



**Doctor of Public Health  
in Leadership Program**

# Conducting public health surveillance in areas of armed conflict and restricted population access: a qualitative case study of polio surveillance in conflict-affected areas of Borno State, Nigeria

By

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September 2020

DISSERTATION Submitted as partial fulfillment of the requirements for the degree of Doctor of Public Health in Leadership at the School of Public Health of the University of Illinois at Chicago, 2020

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## Dedication

This dissertation is dedicated to the heroic efforts of the polio workers in Borno state, especially the community workers on the front line. Without their courageous work, Africa could not have eliminated wild polio virus transmission.

## Acknowledgements

My sincere appreciation goes to all the respondents who gave generously of their time to participate in this study. In particular, I am deeply indebted to Dr. Melton Musa for his tireless support since the conception of this study. I also appreciate the support of Dr. Richard Franka and Dr. Omotayo Bolu of CDC and Ndakilnasiya Waziri of NSTOP in opening the door for me to work with CDC and NSTOP staff to conduct this study. Thank you very much to Dr. Biya Oladayo for graciously agreeing to serve as secondary note taker during this study. I would also like to express my sincere gratitude to my dissertation committee, in particular Dr. Eve Pinsker, for her continued support and guidance during this research. I am sincerely thankful for the support of CDC and my supervisor Dr. John Vertefeuille for supporting me with time and resources to conduct this study. Finally, I would like to give a special thanks to my parents Yehuda and Laura, my son Alex, and Xi for their support during this process.

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## Keywords/Abbreviations

AFP	Acute Flaccid Paralysis
ARCC	African Regional Certification Commission for Polio
CDC	Centers for Disease Control
cVDPV	circulating vaccine derived polio virus
CIIA	Community Informant for Inaccessible Areas
EOC	Emergency Operations Center
GIS	Geographic Information System
GPEI	Global Polio Eradication Initiative
GPS	Geographic Positioning System
IED	Improvised explosive devices
IOM	International /organization on Migration
NSTOP	National Stop Transmission of Polio
OCHA	Office on Coordination of Humanitarian Affairs
OPV	Oral Polio Vaccine
RES	Reaching Every Settlement
RIC	Reaching Inaccessible Children
WPV	Wild Polio Virus
WHO	World Health Organization

## Summary

The Global Polio Eradication Program was established in 1988 with the goal of eradicating polio globally by the year 2000. The program is now 20 years past its deadline and struggling to stop transmission in the remaining polio reservoirs. Sensitive polio surveillance is a key component of the effort to eradicate polio because it allows the program to rapidly detect and respond to any cases of polio and prevent larger outbreaks from occurring. The ability to conduct sensitive surveillance however is curtailed in situations of insecurity due to armed conflict. This study examined the impact of armed conflict on public health surveillance systems, the limitations of traditional surveillance strategies to ensure highly sensitive surveillance in areas of armed conflict, and potential strategies to overcome these limitations.

The primary question this study sought to answer was: how can the conventional polio surveillance system and strategies be modified to address areas of conflict and inaccessible populations? Sub questions focused on the exploring the inhibitors of effective surveillance in the context of armed conflict, strategies to overcome them, modified performance monitoring systems, and systems for collaboration.

The study design was a single case study of polio surveillance in the conflict-affected areas of Borno state, Nigeria. This design was chosen to allow an in-depth exploration of the challenge and strategies at play in one of the most challenging conflict situations. I conducted a document review and semi-structured interviews of a purposeful sample of 16 staff in Borno state who work on polio surveillance or the humanitarian response. I analyzed the data using qualitative methods and sought to identify areas of convergence and divergence across the sample and data sources. A conceptual framework and code book was developed to guide the interviews and the analysis.

The study found that the main inhibitors of surveillance in the conflict areas of Borno state were the inaccessibility of the areas, the destroyed health infrastructure, and the destroyed communication network. These three challenges together created a situation in which the traditional polio surveillance system could not function.

Three main strategies were found to be effective in overcoming these challenges. The first was the use of local community informants to conduct surveillance in the inaccessible areas. The second was local level negotiation with the insurgency groups to bring cases of paralysis to accessible areas for investigation and sample collection. The third was the use of GIS technology to track the places reached for surveillance and to estimate the size and location of the population in the inaccessible areas.

A modified monitoring system was developed focusing on process level indicators such as the number of places reached for surveillance and number of acute flaccid paralysis cases detected and investigated. The monitoring system relied heavily on GIS technology to map the reach of the program and produce regular reports for program use.

Collaboration was extremely strong across organizations involved in the polio program and the humanitarian response and this close collaboration facilitated the effective work achieved by the program. A bottom up approach to collaboration was fostered with a focus on achieving a common goal through innovation, collaboration, attention to data, and accountability. This approach may serve as a model for how NGOs can work together without a top down coordination model.

In August 2020 Nigeria and the entire Africa Region was certified as free from wild polio virus, an achievement that rested largely on the surveillance work conducted in the conflict affected areas of Borno state. This study revealed a very effective system of collaboration to address an adaptive problem with no clear solutions. The approach used in Borno was characterized by intense sustained efforts with large financial backing, constant innovation, strong collaboration, attention to data, and a focus on accountability and transparency. This approach, along with some of the specific strategies of local negotiated access, collaboration with security forces, and use of GIS technology, may be useful for other areas of armed conflict.

## Chapter 1: Background and Problem Statement

### A. Study Objectives

Polio eradication efforts in polio endemic regions rely heavily on a sensitive polio surveillance system, centered primarily on active surveillance for any case of acute flaccid paralysis (AFP) with laboratory testing to identify potential polio cases. Conducting this surveillance requires a comprehensive network of surveillance officers and surveillance focal persons to quickly detect, report, and investigate AFP cases as they occur. This network requires participation by the government and private health care providers, and government surveillance officers. It is often augmented with support from partners such as officers from the World Health Organization (WHO). This system however is threatened and these activities are challenged most directly in areas of armed conflict. This complex problem, which can have far-reaching implications, is exemplified in the northern Nigeria State of Borno where the Boko Haram terrorist insurgency arose in 2001 and remains active in 2020. This research will examine the impact of armed conflict on public health surveillance systems, the limitations of traditional surveillance strategies to ensure highly sensitive surveillance in areas of armed conflict, and potential strategies to overcome these limitations.

### B. Background and Context

Poliomyelitis is an acute paralytic viral disease caused by the poliovirus, an RNA enterovirus in the Picornavirus group. Poliovirus is classified into three types, type 1, type 2, and type 3, each of which is capable of causing paralysis. This highly infectious virus spreads from person to person through the oral-fecal route and respiratory droplets. The virus typically infects young children and can lead to sudden onset of permanent paralysis in otherwise healthy children, typically of the lower or upper limbs but also of the respiratory system<sup>1</sup>. The disease once struck fear in the hearts of people worldwide. It frequently caused large-scale outbreaks leading to thousands of cases of devastating lifelong paralysis or death. For patients with respiratory paralysis,

an apparatus called the iron lung was used to keep them alive by permanently confining them within a constraining full-body breathing device (Figure 1). Prior to the widespread use of polio vaccines, an estimated 350,000 cases of paralytic polio occurred annually worldwide<sup>2</sup>. The first recorded evidence of poliomyelitis was found in Egyptian mummies in ancient times<sup>3</sup>. Prior to the use of polio vaccine in the United States over 20,000 paralytic cases were recorded on average per year<sup>4</sup>. One of the most well-known outbreaks in the United States occurred in the northeast in the summer of 1916 in which over 27,000 polio cases and 6,000 deaths were recorded from 20 states. This outbreak created mass panic in New York City and elsewhere<sup>5</sup>.

*Figure 1: Patients confined to iron lung devices due to the 1916 polio outbreak in the United States*



Source:

[https://www.google.com/search?q=iron+lung&rlz=1C1GCEA\\_enUS898US901&source=lnms&tbn=isch&sa=X&ved=2ahUKEwigivTliZvsAhXOxVkkKHW90B0IQ\\_AUoAXoECCIQAw&biw=1536&bih=754#imgsrc=kHiZlhpbrw-9DM](https://www.google.com/search?q=iron+lung&rlz=1C1GCEA_enUS898US901&source=lnms&tbn=isch&sa=X&ved=2ahUKEwigivTliZvsAhXOxVkkKHW90B0IQ_AUoAXoECCIQAw&biw=1536&bih=754#imgsrc=kHiZlhpbrw-9DM)

The poliovirus was first isolated in the 1931. Efforts to develop a polio vaccine ensued shortly thereafter. The first polio vaccine was developed by Dr. Jonas Salk in the 1950s<sup>6</sup>. Salk's inactivated injectable polio vaccine (IPV) was licensed for use in the United States in 1955 following a clinical trial involving 1.6 million children from the United States, Canada, and Finland. In 1961 a live attenuated oral polio vaccine developed by Dr. Albert Sabin was licensed<sup>6</sup>. The Sabin oral polio vaccine (OPV) was preferable for polio eradication because it is cheaper and easier to administer than IPV and it also confers intestinal immunity and therefore reduces

shedding of the virus (with IPV an individual may still pass the virus through their system without being paralyzed). Both vaccines are highly effective and confer protection against all three types of polio. Following the development and widespread use of these two vaccines, polio transmission was largely controlled in industrialized countries. However, large-scale transmission continued in less developed countries.

Disease eradication is defined as “permanent reduction to zero of the worldwide incidence of infection caused by a specific agent as a result of deliberate efforts”<sup>7</sup>. Polio meets the biological criteria for eradicability in that its only reservoir is in humans, an effective vaccine is available that can prevent infection, and diagnostic tools exist to conduct effective disease surveillance. Other aspects of the feasibility of eradication include societal and political commitment and availability of resources<sup>7</sup>.

Riding on the success of smallpox eradication, in 1988 the World Health Assembly resolved to eradicate polio by the year 2000. In order to implement the polio eradication program, in 1988 the Global Polio Eradication Initiative (GPEI) was formed as a partnership between the World Health Organization (WHO), the United Nations Children’s Fund (Unicef), the Centers for Disease Control and Prevention (CDC), and Rotary international<sup>8</sup>. The partnership capitalized on the unique strengths of each organization. Rotary International is one of the largest humanitarian service organizations and provides a large portion of the funding and volunteer recruitment for the initiative. CDC provides technical, scientific, and laboratory support for the initiative. WHO provides oversight and assistance to developing countries in conducting polio vaccination and surveillance. Unicef provides logistical support in procuring and distributing vaccines and refrigeration equipment as well as leading the effort to conduct mass health education for polio eradication. In 2007, the Bill and Melinda Gates Foundation (BMGF) joined the partnership as a major donor and technical partner. As of 2017 over 15 billion dollars have been invested in polio eradication<sup>9</sup>.

