managers narrated as follows concerning network challenges:

And above all, we look at where network is available because you cannot implement [the project] in a ward that has no network, either Airtel, Glo or MTN... and in Madagali, they have the network, but the network masts were being destroyed by the insurgents as at then. So we did not expand the project there.

IT Use

Despite the poor state of infrastructure, especially in rural areas, the use of smartphones and other related technologies for smartphone-based surveillance has raised enthusiasm among the CHWs and CHIs involved. It has exposed some members to the use of technology to solve the challenges of paper-

based systems of AFP surveillance. Therefore, the adoption of technology encountered no resistance for two reasons. Firstly, community members perceive the smartphone as a luxury that was given freely for AFP surveillance. This has improved a sense of prestige, especially among the CHIs involved in the project. Secondly, the use of technology has reduced workload and saved time in data reporting. Therefore, the use of smartphones was perceived as an efficient and effective method for AFP surveillance. The use of technology has also improved organization, especially among CHIs and CHWs. This is evident through the meetings they set up to discuss and share ideas and organize sensitization campaigns using the smartphones in the project.

Almost all of the interview respondents in this study highlighted that the smartphone application for AFP surveillance installed on the android smartphones was easy to use. While some felt the need for undergoing training, others who were more familiar with android smartphones felt there was no need for intensive training. This research finds perceived ease of use and usefulness elements as critical drivers for adopting the mHealth surveillance project. The simplicity of the smartphone surveillance application has encouraged users in the uptake and utilization of the application to submit reports efficiently. The surveillance application was designed to operate with little training, even for those with no formal education. This mechanism is derived from the technology acceptance model concepts, which posits that users may be willing to adopt new technology provided there is perceived ease of use and perceived usefulness.

Additionally, the 30-second video clip showing the symptoms of the AFP disease and consequences of non-immunization against the disease was also highlighted as an essential feature of the application. The video clip aided the CHWs and CHIs in learning more about the disease themselves and quickly creating awareness among community members. One of the traditional title holders, who had secondary school level of western education responded concerning the ease of using the smartphone application as follows: “yes, it is easy to understand. You know, if someone has been to school no matter how little, it will be different from another person who has not been involved in reading or writing. It will always be different.” Another interview participant serving as a TBA also noted “well, we can say that it was easy to understand. *Alhamdulillah*, it is not difficult to understand as long as one puts some effort and pays attention at the training.”

Cost of IT Infrastructure and Maintenance

The implementation of the smartphone-based surveillance project was not without challenges, especially regarding the aspect of logistics. The importation of the smartphones and other technology devices such as lithium batteries and mobile solar panels from western countries into the SSA countries have been a challenge. Some of these devices have been lost in transit without any form of accountability from the airport authorities. Customs clearance can also be a very daunting task as it involves a lot of back and forth and documentation. Similarly, airlines have restrictions on the type of goods that can be transported through cargo and lithium batteries for the smartphones were among them. Therefore, the implementers had to improvise and go to extra lengths to transport the goods. For instance, one of the informants interviewed noted that:

We had two major barriers last year. One, we couldn't fly lithium batteries from Europe into Africa, and most European carriers refused to carry lithium batteries because they were considered as dangerous goods and needed some sort of documentation and security clearance here and there for us to move them. It cost us a lot of money trying to get alternative routes to get these things across.

Furthermore, on the issue of logistics where some smartphones were unaccounted for, the respondent highlighted as follows:

The third one is theft, and one major scenario I can recall was in South Sudan where we moved phones and handed them over to WHO at the border, the airport management team there took over the equipment, stored them in the warehouse and WHO came the following day [to] confirm the goods and now move to process the clearing only to come back and realize that a stock of 80 phones have all gone missing and we never found them till date.