The strategy for polio eradication is to ensure that children receive three doses of polio vaccine through the routine infant vaccination program, ensure high herd immunity by conducting supplemental mass vaccination campaigns to reach children missed by routine vaccination, conduct high quality polio surveillance, and quickly

respond with a robust vaccination response anytime a polio outbreak occurs. These strategies were developed based on experiences in countries that had effectively eliminated polio. Because of the effectiveness of the vaccine it was expected that achieving polio eradication would be relatively easy. By implementing a routine vaccination program for all infants, polio transmission could theoretically be achieved. However, polio transmission may continue if there are sufficient susceptible individuals in older age groups and if there are pockets of low vaccination coverage with the routine vaccination strategy. To address these limitations, the strategy of mass vaccination campaigns is implemented to provide supplemental doses of polio vaccine to all children aged 0-59 months. The rationale for this age group is that most polio transmission occurs among children less than 5 years of age. Cuba was the first country to conduct a mass vaccination campaign against polio in 1962<sup>10</sup>.

The effectiveness of the bivalent oral polio vaccine currently in use is estimated to be 97% against type 1 poliovirus and 96% against type 3 poliovirus<sup>11</sup>. In addition to routine infant vaccination and mass vaccination campaigns, sensitive surveillance is needed to monitor polio incidence. The main strategy for conducting polio surveillance is a syndromic approach in which all cases of acute flaccid paralysis (AFP) among children less than 15 years of age are investigated and laboratory tested for the presence of poliovirus. The final strategy of the polio eradication program is to conduct targeted vaccination campaigns called “mop up” campaigns anytime polio outbreaks are identified. This allows the program to quickly stamp out any pockets of transmission that occur before they can spread more widely.

### GPEI Successes and Challenges

With the use of these strategies and the support of the GPEI, the program achieved great successes in the 1990s. Since the eradication goal was declared great strides have been made in reducing polio transmission worldwide. In 1988 when the eradication goal was established 325,000 cases of paralytic polio occurred each year in 125 countries around the world<sup>12</sup>. The Americas were the first region to be declared polio free in 1994<sup>13</sup>, followed by the Western Pacific Region in 2000<sup>14</sup> and the European Region in 2002. Important progress has also

been achieved in reducing the types of polio in circulation. Global eradication of type 2 poliovirus was declared in 2015 and global eradication of type 1 poliovirus was declared in 2019.

Progress in achieving eradication was slower however in the Africa, South East Asia, and the Eastern Mediterranean regions. Due to high population density and poor sanitation, in many of the countries in these regions individuals were more susceptible to polio transmission. In addition, poor health infrastructure meant that many countries in these regions were unable to conduct routine immunization and mass campaigns with sufficiently high coverage to stop transmission. While in theory only three mass vaccination campaigns are needed to stop polio transmission, if the campaigns are unable to achieve uniformly high coverage among the targeted population, polio transmission may continue. Indeed this is what occurred in some countries of those regions including India, Pakistan, Afghanistan, Nigeria, and the Democratic Republic of Congo. Political instability in these countries led to poor government oversight, insufficient funding, and poor accountability for the quality of polio mass vaccination campaigns. Armed conflict and sectarian violence, and government opposition also resulted in low coverage in some areas. The existence of isolated and mobile populations such as nomadic groups and migrant workers also led to pockets of populations susceptible to polio in these countries.

By the year 2000 the number of polio cases had decreased to 2,849 in 14 countries and less than 33% of the global population lived in polio endemic areas compared to over 80% in 1988<sup>15</sup>. Polio eradication suffered a serious setback in 2003 however when rumors of tainted vaccine led to a widespread ban on polio vaccination in northern Nigeria<sup>16</sup>. This ban led to a major increase in polio transmission in Nigeria as well as the exportation of the virus from Nigeria to over 20 countries in Africa and Asia. Responding to this setback cost over 500 million US dollars<sup>17</sup>. Despite this setback progress continued and by 2006 only 4 countries remained endemic for polio: Afghanistan, India, Nigeria, and Pakistan<sup>18</sup>. Transmission was limited, by and large, to small geographies within those four countries.

At the start of 2012 polio was still endemic in those four countries and outbreaks were continuing to occur in previously polio-free countries. Donors were becoming fatigued with continuing to fund a program that was 12 years past its deadline and not making progress in stamping out the remaining transmission. There was a serious concern that the goal of polio eradication was in peril and that if the effort to eradicate polio was stopped, large scale polio outbreaks resulting in high numbers of paralysis cases and death due to polio would ensue. As a result, in 2012 the World Health Assembly declared the completion of polio eradication to be a global health programmatic emergency<sup>19</sup>. This infused new energy and resources into the polio eradication initiative including the activation of the CDC emergency operations center to respond to polio outbreaks. In 2012 polio eradication achieved a major victory when India was removed from the list of polio endemic countries. Since that time endemic polio transmission has been limited to Nigeria, Afghanistan, and Pakistan<sup>20</sup>.

Stopping the last pockets of transmission however is proving to be much more challenging than expected. Afghanistan, Pakistan, and Nigeria, the remaining three countries with endemic polio transmission, all suffer from insecurity, political instability, inaccessibility, and armed conflicts. These conditions pose unique challenges to implementing the polio eradication strategies. Without full access to the population for vaccination and surveillance, the poliovirus can maintain a reservoir of circulation and unreached populations will remain susceptible to polio infection. As of December 31 2017 there were a total of 18 wild polio virus cases reported globally, an all-time low, but the goal of zero cases remained beyond reach. Since 2017 there has been an increase in wild polio cases with 33 confirmed cases in 2018 and 176 confirmed cases in 2019.

GPEI developed an end-game strategy for the period 2013-2018<sup>21</sup>. The objectives of the plan were to interrupt all polio transmission, strengthen routine immunization with OPV and withdraw the use of type two OPV, contain all laboratory use of poliovirus, and plan to transition polio resources for other public health goals. The plan included “strategic approaches to end polio transmission, an emphasis on improving immunization systems”, introduction of inactivated polio vaccine (IPV), strategies to address risks such as insecurity, and a timeline for completion<sup>21</sup>.

The plan's first objective however, of stopping wild poliovirus transmission by 2014, was not achieved. The plan was budgeted at 5.5 billion dollars. This was later increased to 7 billion dollars. Given the need for continued mass vaccination campaigns in the three remaining endemic countries, GPEI has recognized that even this is not enough. The program is now 20 years past its deadline and is beginning to ramp down due to funding shortfalls. The risk that polio will re-emerge as a major cause of morbidity and mortality in the world, and will again strike fear in the hearts of people everywhere is very real. It is unlikely that the polio eradication initiative will be able to sustain itself for another five years if eradication is not achieved in the near future.

### Background on polio surveillance

There are four key strategies for polio eradication: mass polio vaccination campaigns, strengthening routine infant polio vaccination, conducting sensitive polio surveillance, and rapidly responding to polio outbreaks. The four strategies are all complementary and essential for eradication. Surveillance is needed for monitoring progress towards polio eradication and rapidly responding to outbreaks to prevent further spread.

A disease surveillance system is the “ongoing, systematic collection, analysis, interpretation, and dissemination” of health-related data<sup>22</sup>. Its functions include monitoring disease trends, guiding disease prevention programs, and guiding immediate outbreak response activities<sup>22</sup>. In order to monitor progress in polio eradication, respond to outbreaks, and document the cessation of transmission, a highly sensitive polio disease surveillance system is needed. The polio surveillance system is crucial to the polio eradication program because it enables the program to rapidly identify and respond to outbreaks of polio. It is also needed to document the interruption of polio transmission. Without a highly sensitive polio surveillance system there is a risk that undetected polio circulation may occur, thereby placing the polio eradication program in jeopardy. If polio is thought to be eradicated while undetected circulation is still continuing, the risk of explosive outbreaks occurring in the future is very high. Unlike smallpox, the only human disease that has been successfully eradicated, not all polio infections are symptomatic. In fact, the polio virus causes paralysis in fewer than 1 out

of every 100 people infected<sup>23</sup>. Therefore missing even one case of paralytic polio means missing a large number of infections.

The role of polio surveillance is to identify any polio case and rule out the existence of polio transmission in areas with no reported cases. The main strategy for conducting polio surveillance is to search for cases of acute flaccid paralysis (AFP), a type of syndromic surveillance (figure 2<sup>24</sup>). While not all polio infections cause paralysis, this is the most identifiable symptom of polio infection. Because a large percentage of polio infections are inapparent, testing sewage samples for poliovirus (environmental surveillance) is conducted in polio high risk areas to augment AFP surveillance<sup>25</sup>. Polio is not the only etiology that can cause acute flaccid paralysis however. For this reason it is necessary to test specimens from identified AFP cases to confirm or rule out polio as the cause of the paralysis.

*Figure 2: Components of the AFP surveillance system<sup>24</sup>*

## Components of the Polio surveillance system

1. Find and report all children with acute flaccid paralysis (any child less than 15 years of age or anyone of any age for which a clinician suspects polio) – global indicator is at least 1 case per 100,000 children under 15 years of age (or two cases per 100,000 in endemic areas).
2. Collect two stool specimens from each case – specimens should be collected within 14 days of onset of paralysis and 24-48 hours apart. Global indicator is at least 80% of AFP cases with adequate specimens collected.
3. Conduct laboratory testing of the specimens to determine if it is polio and, if yes, to determine the type.
4. Conduct advance laboratory testing to determine and map the virus genotype for all wild polio viruses to examine the chains of transmission.

A global laboratory network of 145 laboratories has been created for polio surveillance including stringent quality assurance and accreditation systems and regional and global reference laboratories<sup>26</sup>. Advance

laboratory methods are used to confirm polio cases and conduct molecular epidemiology including genomic sequencing of positive cases<sup>27</sup>. The existence of poliovirus infection is confirmed by conducting a culture of a stool specimen, determining the polio serotype, and conducting intra-typic differentiation to distinguish vaccine virus from wild virus. Poliovirus neutralization procedure is conducted on RD and L20B cell cultures. Intratypic differentiation is conducted using polymerase chain reaction (PCR) laboratory methods<sup>28</sup>. Genomic nucleotide sequencing is conducted on confirmed polio cases to monitor the genetic lineages through phylogenetic analyses<sup>29</sup>.

In order to ensure that no cases of polio are missed, the background rate of AFP based on the observed occurrence of GBS (the most common cause of AFP) was used as the benchmark for sensitive AFP surveillance. Studies indicate that GBS occurs in children at a rate of approximately 1 case per 100,000 population per year<sup>30</sup>. Therefore, the global standard for AFP case detection is at least 1 case per 100,000 children under the age of 15<sup>31</sup>. Individual countries have chosen to increase this standard to ensure the highest possible sensitivity of their AFP surveillance system.

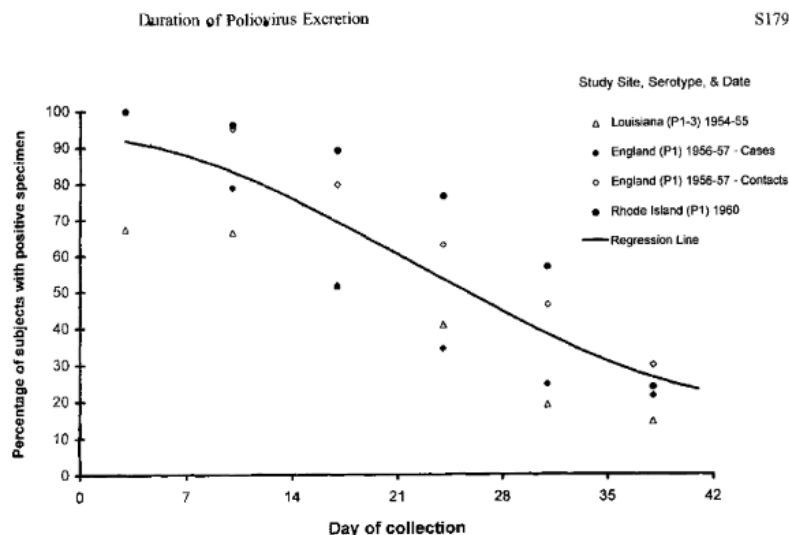
The global standards for AFP surveillance recommend conducting both passive and active surveillance for AFP. The passive surveillance includes immediate reporting and investigation of all AFP cases and outbreaks, inclusion of AFP counts in monthly routine surveillance reporting, and regular reporting of AFP counts from selected designated reporting sites. Active surveillance involves regular visits to priority sites to search for unreported AFP cases<sup>31</sup>. For each AFP case detected the system requires collecting two stool specimens for laboratory testing within 14 days of paralysis onset (this is the period with the highest likelihood of detecting the polio virus.)

The acute flaccid paralysis (AFP) surveillance system may well be the most sensitive public health surveillance system in the world. Indeed, in 2016 globally over 100,000 AFP cases were investigated with laboratory testing with an overall detection rate of 5.8 non-polio AFP cases per 100,000 children under the age of 15<sup>32</sup>. The system is in place in all countries of the world with a target of detecting and investigating at least

one case per 100,000 children under 15 years of age<sup>31</sup>. This highly sensitive system is needed because the goal of polio eradication, which was endorsed by the World Health Assembly in 1988 and has cost over 15 billion dollars to date, requires the ability to quickly detect and respond to any polio transmission anywhere in the world<sup>33</sup>.

WHO has published a global guide to conducting surveillance for vaccine preventable diseases including polio; globally the standards for AFP surveillance are a non-polio AFP rate of 1 per 100,000 children under fifteen years of age, and at least 80% of cases with 2 stool specimens collected within 14 days of onset of paralysis<sup>31</sup>. The reason for collecting specimens within 14 days of paralysis onset is to maximize the likelihood of detecting the virus (Figure 3)<sup>34</sup>. WHO bolsters the AFP surveillance guidance in countries that remain endemic for polio or are at high risk for polio due to low immunity levels. In these countries the system involves establishing a wide network of reporting sites, conducting active surveillance based on site prioritization, sensitizing clinicians on the importance of reporting cases, creating a robust laboratory network for specimen testing, and supplementing AFP case searches with laboratory testing of sewage samples from high risk areas. In Nigeria the standard for AFP detection was raised to 3 per 100, 000 children to ensure that no case is missed.

Figure 3: Duration of poliovirus excretion after paralysis<sup>34</sup>



According to the national AFP surveillance guidelines for Nigeria, reporting sites should include hospitals, health facilities, traditional healers, pharmacies, and private clinics<sup>35</sup>. These reporting sites are categorized as high, medium, and low priority based on the likelihood of AFP cases presenting at the sites (hospitals being the highest priority). District surveillance officers are expected to regularly visit the reporting sites for active surveillance, with more frequent visits to higher priority sites. Each reporting site is expected to designate an AFP surveillance focal person to identify and immediately report any AFP cases presenting at the site and also submit weekly reports on the aggregate number of cases identified. Partner organizations such as WHO play a large role in supporting the surveillance system, including providing training to health workers and surveillance staff and supporting the collection and analysis of AFP case data.

In order for the AFP surveillance system to be effective, surveillance officers must be designated and trained to run the system. Resources are needed for conducting active surveillance and supervision, training surveillance staff, maintaining and analyzing surveillance data, conducting laboratory testing, producing surveillance communication materials, conducting outbreak investigations, and transporting specimens for testing. Political commitment is needed to ensure that the resources and staff are deployed to run the system. The system can break down when resources are not available to conduct surveillance, health workers are not regularly trained and sensitized about the need to report cases, reporting networks are not regularly updated, surveillance data are not regularly analyzed and used for corrective purposes, and laboratory procedures are not followed. Among other things, resources are needed to conduct active surveillance, supply tools and specimen collection kits, and transport specimens to the laboratory. Regular training of health workers on surveillance is needed to ensure that they remain aware of the need and process for conducting AFP surveillance. Reporting networks require updating as new health facilities are established or when new important surveillance sites are identified. Analysis of surveillance data is needed to identify gaps in the surveillance system such as areas of low case detection or investigation. Following laboratory procedures is critical to ensuring that accurate test results are obtained. Other problems that affect the quality of the system include a lack of sufficient health facilities in the network, remote or nomadic communities with poor access to health facilities, and home treatment for

paralysis. For example, if a population does not have access to a nearby health facility, they may not seek health care for paralysis and therefore it is much more difficult to identify the case.

The AFP surveillance system worldwide has achieved a very high level of sensitivity to detect polio virus transmission. In 2017 (as of August 22 2017) a total of 60,050 AFP cases were reported worldwide. From January 1 – August 2 2017 a total of 19,308 AFP cases were reported in the 47 countries of the WHO Africa region with an annualized non-polio AFP detection rate of 6.85 per 100,000 children under the age of 15 years. In the 21 countries of the WHO Eastern Mediterranean during the same time period a total of 10,963 AFP cases were reported with an annualized non-polio AFP detection rate of 7.7 per 100,000 children under the age of 15 years<sup>36</sup>. For both of these regions (the only two with remaining endemic polio transmission) the non-polio AFP detection rate exceeded the target. The annualized reporting rates for the other regions of the world ranged from 7.17 in Southeast Asia to 0.67 in the Americas<sup>37</sup>.

#### Impact of armed conflict

While the AFP surveillance system has been clearly defined, unique challenges can hinder the effectiveness of the system. Armed conflict, in particular, creates serious challenges for conducting sensitive disease surveillance. For example, an outbreak of polio in South Sudan detected in 2008 represented three years of undetected transmission due to ongoing conflict in that country<sup>38</sup>. Disruption in both vaccination and surveillance has led to polio outbreaks in Afghanistan, Somalia, Angola, and the Democratic Republic of Congo as well<sup>39</sup>. Somalia for example interrupted polio transmission in 2002 but ongoing armed conflict led to disruption in health care including vaccination which resulted in large polio outbreaks occurring in 2005-7 and also in 2013<sup>40</sup>. As will be discussed in more detail below, in Nigeria the Boko Haram terrorist insurgency in the northeast of the country resulted in a similar disruption in health care including both surveillance and vaccination activities. At the height of the Boko Haram territorial expansion in 2015 over half of Borno state was inaccessible for health services. In 2016 it was estimated that approximately 337,000 children under five years of age were inaccessible for vaccination or surveillance (detailed estimates for 2015 are not available)<sup>41</sup>.

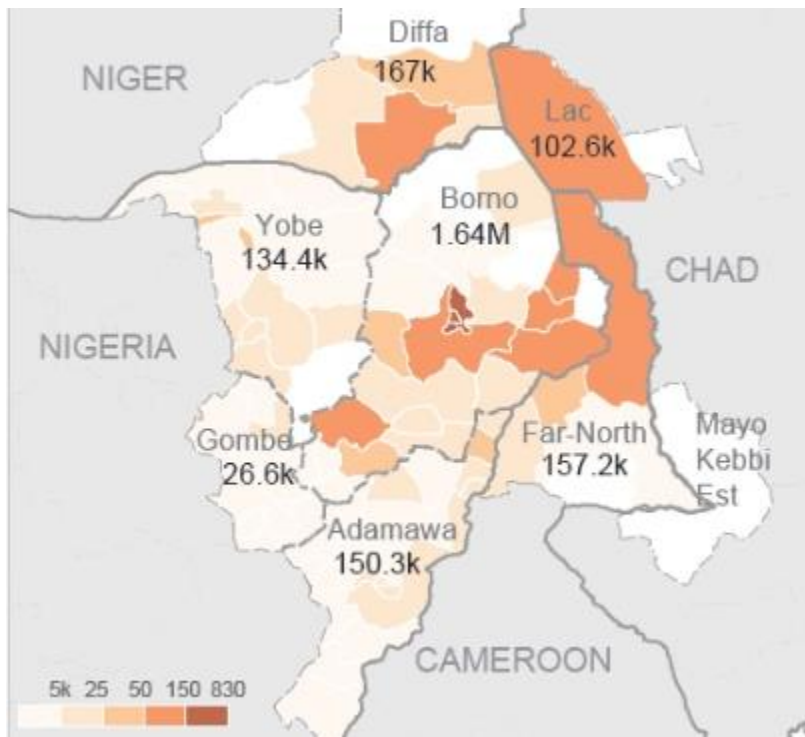
Overall, the performance of the AFP surveillance system in Nigeria was very high with 11,492 AFP cases reported between January 1 and August 22 2017, the highest reporting rate in Africa. However, this high performance masks gaps in surveillance at the subnational level. For example, high reporting in some areas can result in an overall adequate performance as measured by standard indicators even though there may be geographical areas where surveillance is not taking place. In Borno state, where Boko Haram operates, 2 districts (Abadam and Marte) did not report any AFP cases in 2017 and overall 43 percent of subdistricts had not reported any AFP cases in that year. In addition, in 2017 one AFP case from the same area of Borno as a confirmed case from 2016 was not investigated in time and was therefore classified as a polio compatible case, indicating potential continued polio transmission<sup>42</sup>.

### Boko Haram in Nigeria

As presented here, conducting polio eradication activities in endemic regions relies on effective AFP surveillance to identify potential polio cases. Conducting this surveillance relies on a system of local reporters and support systems to detect and investigate cases including collecting specimens. This system is threatened and these activities are challenged most directly in areas of armed conflict. This complex problem, which can have far reaching implications, is exemplified in the northern Nigeria province of Borno State, where the Boko Haram terrorist insurgency arose in 2001 and continues today.

For over a decade Northeast Nigeria, and particularly Borno state, has been plagued by ongoing attacks by the Boko Haram terrorist group. Boko Haram is responsible for mass killings, hostage takings, and destruction of houses and infrastructure including health facilities. Since 2014, the terrorist group gained control of significant territory in the state with disastrous results. Around 2.2 million people have fled their homes due to the terrorist activities and 7 million are in need of humanitarian assistance<sup>67</sup>. The majority of the internally displaced persons (IDPs) are located in the state capital of Maiduguri (Figure 4). The government of Nigeria declared a state of emergency in Northeastern Nigeria in 2012, and in 2016 the World Health Organization declared a Grade 3 humanitarian emergency in Borno.

Figure 4: Estimated number of IDPs by District, Borno 2016



Source: UNOCHA. Lake Chad Basin: Crisis Overview 11 July 2016.