Improved Detection of AFP

The implementation of the smartphone-based surveillance project has motivated CHWs and community members in the detection of AFP cases. The smartphone and other incentives provided from the project have equipped the CHWs and CHIs with the appropriate skills and tools required to detect and report suspected cases of AFP. Compared to other non-implementing LGAs, the detection rates for those LGAs where the mHealth project was implemented is much higher. This is primarily attributed to the deployment of technology to support health workers in achieving their objectives. The project managers have also observed that non-AFP cases are reported on the same platform even though the project only focused on reporting AFP cases. For example, in Adamawa state, an early case of cholera was detected and reported through the mHealth surveillance platform.

Similarly, true cases of COVID-19 have also been detected and reported through the platform. This outcome may be unintended but helpful in strengthening disease surveillance within the communities. This also shows that the project holds promise for expansion into detecting other priority diseases efficiently.

One of the primary objectives of implementing the smartphone-based surveillance project was to improve timely and accurate reporting of surveillance data from the community level to the national level. Since the surveillance activities had relied on manual paper-based processes before the project, several cases of delayed detection and reporting of suspected cases were often detrimental to the collective efforts of eradicating the AFP disease. More surveillance coverage has been achieved with this project by recruiting key community members to report suspected cases through smartphone use. This has resulted in achieving near real-time updates from the community level to the national level of the health system. The relevant stakeholders involved receive notification updates and closely monitor the status of the investigation. This enables the superior health officers to follow up and ensure that all cases have been investigated and closed in the shortest possible time. This is essential to ensure that an outbreak does not occur.

Interestingly, CHIs have also detected suspected cases of COVID-19 after creating awareness about its signs and symptoms during their meetings and workshops. Similarly, pockets of other diseases such as cholera, rubella and yellow fever are being reported. However, phone calls are made to relevant authorities since the application is designed specifically for AFP. One of the DSNOs recalls an incidence of cholera whereby an outbreak was averted by one of the CHIs in the project. To further substantiate, one of the interview participants narrated as follows:

With this project, you can instantly open the ODK [open data kit], which allows you to enter the name, address, date of onset, and phone number. Therefore, as the DSNO receives the notification, all the relevant information is available even without contacting the informant who reported the case. The DSNO could follow up with the case immediately, even on that same day,

as long as there is no network issue. So you see that has resulted in early detection, early reporting, early investigation, early sample collection and early transportation.

Similarly, another interview participant overseeing surveillance activities at the state level highlighted that:

With the non-implementing LGAs, we have to wait for the weekly reports. We have to wait for them to report to us on [a] weekly basis. But with this project, we have the reports within short period of time so that we can respond and investigate the reality of the report instantly.

DISCUSSION OF FINDINGS

We draw from the literature on smartphone-based surveillance, in which infrastructural challenges are significant barriers in implementing smartphone-based surveillance projects in SSA countries (Brinkel et al., 2014). These challenges include poor network coverage and power (electricity) supply, maintenance of the mobile phones and challenges with the open-source software (Asimwe et al., 2011; Ide et al., 2019; Mandyata et al., 2017; Ngabo et al., 2012). These infrastructural challenges in the literature are similar to what we find in our study. However, our study also reveals the role of armed conflict and destructive activities of terrorist groups and insurgents in posing further challenges towards the infrastructure required for successful project implementation. The occurrence of armed conflict, including civil war such as the case of Liberia, often fragments a country's health system and infrastructure (Berman et al., 2017). This, therefore, highlights and re-emphasizes the role of government and security agencies to protect these critical infrastructures. From our perspective, the stakeholder groups most affected by infrastructural challenges are the community members where the project is targeted, and health workers burdened with disease surveillance. In line with the above findings, we pose the following proposition:

Proposition 1

The availability of relevant infrastructures (C) such as good network quality and functional smartphones triggers some sense of connectedness (M) as well as accountability and ownership (M) among health workers. This results in improved community engagement and mobilization (O) among the health workers and impacts the cost of maintenance and replacement of smartphones (O).