<http://reliefweb.int/sites/reliefweb.int/files/resources/Lake%20Chad%20Basin%20Snapshot%2011%20July%202016.pdf>

Boko Haram literally means “Western Education is Forbidden”. It is an affiliate of the Islamic State of Iraq and Syria (ISIS) and goes by the name Islamic State of West African Province. The group has killed over 20,000 people since 2009. In one of the acts of terror most widely covered by the media, the group abducted 279 school girls in 2012 (the “Chibok Girls”), many of whom are still missing. The group demonstrated its danger to the international community in 2011 when it bombed the United Nations building in Abuja (the capital of Nigeria), killing 21 people. Similar to ISIS in the Middle East, Boko Haram has claimed control over a large geographical area in Borno State in Nigeria. The Boko Haram controlled areas are completely inaccessible to the government and any other individuals not living in those areas<sup>43</sup>.

The impact of the Boko Haram terrorist insurgency is devastating. An estimated 1.3 million people are internally displaced in Borno and are struggling to obtain the basic necessities of food, water, shelter, and

healthcare<sup>44</sup>. The high rates of severe acute malnutrition led the Nigerian Minister of Health to declare a nutrition emergency in Borno State in 2016. As of October 2017 an estimated 3.4 million people in northeast Nigeria were in need of nutrition assistance<sup>45</sup>. The reduced immunity due to malnutrition, coupled with crowded and unhygienic living conditions among the displaced populations and a severe shortage of health facilities and medicines has led to large and unusually severe outbreaks of infectious diseases including malaria, cholera, measles, and respiratory tract infections. Over half (334/632) of the state's health facilities have been abandoned or destroyed and no health services are available in Boko Haram controlled areas.

Since 2017 the government of Nigeria was able to regain control of most major towns that were previously under Boko Haram control. In addition, many rural villages under Boko Haram control were abandoned. By the end of 2019 the size of the population living under Boko Haram control was significantly reduced compared to 2016 and 2017 but there remains a substantial population living in inaccessible Boko Haram controlled areas.

### The impact of Boko Haram on polio eradication and polio surveillance in Borno

In Borno state in northeast Nigeria, the widespread devastation caused by the Boko Haram terrorist group has affected all aspects of life, including AFP surveillance. In 2015 after having gone over a year without any reported polio cases, Nigeria was officially removed from the list of polio endemic countries<sup>46</sup>. However, in 2016, approximately one year later, four paralytic polio cases were reported from Borno state<sup>47</sup>. This occurred shortly before Africa was due to be certified as polio free and was a major setback for the global polio eradication initiative. If this outbreak had not occurred, polio would have successfully been limited to a small geographic area of Afghanistan and Pakistan and the world would have been much closer to achieving global polio eradication.

The outbreak posed a very high risk of spreading polio transmission to other vulnerable populations in the Lake Chad basin of Africa, an area with some of the lowest health indicators in the world<sup>48</sup>. This is because Nigerians travel a great deal internationally for trade and can bring the virus with them when they travel. In areas with a high number of susceptible individuals due to low vaccination coverage, the re-introduction of the virus leads to explosive outbreaks such as those that occurred after the 2003 polio vaccination ban in Northern Nigeria<sup>17</sup>.

The 2016 polio cases were detected in children in newly liberated areas of Borno State and among recently displaced people fleeing Boko Haram controlled areas. This outbreak highlighted the gaps in the AFP surveillance system caused by the armed conflict in Borno state. The polio cases were most closely linked to an outbreak in 2011 which suggests that the transmission had been continuing undetected for a period of at least five years<sup>49</sup>. Undetected polio transmission for several years is a major breakdown of the polio surveillance system, which aims to rapidly detect all paralytic polio cases. This type of breakdown in the surveillance system undermines the ability of the program to rapidly respond to polio outbreaks and presents a risk of further spread of polio transmission to polio-free areas in the context of low immunity and high population susceptibility to polio in the Lake Chad basin of Nigeria, Chad, Niger Republic, and Cameroun.

The polio surveillance system is severely hampered in Borno State due to the Boko Haram terrorist insurgency. Approximately half of the settlements in Borno state have been inaccessible since 2014 and cannot be reached by the polio program staff (including local government or NGO workers) for vaccination or surveillance. This means that active surveillance cannot take place in those areas. In addition, health facilities are no longer operational in the Boko Haram controlled areas and therefore passive surveillance by health workers is also not possible. Also, cellular network for telephone communication is unavailable in most of the inaccessible areas because the cell phone towers were destroyed and therefore remote reporting of cases by local community members is also impossible. This leads to a situation in which AFP cases cannot be detected or investigated and therefore the extent of polio circulation in Boko Haram controlled areas cannot be ascertained.

As a result, therefore the country could not be certified as being polio free even in the absence of reported cases.

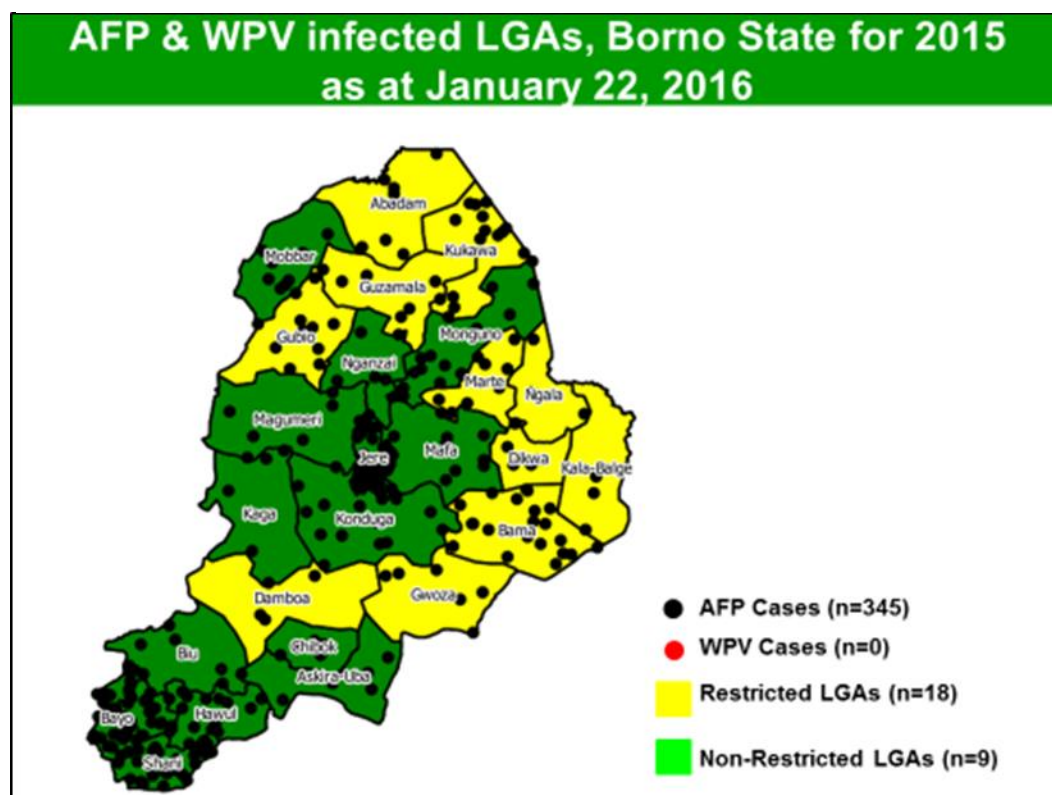
The two main indicators that are used to measure the performance of the polio surveillance system globally are the non-polio AFP rate and the stool adequacy rate. The non-polio (NP) AFP rate is measured by the number of cases detected per 100,000 children under the age of 15 and the target set by Nigeria is at least 3 cases per 100,000. The stool adequacy rate is the percent of detected AFP cases for which two stool specimens are collected within 14 days of onset of paralysis and shipped to the laboratory in good condition. The global target for stool adequacy is 80%.

In 2015 and 2016 (up to August) the surveillance indicators (NP-AFP rate and stool adequacy) in Borno State were well above the global and national standards for Nigeria.

- 2015 non polio AFP rate: 16 per 100,000 at the state level, at least 2 in every district<sup>50</sup>
- 2015 stool adequacy: 99% at the state level, at least 93% in every district<sup>50</sup>
- 2016 non polio AFP rate (up to August): 29 per 100,000 at the state level, at least 4 in every district<sup>51</sup>
- 2016 stool adequacy rate (as of August 19):99% at the state level, at least 95% in every district<sup>51</sup>

In addition to the indicators, the AFP spot maps produced by WHO Nigeria (Figures 5 and 6) showed a fairly even distribution of AFP cases across the state for 2015 and 2016 in both restricted and non-restricted local government areas (LGAs).

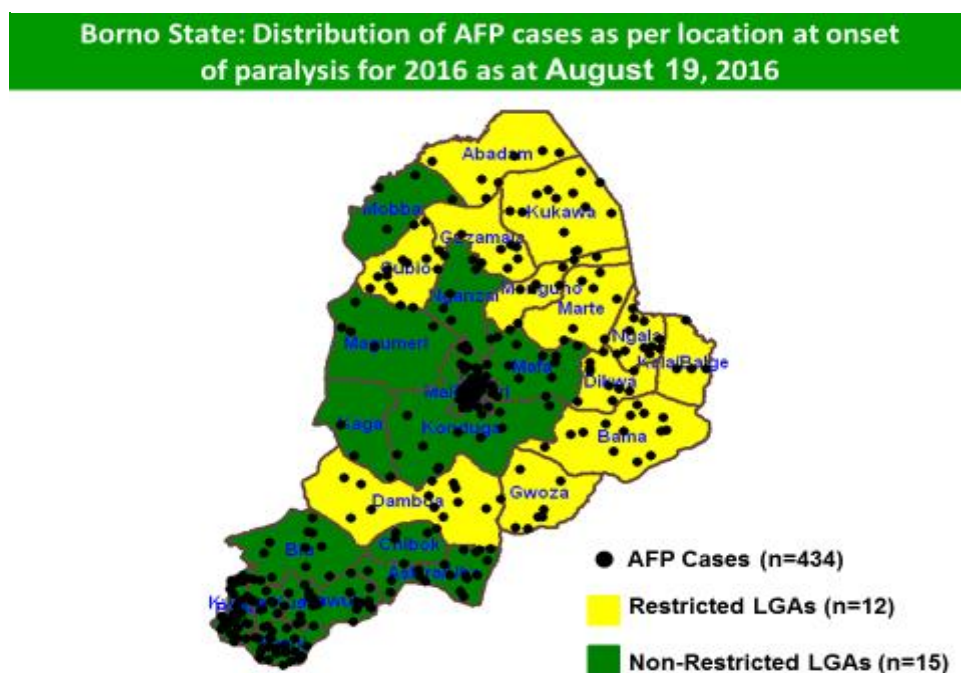
Figure 5: Borno AFP case map, January 1 – December 31 2015 (cases randomly plotted within districts)



Source: WHO Nigeria

WPV means wild polio virus. LGA means local government area (equivalent to district)