Smartphone-based surveillance has been shown to improve the timeliness and completeness of data reporting in emergency settings, including post-conflict regions (Asi & Williams, 2017; El-Khatib et al., 2018). Our findings reveal that despite the security challenges being faced by some of the communities, the smartphone-based surveillance still thrived to ensure completeness and timeliness of data reporting. While armed conflict and other security challenges lead to population displacement, rendering affected communities scattered, displaced and isolated, the smartphone-based surveillance project could bridge this challenge by creating a sense of connectedness and continued communication with inaccessible communities due to security challenges. This sense of connectedness among the health workers improves community engagement and mobilization, focusing on achieving the project's objectives despite the security challenges. Therefore, we find that security challenges barely impact the timeliness and completeness of data reporting. This is in line with findings in El-Khatib et al. (2018), where an improvement in the completeness of data reporting more than doubled to 81%, whereas timeliness improved by 50% in a post-conflict setting in the Central Africa Republic. In our study, the occurrence of security challenges led to improvisation of technology use to overcome the challenges of visiting hard to reach areas caused by a lack of security. Therefore, we pose the following proposition:

Proposition 2

In the context of high security challenges (C), there is a heightened sense of fear and apprehension (M) among health workers during active case surveillance. This results in technology improvisation to avoid known conflict areas and achieve high surveillance coverage with timeliness and uncompromised detection rates (O).

Furthermore, our findings reveal the evident challenge of a limited healthcare workforce, a common phenomenon among low-resource countries, especially in the SSA region (Nguku et al., 2014). To address this limitation, low-resource countries have resorted to employing cost-effective healthcare workers to support skilled medical personnel. This group of cost-effective healthcare workers include CHWs, health surveillance assistants, nurses and volunteers. Our study identified more categories of health worker volunteers playing essential roles in smartphone-based AFP surveillance, including TBAs, traditional medicine practitioners, spiritual healers/traditional bone setters, religious leaders, and chemist attendants. The literature on the link between mHealth innovations and the health workforce remain scarce (Lapão & Dussault, 2017). However, this study reveals the potential of mHealth projects to provide employment opportunities, career growth, and recognition through the reward system for best-performing individuals. The provision of these opportunities serves as an essential motivator to the health workers and volunteers involved in the project leading them to take their roles seriously and develop a sense of ownership to excel and contribute to the development of their various communities. This important motivating factor further reinforces commitment towards meeting the project's objectives, especially among the healthcare volunteers. Ultimately, the effectiveness and efficiency of health volunteers led to a reduction of health workers' workload. Thus, we pose the following proposition:

Proposition 3

In the context of a high unemployment rate (C), the implementation of the mHealth surveillance project offers opportunities to community members and volunteers, which triggers a sense of fulfilment and social prestige (M) within their communities. This reduces health workers workload (O), thereby leading to improved job satisfaction and efficiency.