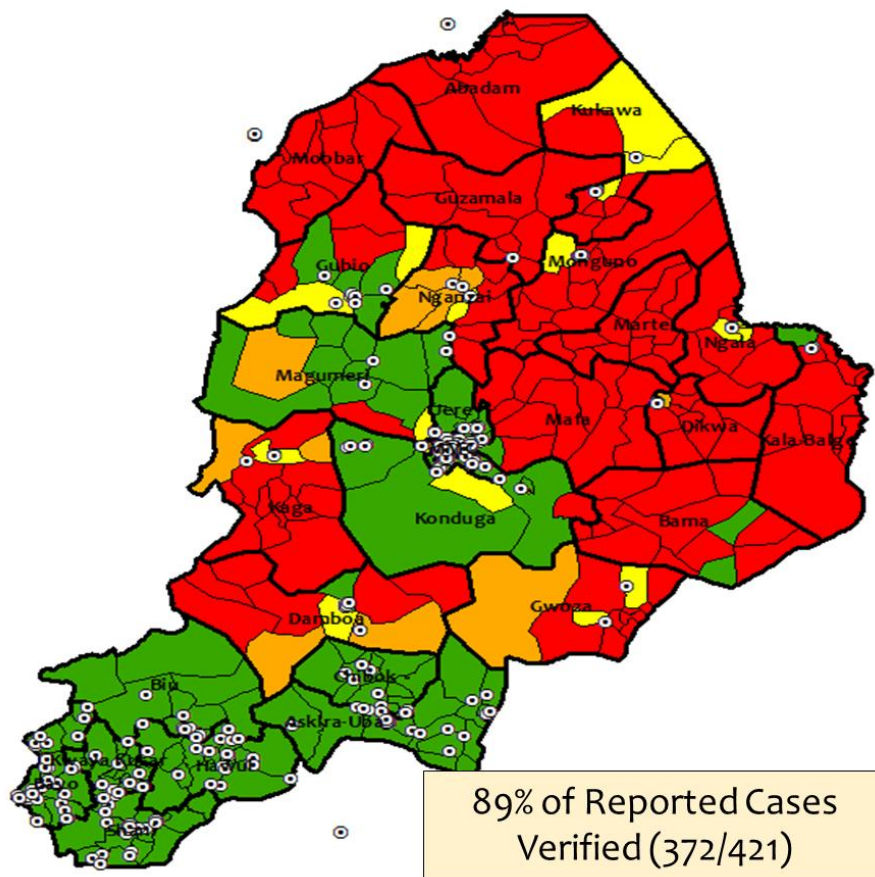
Figure 6: Borno AFP case map, January 1-August 19 2016 (cases randomly plotted within districts)



Source: WHO Nigeria

In Borno, the AFP maps produced by WHO for 2015 and 2016 and the NP-AFP rate indicator by district both indicate presence of a highly sensitive AFP surveillance system, even reaching to security compromised inaccessible areas. However, when plotting the GPS coordinates of the AFP cases (figure 7) it became clear that, in reality, the detection of cases in 2016 covered a small area of Borno in the accessible areas and garrison towns established within inaccessible districts. The mapping of cases using GPS coordinates revealed a serious flaw in the validity of the data on location of AFP cases being presented. This indicated that surveillance in the inaccessible areas was not as sensitive as is perceived through earlier analysis (Fig 5, 6). One of the reasons for this gap in the surveillance system is the mapping of AFP cases by randomly assigning locations within the district which makes the distribution of cases appear more even than they actually are. More serious was the practice of assigning cases from IDP camps to the district that they fled from rather than the location of the IDP camp. This was perhaps done because the IDPs were often organized according to their district of origin in the IDP camps in accessible areas (primarily in and around metropolitan Maiduguri). Much of the government district staff including the disease surveillance notification officers (DSNO) were relocated to the camps and continued providing services to their displaced district population in those camps. In this context it can be understood that AFP cases detected in those camps were assigned to the district of origin rather than the actual place of onset of paralysis or detection. Assigning those cases to the district of origin however masked the absence of surveillance among the population living in the inaccessible areas and led to a false reassurance that there was no polio transmission in the inaccessible areas. The map in figure 7 of the actual location of AFP cases identified in Borno makes it clear that, in fact, cases were not being detected in inaccessible areas and therefore the existence of polio transmission in those areas could not be ruled out. Had that map been available when WHO was considering removing Nigeria from the polio endemic list, it is unlikely that they would have come to the conclusion that sufficient evidence was available to conclude that transmission had stopped.

Figure 7: Actual coordinates of AFP cases, January-August 2016



Source: WHO Nigeria

An external review of the AFP surveillance system in Nigeria conducted by GPEI partners in August 2016 concluded that although there is a well-defined surveillance structure with well trained workforce, surveillance is severely limited in Borno because close to half of settlements are inaccessible and almost 40% of the health facilities are either destroyed by insurgents or are not functional due to insecurity.

The premature removal of Nigeria from the polio endemic list in 2015 was a major error for the polio eradication program and led to an erosion in the confidence in the surveillance data provided by Nigeria and an increased scrutiny of the program. The entire GPEI and the government of Nigeria are now very attuned to this issue and recognize the importance of ensuring that surveillance reaches all areas of Borno before claiming to be polio free.

### C. Problem statement and Study Questions

The global polio eradication program is now years past its deadline for eradication and billions of dollars over budget and is in jeopardy of becoming the most expensive public health failure in history. Ensuring high quality surveillance in conflict-affected areas is critical to reaching the goal of global polio eradication but current models have not been successful in achieving the required level of surveillance sensitivity in the inaccessible areas.

The lack of an effective approach or system for conducting surveillance in these inaccessible areas is currently a major stumbling block for the global polio eradication program. The existing model for AFP surveillance has not proved successful in conflict settings such as Borno. The polio program has been unable to conduct surveillance in inaccessible areas of Borno State which led to undetected polio transmission for a period of five years. Reasons for this include that active surveillance is not possible in inaccessible areas, regular passive reporting is not possible when reporting sites and communication systems are destroyed, and traditional surveillance indicators were not designed to ensure high quality surveillance in specific sub populations such as trapped populations. It is also not clear how to assess populations living in areas made inaccessible due to armed conflict when direct negotiation with parties in the conflict is not possible and populations cannot be directly accessed to conduct disease surveillance or provide public health services. As a result it was unknown if polio transmission is still occurring among the trapped population in places such as Borno. A further challenge for the polio eradication program is that unless the surveillance system is sensitive everywhere, there is a risk of polio transmission that could conceivably spread anywhere in the world and lead to further morbidity and mortality from poliomyelitis and further delays in achieving global eradication. These adaptive challenges the program is facing are putting extreme pressure on the system and its resources. New strategies are needed to solve these adaptive challenges and ensure polio transmission is not missed in security-compromised areas. At present more information is needed about the factors that could support or hinder new or more effective

approaches for polio surveillance in inaccessible areas. This research, focusing on AFP surveillance in Borno State, as a case study, seeks to answer the question of how AFP surveillance can be effectively conducted in areas with populations that are inaccessible due to armed conflict.

The overarching question is: How can the conventional polio surveillance system and strategies be modified to address areas of conflict and inaccessible populations?

Specific sub-questions include:

1. What are the inhibitors of effective surveillance in the context of the armed conflict in Borno State, Nigeria?
2. What are the opportunities for effective surveillance in these settings? What strategies and field methods would enable effective surveillance in these settings?
3. What monitoring procedures and indicators may be useful in monitoring surveillance performance in inaccessible areas?
4. What systems are in place for collaboration and information sharing for polio surveillance between the various actors (governmental, non-governmental, and multinational) that are supporting the humanitarian response in Borno?

#### D. Leadership Implications

This project has practical considerations for the field of humanitarian assistance in complex emergencies with inaccessible areas. It is hoped that the findings from this project will lead to adoption of better methodologies and more systematic approaches to conducting disease surveillance and providing public health services in complex emergencies. This would include more accurate identification of the size and location of high risk populations in complex emergencies and earlier responses to the people at the highest risk of morbidity and mortality in conflict settings. For polio and other disease eradication programs this research will ideally lead to the development of better guidance on the unique challenges posed by armed conflict and the

utility of new approaches to ensuring the absence of disease when traditional disease surveillance approaches are not implementable due to conflict.

## Chapter Two: Conceptual and Analytical Framework

### A. Literature review

#### Current AFP surveillance system

The available literature on conducting sensitive polio surveillance describes approaches that are effective when populations can be reached and active engagement is possible<sup>31</sup>. These include use of data for decision making at the local level, timely data submission, development of standard guidelines, surveillance training, and teamwork<sup>52</sup>. Attributes of an effective surveillance system are shown in figure 8<sup>53</sup>. Each of these 9 attributes is relevant for AFP surveillance and surveillance in areas of armed conflict. For example, if people are not willing to conduct surveillance either because they do not have the time or motivation or because it is dangerous, the system will not work. If the quality of data collected is low, the wrong interpretations may be made with the data. Predictive value positive is also relevant as false positives can result in costly and unnecessary responses. Stability is especially difficult to maintain in the unpredictable and rapidly changing context of armed conflict. Timeliness also suffers when communication and transportation networks break down. Maintaining simplicity, while important, becomes challenging when the barriers of armed conflict are introduced to the system. Flexibility may be one of the key attributes for situations of armed conflict that require quick adaptations to a rapidly changing environment. It is important to remain cognizant of risks to representativeness in situations of armed conflict that limit the reach of the surveillance and may exclude certain groups or areas. For a program with a disease eradication goal such as polio, achieving high surveillance sensitivity is extremely important to ensure that no cases are missed.

As defined in the global WHO guidelines for conducting surveillance for vaccine preventable diseases, polio surveillance is conducted by a system of reporting and investigating acute flaccid paralysis cases (AFP)<sup>31</sup>.

Strategies for implementing AFP surveillance include creating a reporting network, identifying and training surveillance informants, conducting regular active surveillance visits, and regularly analyzing surveillance data to assess if the core surveillance indicators are being met<sup>351,54</sup>. The system components for AFP surveillance described in the guideline are: routine monthly aggregate reporting of AFP, “zero reporting”<sup>i</sup> of AFP on a weekly or monthly basis from designated surveillance sites, immediate investigation of all outbreaks, immediate reporting of all AFP cases among children under 15 years of age with collection of two stool specimens 24-48 hours apart within 14 days of paralysis onset, and regular active surveillance to priority reporting sites to search for unreported AFP cases<sup>Error! Bookmark not defined.1</sup>. These strategies can be categorized into passive surveillance strategies including routine monthly aggregate reporting and “zero reporting” from designated sites, and active surveillance strategies including investigation of cases and outbreaks and active case searches.

*Figure 8: Attributes of a surveillance system<sup>53</sup>*

### Attributes of a surveillance system (generic)

ACCEPTABILITY: WILLINGNESS OF PERSONS AND ORGANIZATIONS TO PARTICIPATE IN THE SURVEILLANCE SYSTEM.

DATA QUALITY: THE COMPLETENESS AND VALIDITY OF THE DATA RECORDED IN THE PUBLIC HEALTH SURVEILLANCE SYSTEM.

FLEXIBILITY: ABILITY TO ADAPT TO CHANGING INFORMATION NEEDS OR OPERATING CONDITIONS

PREDICTIVE VALUE POSITIVE: THE PROPORTION OF REPORTED CASES THAT ACTUALLY HAVE THE HEALTH-RELATED EVENT UNDER SURVEILLANCE (43).