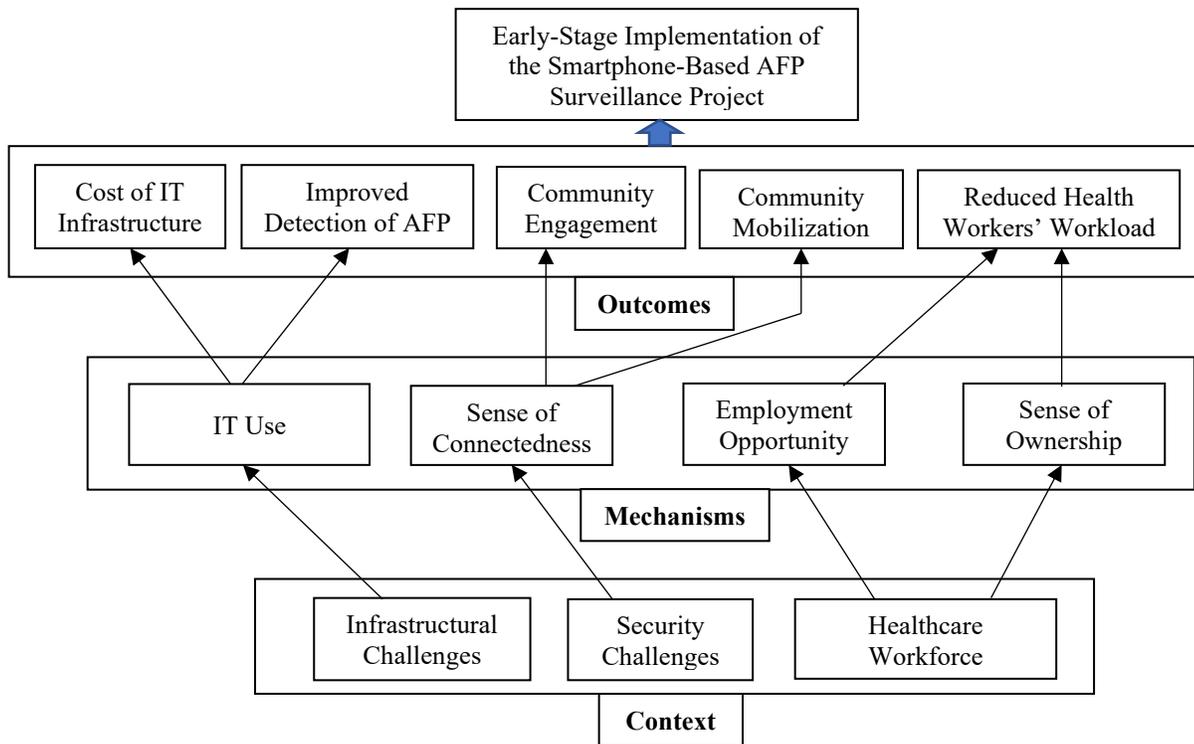
Another important finding from this research highlights the use of the smartphone-based surveillance project in clearing misconceptions about the AFP diseases by creating more awareness in the communities, including the CHWs and CHIs. Before implementing this project, especially in rural communities, community members often associate the symptoms of AFP disease to spiritual illness caused by spiritual beings called *aljanu* in the Hausa language. *Aljanu* is a Hausa word derived from the Arabic word *Jinn*, which roughly refers to a class of supernatural beings below the level of angels and demons and can cause harm to human beings. This also has its roots in Islamic religious teachings and theology. Therefore, Nigeria being a highly religious country, the majority of community members hold on to these beliefs. This presents grounds for the traditional health system to thrive. However, the implementation of this smartphone-based surveillance project has addressed some of these misconceptions among community members. To the best of the authors' knowledge, no IS studies have discussed how smartphone-based disease surveillance has addressed misconceptions about diseases supposedly caused by supernatural beings.

In addition, this research reveals both negative and positive consequences concerning the effectiveness of the project in the context of security-constrained settings. The negative consequences include the destruction of government and private infrastructure such as telecommunications masts, primary healthcare centres and power supply by the Boko Haram insurgents. This challenge has also been

highlighted in Wilson (2018). This affects the implementation of the project as it relies heavily on these infrastructures. Furthermore, theft and robbery have been revealed to be significant challenges resulting from rising levels of security shortages. Similar findings have also been reported in Dick et al. (2017), arguing that mobile phones are still seen as a luxury in developing economies, making them targets for theft and threatening confidentiality issues. This also affects the effectiveness and performance of the surveillance team in the particular setting experiencing these security challenges. However, from an optimistic view, this study shows that the smartphone-based surveillance project has contributed to strengthening surveillance efforts despite some communities remaining inaccessible due to lack of security. This has allowed the CHIs to devise new improvised strategies to circumvent security threats and continue surveillance. This may not have been possible without implementing the project from a community-based approach and involving the local community stakeholders. The advantage of involving local community members in security-constrained areas who understand the terrain and various routes to avoid direct encounters with insurgents has been crucial to the project's success.