REPRESENTATIVENESS: ACCURATELY DESCRIBES THE OCCURRENCE OF A HEALTH-RELATED EVENT OVER TIME AND ITS DISTRIBUTION IN THE POPULATION BY PLACE AND PERSON.

SENSITIVITY: ABILITY TO DETECT CASES AND OUTBREAKS

SIMPLICITY: INCLUDES ITS STRUCTURE AND EASE OF OPERATION.

STABILITY: THE ABILITY TO COLLECT, MANAGE, AND PROVIDE DATA PROPERLY WITHOUT FAILURE

TIMELINESS: THE SPEED BETWEEN STEPS IN A PUBLIC HEALTH SURVEILLANCE SYSTEM.

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<sup>i</sup> Zero reporting refers to reporting at set intervals even if no cases are detected.

## Passive surveillance strategies

Passive surveillance is the predominant form of public health surveillance used globally. This is because it can be implemented on a national scale with minimal resources. It relies on local health workers to identify and report cases. The regular aggregate reporting of AFP cases can help assess whether the system is functional across the entire country by reviewing reports of cases by region and district. Drawbacks of passive surveillance are that only aggregate data on numbers of cases are collected and analysis of demographic data and laboratory diagnosis cannot be performed. In addition, passive surveillance is often incomplete because it relies on the health workers' motivation and knowledge of the need to report cases. Monthly routine AFP reporting is typically integrated into a country's national disease surveillance reporting system<sup>55</sup>. To increase the timeliness and sensitivity of AFP reporting, the passive AFP surveillance system also involves developing a reporting network of designated priority AFP reporting sites that are expected to submit supplemental AFP surveillance reports on a weekly or monthly basis. This reporting is typically combined with reporting of other priority diseases such as measles and neo-natal tetanus. Sites are selected based on the likelihood of AFP cases presenting there. These typically focus on hospitals and high-volume health facilities but can include pharmacies and traditional healers. The sites are expected to submit reports even if no cases are seen. This supplemental passive surveillance is useful in ensuring that no cases were missed by adding increased focus on the need for AFP reporting. By requiring the surveillance sites to submit reports, the surveillance focal persons at each site are reminded of the need to identify and report cases. Limitations of this strategy are that the person responsible for reporting may not be knowledgeable on the case definition for AFP and may not take the time to check with all clinicians and review the medical records to ensure that all cases are identified before submitting reports or may not be regular in submitting reports. Banerjee et al (2000) describe the developing of the AFP polio reporting network in India. Initially 7,500 sites were selected for the network and this was increased to 11,533 by the year 2000<sup>56</sup>. This large network facilitated the swift reporting and investigation of potential polio cases from across the country.

## Active Surveillance strategies

Active surveillance is the process of actively searching for cases or actively investigating cases or outbreaks. It also involves increased training and supervision of health workers (typically staff with nursing degrees or short courses in preventive care). Active surveillance is typically used in response to outbreaks or suspected outbreaks of infectious diseases of public health importance such as Ebola. Types of active surveillance include community case finding and visits to priority reporting sites.

Active surveillance is a cornerstone of the AFP surveillance system. AFP active surveillance involves regular visits to priority surveillance sites to search for unreported cases. Typically, surveillance officers at the district level do the majority of this work by developing and implementing a monthly work plan of active surveillance visits. Upon visiting a surveillance site, the surveillance officer will review medical records (typically patient register books) and speak with clinicians to ask if they saw any AFP cases. Active surveillance can also be conducted in communities by asking community members or community leaders if they have seen any AFP cases. Health workers can also conduct active surveillance during other health activities such as mass vaccination campaigns. Weaknesses of this strategy are that it is very resource intensive and, in practice, it is not feasible to visit all surveillance sites frequently. In addition, some health facilities do not keep high quality patient registers which makes it difficult to assess if any cases were missed. Surveillance officers are encouraged to leave a record of their visits at the surveillance sites as documentation of the active surveillance. A study in China found that, in the absence of active surveillance, only 64% of AFP cases were reported (Yasuo et al 2001)<sup>57</sup>. A report of a polio outbreak in Namibia also highlighted the importance of active surveillance in order to detect and respond to outbreaks before they spread (van Niekerk et al 1994)<sup>58</sup>.

An additional polio surveillance strategy that has been implemented in areas that are endemic or at high risk for polio transmission is environmental surveillance. This consists of regularly collecting and testing sewage samples from priority areas for the presence of poliovirus. This strategy has been very effective in identifying

poliovirus even in the absence of cases of paralysis<sup>25</sup>. The system however cannot be implemented in areas without suitable sewage collection points that cover a large catchment population or in areas that are insecure and cannot be regularly accessed to collect specimens.

### Performance monitoring system

The AFP surveillance system is monitored by analyzing the core indicators with a heavy emphasis on the non-polio AFP detection rate and the stool adequacy rate (Table 1<sup>Error! Bookmark not defined.1</sup>). The non-polio AFP detection rate is measured by calculating the rate of non-polio AFP detection per 100,000 people under the age of 15 years. It is analyzed at the national level as well as at the province and district level. The global standard is at least one case per 100,000 population less than 15 years of age. This is the key indicator of the sensitivity of the AFP surveillance system. It is impacted by the accuracy of both the reporting of cases and also the population denominator. The standard of one case per 100,000 is based on the background rate of Guillaine Barre Syndrome<sup>59</sup>. It is difficult to know however exactly what rate of AFP occurs in the absence of polio. The focus on children under 15 years of age is based on the expected epidemiology of polio, which typically affects children under 5 years of age and rarely affects adults. While achieving a high non-polio AFP rate does not guarantee that no AFP cases are missed, it is a very useful tool for assessing the sensitivity of the AFP surveillance system.

Polio is diagnosed by laboratory testing of stool specimens and therefore collecting adequate stool specimens is critical to the polio surveillance system. The likelihood of detected poliovirus in the stool of someone who was paralyzed by polio is highest immediately after paralysis and reduces to around 70% two weeks after paralysis. (Figure 3). Because the rate of virus excretion varies by day, it is recommended to collect two specimens at least 24 hours apart to maximize the likelihood of detecting the virus. Stool adequacy is therefore defined as the collection of two stool specimens 24-48 hours apart within 14 days of paralysis onset that arrive in the laboratory in good condition. The global standard is to have adequate stool specimens collected from at least 80% of reported AFP cases. This is to maximize the likelihood of isolating the poliovirus in

infected AFP cases. Similar to the non-polio AFP rate, stool adequacy is analyzed at the national and subnational levels. For both these indicators, the intent is that corrective actions should be taken for areas where the indicators are below the global standards. These two indicators are the primary methods of monitoring the quality of the AFP surveillance system and have been reported in scores of scientific articles on the progress of polio eradication<sup>ii</sup>.

Other indicators recommended in the WHO guideline include the completeness of routine aggregate reporting, percent of AFP cases investigated within 48 hours of detection, percentage of specimens arriving at a WHO accredited laboratory within 3 days of shipment, and percentage of specimens with laboratory results available within 28 days of receipt of specimen<sup>Error! Bookmark not defined.1</sup>. Completeness of reporting is an important indicator of the quality of the passive surveillance system. Limitations of this indicator include that the data to monitor the indicator are often not systematically collected and indicator does not measure the quality of reporting. The indicator on percentage of specimens arriving at the laboratory within 3 days is useful to avoid delays in transporting specimens. These delays make it difficult to ensure the quality of the specimen and also result in delays in testing the specimens. In situations of armed conflict however there are often unavoidable delays in specimen shipment due to road closures. The indicator on percentage of specimens with laboratory results sent within 28 days of receipt is designed to avoid delays in testing and reporting the results back to the program. This is a useful indicator to avoid delays in receiving laboratory results. One of the two WHO-accredited polio laboratories in Nigeria is based in Maidugiri, the capital of Borno state. The conflict in Borno has the potential to disrupt the testing of specimens if laboratory supplies cannot be sent on time, if senior laboratorians are not willing to go to Borno to monitor the laboratory performance, or if the laboratory infrastructure and equipment cannot be maintained.

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<sup>ii</sup> A quick search on Pubmed using the keyword “progress towards eradication of polio” brought up 156 articles, most of which report the polio indicators such as: *Progress towards poliomyelitis eradication: Pakistan, January 2016– September 2017 (Morbidity and Mortality Weekly Report 66.46 (2017): 1276)* or *Progress towards poliomyelitis eradication: Nigeria, January–December 2017 (Morbidity and Mortality Weekly Report 67.8 (2018): 253)*

Table 1: Recommended indicators for AFP surveillance<sup>31</sup>

Indicator	Target
1. Percentage of expected monthly surveillance reports received	90%
2. Annualized non-polio AFP rate per 100,000 children less than 15 years of age	1/100,000
3. Percentage of AFP cases investigated with 48 hours	80%
4. Percentage of AFP cases with two stool specimens collected 24-48 hours apart and within 14 days of onset of paralysis	80%
5. Percentage of specimens arriving in the laboratory in good condition	80%
6. Percentage of specimens arriving in a WHO-accredited laboratory within 3 days of being sent	80%
7. Percentage of specimens for which laboratory results are sent with 28 days of receipt of specimen	80%

This surveillance system has been used successfully around the world. It is resource-intensive however and tends to break down in hard to reach places with poor infrastructure, insufficient resources, and insecurity. This can result in missed transmission in specific areas. Tangerman et al (2000) report that from 1997-1999 Afghanistan, Angola, the Democratic Republic of the Congo (DRC), Somalia, and South Sudan, all countries affected by protracted civil wars, were unable to maintain a non-polio AFP rate above 1 per 100,000 children less than 15 years of age at the national level<sup>39</sup>. In South Sudan large areas of the country were not in the control of the government at that time which severely hampered the government's ability to conduct sensitive surveillance<sup>40</sup>. In 2009 South Sudan reported a polio outbreak that, based on genomic analysis of the virus, was most closely related to a virus that was circulating in 2005. This suggests that the circulation had continued undetected in the area for three years, indicating major gaps in the surveillance system as a result of destroyed infrastructure and ongoing conflict and insecurity<sup>60</sup>. Evidence of undetected polio transmission in 2009-2010

was also reported in Angola and DRC<sup>60</sup>. These examples highlight the impact of conflict on surveillance and the resulting failure of the surveillance system to rapidly detect polio transmission. Similar conditions hampering surveillance exist in Borno State in Nigeria where some areas of the state are inaccessible due to insecurity.

### Assumptions of the Conventional AFP Surveillance System

The AFP surveillance system is based on several assumptions that do not hold true in armed conflict settings. One of these assumptions is that the traditional indicators of surveillance performance are sufficient for monitoring performance even in areas of armed conflict. The key indicator of surveillance sensitivity is the non-polio AFP rate<sup>Error! Bookmark not defined.1</sup>. As described in chapter one however, in a conflict setting where some populations cannot be reached, achieving a high non-polio AFP rate does not necessarily mean that any potential AFP case would be detected and reported. By tracking the rate of detection of AFP cases as an indicator of surveillance sensitivity, an assumption is made that surveillance activities are evenly conducted across geographical areas and that with an adequate non-polio AFP rate, any AFP cases that occur anywhere within the administrative area being analyzed would be detected and reported. This assumption however can only hold true if all areas are accessible. Even in areas with low population density, where few non-polio AFP cases would be expected, a polio outbreak with many paralytic polio cases could occur. With a reliance on standard indicators that do not take this into account, potential pockets of transmission could be overlooked. Indeed, a high non-polio AFP rate in an area with some inaccessible populations can actually mask the lack of surveillance in the inaccessible areas by compensating with improved detection and reporting from the accessible areas. The high non-polio AFP rate in Borno helped lead to the erroneous decision to remove Nigeria from the polio endemic list in 2015, only later to discover that there was ongoing and undetected transmission among the population living in the inaccessible conflict-affected areas.

Another assumption of the AFP surveillance system is that populations are relatively stable and accessible. A stable population is needed for calculating the non-polio AFP rate and for developing a representative AFP reporting network. Census population data is typically used for these calculations. If the

population estimate is too low this could lead to an overestimate of the non-polio AFP rate and a false reassurance that the sensitivity of the system is high. If the population estimate is too high this could lead to an underestimation of the non-polio AFP rate and a false concern with low sensitivity of surveillance. When populations are highly dynamic such as in areas of active armed conflict, the denominator for calculating rates becomes unstable and unreliable and the calculated rates may over or under estimate the true rate. Data from the United Nations Organization of Coordination of Humanitarian Affairs, for example, estimate that 2.2 million people have been displaced due to the Boko Haram terrorist group activities in Northeastern Nigeria (Figure 4). This means that in areas where these people settled, the true population is likely to be much higher than the census data and in areas where these people fled from, the true population is likely to be lower than the census data. Because to the high movement of population in Northeast Nigeria as a result of the ongoing armed conflict, the United Nations International Organization on Migration (IOM) produces a weekly update on new arrivals and departures in Northeast Nigeria using its Displacement Tracking Matrix Emergency Tracking Tool<sup>iii</sup>. These data could be used to update the population estimates for the conflict affected areas.

### Prerequisites of the Conventional AFP Surveillance System

Among the prerequisites for the AFP surveillance system to function is having good knowledge of the population including the size and location of settlements. In situations of conflict however there is often major population movement which creates uncertainty in the location and size of populations. In Borno State for example it was believed that many districts were completely abandoned due to armed conflict, but recent evidence from satellite imagery suggests that many villages in those areas are still inhabited and as many as 100,000 children remain inaccessible and unreachable for vaccination or surveillance<sup>iv</sup>.

Another major prerequisite is to be able to reach the population. This is important for conducting active surveillance as well as supervision and assessments of the surveillance system performance. However, in areas

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<sup>iii</sup> The Emergency Tracking Tool reports for Nigeria are available online at: <http://www.iom.int/countries/nigeria>

<sup>iv</sup> An unpublished manuscript of these findings is available upon request. There are also many internal documents from the polio program in Nigeria that describe this and could be shared with permission from Government of Nigeria.

that are inaccessible due to armed conflicts, some populations are inaccessible. In Afghanistan, Nigeria, and Somalia, accessibility to children for vaccination and surveillance are major obstacles to polio eradication. In Somalia for example it is estimated that 231,000 children are living in areas controlled by a rebel group that does not allow vaccination activities to take place<sup>v</sup>. In Nigeria the lack of access is more absolute than in Afghanistan and Somalia where some negotiated access for surveillance activities is possible. Thus, in the conflict zones of Somalia and Afghanistan there is still some degree of surveillance taking place with the consent of the armed groups whereas in the Boko Haram controlled areas of Nigeria no surveillance activities can be openly conducted.

A third important prerequisite for the system to function is the existence of a network of health facilities that provide health services for the population. The surveillance system relies on these health facilities to provide routine surveillance reports (passive surveillance) as well as to conduct active surveillance visits. When health facilities close down, patients may not be able to reach a health facility to seek treatment and therefore serious conditions such as paralysis may go unnoticed. In 2018 in Borno State it was reported that, of the 755 assessed health facilities, 375 (50%) are non-functioning due to the insurgency including 292 that were totally destroyed<sup>61</sup>. Finally, the surveillance system requires communication. AFP cases are reported by phone, in writing, and by using mobile phone data entry programs. When the major modes of communication breakdown in an area including the ability to transmit information by phone, email, or mail, it becomes nearly impossible to monitor surveillance in that area. Armed insurgency groups often destroy means of communication in order to prevent the local population from communicating with the outside world. This is true in parts Afghanistan, Somalia, and Borno state in Nigeria<sup>vi</sup>.

## Inhibitors

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<sup>v</sup> These inaccessible children are presented in internal reports from the polio program in Somalia that are available with permission from the Somalia polio program.

<sup>vi</sup> Personal communication with polio staff from Nigeria, Somalia, and Afghanistan, March 2018.

For each of the strategies of polio surveillance, there are specific challenges associated with areas of armed conflict. These inhibitors are related to the prerequisites and can prevent the system from achieving its goal of a sensitive polio surveillance system capable of rapidly detected and investigating all potential polio cases. Among the key inhibitors of polio surveillance are inaccessible populations and inaccessible regions, destroyed health facilities, destroyed communication infrastructure, dynamic population movement, traumatized populations, and widespread malnutrition and disease outbreaks.

For areas that are completely inaccessible, active surveillance cannot take place and the system supporting passive surveillance through training and supervision is also shut down. This means that the main system for ensuring that cases are not missed is disabled and, even if passive surveillance is taking place, less confidence can be placed on the sensitivity of the surveillance in that area. In addition, it means that if cases are identified, surveillance officers may not be able to access the patient to conduct an investigation. The underlying foundation of the AFP surveillance system is the physical investigation and collection of stool specimens from each reported AFP case. If cases are reported in inaccessible areas but cannot be investigated with stool specimens collected, it is impossible to determine whether the paralysis was caused by the polio virus or something else. Therefore, not being able to physically visit and collect specimens from identified cases is a major impediment in conducting surveillance in areas of armed conflict. For example, during the last outbreak assessment in Borno in November 2017, information was reported on two AFP cases that were observed by military personnel who had visited an inaccessible area. The cases however were not investigated. In addition, an AFP case in an area that had a confirmed polio case in 2016 was reported in 2017 but not investigated until over a month following the onset of paralysis because a military convoy was required to reach the area which slowed down the reporting and investigation of the case.

The lack of a network of health facilities impacts the ability to conduct both active and passive surveillance. For areas without a network of health facilities, individuals in need of health care will often remain at home and information about the diseases will not reach the health care system. Passive surveillance through use of a reporting network is only effective when there is a functioning network of health facilities to serve the

population of an area. Active surveillance as performed by visiting health facilities to search for unreported AFP cases is also not possible in the context of a destroyed health infrastructure. If it is possible to visit communities and informal health providers (such as traditional healers) some active surveillance may still be possible but conducting active surveillance visits to all communities is much more labor and resource intensive than conducting active surveillance to health facilities.

For areas with destroyed communication infrastructure, health facilities and community members have no easy way of reporting suspected polio cases or submitting monthly passive surveillance reports. This means that, even if local health officials or community members want to report a suspected polio case or a cluster of cases, the case(s) may still go unreported and a true polio outbreak may go unreported.

Dynamic population movement is another key inhibitor of effective polio surveillance. Knowing the population is key to both conducting polio surveillance and also monitoring polio surveillance performance. The indicators of polio performance as described above are based on an understanding of the population per area. Rates of AFP case detection may be over or underestimated if the population data is inaccurate. This could lead to a misclassification of an area as achieving the certification level non-polio AFP case detection rate. For example, if an area is estimated to have 100,000 children under 15 years of age but, due to an influx of displaced people, the population increases to 300,000 children under 15 years of age, the non polio AFP rate will be artificially high using the population estimate not accounting for the arrival of the displaced population<sup>vii</sup>. More importantly, it could lead to areas being de-prioritized for polio surveillance because of a belief that they have been depopulated when, in fact, people are still living in those areas.

The atmosphere of fear and physical and psychological trauma associated with armed conflict can also impede effective implementation of surveillance plans. Local staff as well as outsiders are often preoccupied with their own safety and unable to focus on the tasks of surveillance. The work of polio surveillance requires

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<sup>vii</sup> While the example may seem exaggerated, in Maiduguri, the capital of Borno State in Nigeria, it is estimated that the population increased fourfold as a result of the armed conflict.

good organization, attention to details, and follow up. In the context of frequent and unpredictable deadly bombings and attacks, it is difficult to expect people to work with the same level of quality as can be achieved under normal conditions. When I personally visited several camps for internally displaced people in the capital of Borno State, for example, the local officers would often get nervous and insist that we leave the camps before we completed our review. This is understandable as the camps are frequently targeted for bombings but means that the quality of surveillance is reduced due to the atmosphere of fear. A review team in 2016 also found evidence of polio specimens that had never been sent to the laboratory due to poor follow up and supervision which are the consequences of the external conditions and environment<sup>62</sup>.

The priorities and needs in situations of armed conflict are often overwhelming, leading to a deprioritization of routine surveillance activities such as AFP surveillance. In Borno the armed conflict led to widespread severe malnutrition and outbreaks of cholera, measles, and malaria with high fatality rates. For example, in August 2018 in Borno thousands of cases of acute watery diarrhea, malaria, acute respiratory infection, and severe acute malnutrition were reported in a one week period<sup>63</sup>. These immediate emergencies by necessity outweigh other public health priorities such as AFP surveillance.

### Enabling factors

Some factors can help support efforts to conduct sensitive surveillance in areas of armed conflict. A key factor is governmental support. With strong political commitment for ensuring public health priorities including high quality disease surveillance, much can be accomplished. The government is capable of allocating human resources, logistics such as vehicles, and security support for public health initiatives. The government can direct local surveillance and health facility staff to heighten their vigilance for disease surveillance. Without this governmental leadership, it is very difficult to achieve and sustain any public health goal. The government can also deploy military and security forces to assist in conducting public health programs such as AFP surveillance and polio vaccination.

Non-governmental organizations and multi-national organizations can also support achieving public health goals such as sensitive AFP surveillance in areas of armed conflict. The Red Cross has a vast network of community volunteers that can be engaged for surveillance. The Red Cross keeps a neutral stance in conflicts and therefore these volunteers may be able to work in areas that are off-limits to others. Multi-national organizations such as the United Nations can provide substantial support to strengthen AFP surveillance in areas of armed conflict. The World Health Organization established a network of surveillance officers at the district and subdistrict level in Borno state to increase the sensitivity of AFP surveillance in the state. The United Nations Children's Fund (Unicef) established a network of volunteer community mobilizers to report AFP cases in their communities funded by the Bill and Melinda Gates Foundation (BMGF). Substantial efforts are made to ensure that the governmental and organizational staff working on polio has the skills, training, and supervision to operate effectively. The existence of a large workforce with good technical capacity is a major asset that can enable effective polio eradication activities to take place. This support however is limited to areas where the staff are able to access.

Influential donors such as Mr. Bill Gates help advocate for increased government support by speaking with high level politicians. Donations for polio eradication also play a critical role in enabling effective AFP surveillance. The Global Polio Eradication Initiative has spent over 15 billion dollars as of 2017 on polio eradication worldwide and these funds came from private, governmental, and organizational donations such as from Rotary International<sup>33</sup>. While conflict prevents external partners from doing direct work in the conflict-affected areas, both external funding and external influence have an impact on program success.