Furthermore, this paper argues that CHWs and CHIs comprise the most critical stakeholders in implementing smartphone-based surveillance projects, in line with Tariq and Akter (2011). Therefore, it becomes necessary to protect the needs and interests of this stakeholder group for effective and successful project implementation. Some of the project resources that keep these stakeholder groups motivated include the provision of incentives in the form of cash, airtime, and smartphones. These incentives mean much, considering the economic hardship faced by the majority of the population in the country. The project helps ease the economic hardship of CHWs and CHIs and serve as an additional source of income. Studies such as Larsen et al. (2017) and Manya and Nielsen (2016) also highlight the importance of incentives to improve health workers' motivation and quality of data reporting. Another motivation for CHWs and CHIs is the reputational benefit of being part of an important project to bring development into their community. The project has given some of the community members involved in the project more relevance within the community. This social prestige experienced among CHWs has also been reported in other mHealth studies such as Maiga and Namagembe (2014) and Ide et al. (2019). However, these mHealth studies did not focus on disease surveillance or post-conflict regions. Motivation is also drawn from the improved level of supervision and community engagement provided by free monthly airtime and CUG service incentives. This helps ensure adequate follow-up of cases and timely data transmission from the community to the national level.

The findings of this research also highlight elements of perceived ease of use, similar to the findings in Toda et al. (2017). This indicates that despite the wide range of stakeholders involved, and irrespective of their technological savviness, the smartphone-based surveillance application was easy to operate, averting conflicting needs or interests among the technology users. In addition, the stakeholder groups of CHWs and CHIs share similar interests concerning the need for their superiors to improve fairness in the selection of members invited to the quarterly review meetings and further incentivized. They also share similar needs in calling for a quicker turnaround in repairing or replacing smartphone parts. From the perspective of the DSNOs, similar interests echoed the need to confer more authority to them to allow them to retrieve and re-allocate smartphones from "silent reporters" to more serious and willing volunteers.

Figure 1*Early-Stage Implementation Model for Smartphone-Based AFP Surveillance*

Note. AFP = Acute flaccid paralysis; IT = Information technology.

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

This study has explored how three contextual conditions (infrastructural challenges, security challenges and health workforce) in armed conflict communities influence the early-stage implementation of the smartphone-based AFP surveillance project in Northern Nigeria. The infrastructural challenges affect the use of IT, especially in cases where the mobile network is poor or unavailable due to the destruction of property. The availability of a good network in rural communities is essential as the project relies on it to improve AFP surveillance scope and detection rate. IT also comes with a high purchase, logistics, and maintenance cost, especially in early-stage implementation. This raises concern for the project's sustainability considering the limited financial and human resources available in the health sector. Secondly, security constraints trigger a sense of connectedness and fear, especially from the perspective of community members. This makes them leverage the smartphone network to avoid or navigate known territories of prevalent armed conflict. This sense of connectedness improves community engagement and mobilization. Thirdly, the opportunities provided for community members to volunteer cushions the effect of low health workforce numbers in the rural communities. Considering the unemployment rate, some CHIs have no other source of income besides the incentives from the AFP surveillance project. Therefore, many of them take volunteering seriously because good performance can be rewarded with full-time employment and other benefits. The project, therefore, plays a role in improving the living standards of the community members and ultimately spreads the workload among CHWs and CHIs.

While our study provides valuable insights into the early-stage implementation of the smartphone-based AFP surveillance in armed conflict communities, we acknowledge its limitations. First, the study focused on the early-stage implementation of the project, although findings may change over time. This presents an opportunity to conduct a longitudinal investigation of the later phases of the smartphone-based AFP surveillance project in armed conflict communities. Secondly, the communities investigated have mild cases of armed conflict. However, this was intentional for the safety of the researcher responsible for data collection. The impact of security constraints could be more pronounced in communities with more severe cases of armed conflict. However, these limitations do not deprive the study of its value to the IS community by contributing to a topic with scarce empirical literature.

Our recommendation for the project designers of disease-specific surveillance interventions in armed conflict communities is to ensure that CHWs and CHIs are involved early in the project planning. It is also essential to identify and manage conflicting stakeholder needs and interests from the onset. The integration of the traditional or informal healthcare system is also relevant in achieving a successful project implementation. In addition, the DSNOs should be involved in the selection and recruitment of community members to ensure the right people are selected and ensure workforce efficiency. Further, incentives play an essential role to motivate CHWs and CHIs for better work performance.

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