### Existing theories

There is some available literature on approaches to health service provision and surveillance in armed conflict settings. Bush (2000) suggests that negotiating cease fires is not only an effective strategy to advance public health goals, but can also help end conflicts<sup>64</sup>. Tangerman et al discuss the role of cease fires ("days of tranquility") and engagement of local communities to access conflict affected areas<sup>65</sup>. For example, days of

tranquility were negotiated in Afghanistan in 1999 which facilitated access to children during polio mass vaccination campaigns<sup>65</sup>. In conflict-affected areas of Somalia ceasefires were not possible, however through engagement with local communities including nongovernment organizations and local community leaders the polio program was able to institute vaccination and AFP surveillance at the local level<sup>65</sup>. These approaches however may not be feasible in armed conflicts such as the current conflict in Borno when one of the warring parties refuses to negotiate or grant any access for health services and engaging with local actors is not possible.

Other approaches include collaborating with security personnel, security assessments, and provision of services at the boundaries of conflict-affected areas<sup>66</sup>. Collaborating with security personnel can enable the program to reach areas that are insecure with support from security personnel including police, military, or civilian security groups. Security assessments are conducted by security professionals and involve categorizing locations by level of risk. This allows the program to plan to reach the areas that can be reached and to monitor the security situation for changes over time. Provision of health services including disease surveillance around the boundaries of conflict zones is an approach that can help prevent outbreaks occurring in inaccessible areas from spreading and can also assist in detecting and preventing disease in conflict areas if some people are able to move in and out.

Declaring an area to be a graded emergency may be effective in garnering political commitment and partner support for addressing the conflict and for creating a sense of urgency to rapidly response. WHO's framework for emergency response defines three grades of emergencies<sup>67</sup>. A global emergency management team (GEMT) is convened to grade serious emergencies. The complexity and context of the emergency are considered when grading the emergency. Based on this framework, in 2016 WHO declared the crisis in Borno a grade 3 emergency, the highest level. A grade 3 emergency is defined as "a single or multiple country event with substantial public health consequences that requires a substantial WHO Country Office (WCO) response and/or substantial international WHO response...."<sup>67</sup>. For grade 3 emergencies an emergency support team is engaged, a humanitarian coordinator is appointed, and a surge team is deployed. While the framework outlines the level of response for emergencies, it does not include details on effective strategies for responding to

complex humanitarian emergencies<sup>67</sup>. The Organization for Coordination of Humanitarian Assistance (OCHA) has been publishing regular updates on the international response to the crisis in Borno, including the percentage of people in need who have been reached, and the percentage of required funding received<sup>68</sup>. These updates are useful for monitoring the response and advocating for additional resources when needed. The updates indicate that the resources available for the Borno response, while substantial, are not sufficient for addressing the needs.

### Novel approaches

Novel approaches may help overcome the barriers to effective surveillance in areas of armed conflict. One novel approach is the engagement of community members to conduct surveillance in inaccessible areas. Community surveillance informants are community members who are able to gather information about paralysis cases in their community. With training and engagement, they can be effective in reporting AFP cases within their communities. This strategy can be effective in areas that do not have easy access to health care or where some community members may not seek health care for paralysis. By drilling down to the community level through the use of informants, the sensitivity of the system can be increased. Weaknesses of this strategy are that, due to the large number of communities, it is costly to identify and train community informants to cover a large number of communities. The strategy is also limited by the motivation of the community informant to take the time to look for and report all cases. Dil et al (2012) discuss the use of community based surveillance (CBS) volunteers in Ghana. They describe sources of motivation for the CBSs including a sense of duty to their communities and pride in their work. Challenges identified included lack of transportation and compensation<sup>69</sup>. Curry et al (2013) describe the use of community based surveillance (CBS) for polio in Ethiopia. They report that the use of CBS almost doubled the AFP reporting in the project areas due to their ability to serve as a linkage between communities and health facilities<sup>70</sup>.

The use of community informants is a promising strategy for security compromised areas but also faces serious challenges. Bolu et al (2018) report the use of community informants in inaccessible areas of Borno

Nigeria for identifying and reporting AFP cases from areas that were inaccessible to public health officials<sup>71</sup>.

Identifying community informants in areas that program staff cannot physically visit is a major challenge. One approach is to use community leaders in accessible areas to help identify potential community informants living in inaccessible areas. Another approach is to identify community members from inaccessible areas who manage to temporarily exit the inaccessible area to go to a market or visit relatives<sup>viii</sup>. This system holds promise because it provides an opportunity for program staff to interact with individuals living in inaccessible areas during the period when they temporarily exit the inaccessible areas. Even if informants are identified, regularly training and communicating with them is limited by the availability of effective communication methods. There may also be security risks for the informants involved in collecting and reporting surveillance data from areas controlled by insurgents.

Potential strategies for overcoming these obstacles include identifying community informants as they come to markets in accessible areas and establishing a flexible system for paper-based reporting as they are able to come out to an accessible area. Monitoring and reporting the work of community informants is needed in order to document the existence of AFP surveillance in the areas covered by community informants. The traditional reporting system which is regular and time bound (such as weekly or monthly) may not be possible for people whose ability to exit the inaccessible areas is sporadic and unpredictable. By providing the informants with the opportunity to report their activities using a flexible schedule the program would be able to still generate useful evidence of surveillance without assigning unfeasible deadlines for such reporting. The reports could cover their surveillance activities and findings for the period since their last exit from the inaccessible area.

An electronic phone application for community-based surveillance that provides video examples of children with acute flaccid paralysis and allows for immediate electronic reporting has been piloted in some areas at high risk for polio transmission. The program, Audio Visual AFP Detection and Reporting (AVADAR) has

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<sup>viii</sup> In Borno people have been known to leave the inaccessible areas but report that they are forced to leave behind family members who would be killed by the terrorists if they do not return.

been used in parts of Borno and other high risk areas<sup>71</sup>. AVADAR is a mobile phone App that was developed to enable community informants to show a short video portraying a child with AFP to community members to help them understand what an AFP case looks like. The AVADAR App also allows the community informants to immediately report AFP cases through the App and to report their surveillance activities on a weekly basis through the App. A limitation of this system is that it only works in areas with cell phone reception.

A challenge with the use of community informants for insecure areas is that the reported cases require detailed investigation by qualified medical personnel and collection of stool specimens for laboratory testing and community informants do not have the training and skills to perform these tasks. One strategy that has been used to investigate cases that occur in inaccessible areas is for families of AFP cases in inaccessible areas to take the child to an accessible area for treatment and investigation. This has been done successfully in some cases in Borno but it is a risky approach because it puts the family of the AFP case in danger and, depending on the security situation, is not always possible.

Monitoring of remote sensing data through GIS technology can provide updated information on populations living in inaccessible areas even when direct contact with those populations is impossible. Satellite imagery has been available since the 1950s. Its use for public health planning however has been limited. The availability of high-resolution satellite images now makes it possible to assess changes in populations by comparing images of the same places over time. For example, there are over 8,000 commercially available images from Nigeria between 2010 and 2012. GIS technology is advancing which makes it easier to extract features and compare imagery over time. There has been limited work however in testing the utility of satellite imagery for estimating population dynamics in inaccessible areas and in developing methodologies for this work. Some work has been done in using satellite imagery to assess the establishment of internally displaced person camps, population movement, and destruction of villages<sup>72</sup>. This method is limited by the quality and frequency of imagery, ability to estimate occupancy per structure, lack of an established methodology for assessing habitation status based on satellite imagery, and lack of an automated system for assessing the status of settlements.

The use of radio and television to spread messages among the public on the need to report AFP cases is another strategy that has been attempted in conflict affected areas. Hamisu et al (2016) report on the use of radio programs including phone-in programs, “jingles”, and broadcast information on surveillance<sup>73</sup>. An advantage of this system is that it can reach a large audience in areas that otherwise cannot be accessed. In inaccessible areas however it is not clear whether people are using radios and which areas are reached by radio.

Engagement with military personnel can facilitate access to populations that are off-limits to civilians for both public health surveillance as well as provision of emergency provisions including vaccines. Nnadi et al (2017) describe the use of military and other security personnel for delivering humanitarian assistance during armed conflicts<sup>66</sup>. For example, in Pakistan armed police officers escorted vaccinators in some areas after several targeted attacks against vaccinators occurred in 2012<sup>74</sup>. A major limitation of this strategy is the difficulty of recruiting and funding sufficient security officers to protect vaccinators for repeated large-scale mass vaccination campaigns. In areas of intense fighting or total insurgency control, even military personnel may not be able to access populations to provide humanitarian services.

Expanded use of the laboratory for testing of stool specimens from healthy children and sewage samples can help identify virus transmission even in the absence of reported cases of paralysis. This strategy provides additional methods of identifying poliovirus transmission in situations when sensitive AFP surveillance is not taking place. Tambini et al (1993) describe the utility of healthy children stool surveys and virologic analysis of community sewage to assess polio transmission in Colombia<sup>75</sup>. Virologic analysis of sewage samples was also effective in identifying circulating polio in Israel in 2011<sup>76</sup>. Limitations of these strategies are the relatively rare occurrence of polio transmission, the challenge of identifying a suitable site for collecting sewage samples in areas without central sewage systems and the inability to reach inaccessible areas for sewage sampling or healthy children sampling.

Collection of stool specimens from contacts of AFP cases is another method that can help identify virus transmission when cases are identified late due challenges including limited access to an area. Because the

period of viral shedding is time-limited, a child paralyzed due to polio may no longer be shedding detectable polio virus if the stool specimen is collected two or more weeks after paralysis onset. Close contacts to the paralyzed child however may have been subsequently infected and may still be shedding the virus. This strategy led to the identification of a case of wild poliovirus in Borno in 2016.

More process-oriented performance indicators can help monitor the areas in which surveillance activities are taking place even if cases of paralysis are not detected due to low population. The global surveillance guidance for example includes an indicator on the completeness of monthly surveillance reporting<sup>Error! Bookmark not defined.1</sup>. In practice little focus is placed on this indicator, however by analyzing this indicator specifically for conflict-affected areas, the extent of passive surveillance could be assessed. Health facilities and reporting sites that are not submitting expected reports could then be visited to ensure that there are no unreported cases and to provide on the job training to the surveillance focal person for that site.

In addition, spatial analysis and mapping of surveillance activities in inaccessible areas could provide a useful visualization of the areas covered by surveillance activities. Detailed mapping of surveillance activities overlaid with locations of settlements, health facilities, roads, and other relevant geographic data would provide a more complete picture of the reach of the surveillance system. Understanding which areas do not have adequate surveillance activities would help inform program decisions such as where to prioritize surveillance activities and when to consider an area to be polio-free.

The frequency and completeness of active surveillance visits is another potentially valuable process indicator. If the number of active surveillance visits is less than required or certain sites are not being visited, this information can be used to plan corrective actions as needed. To measure this indicator data on the active surveillance network, planned active surveillance visits, and conducted active surveillance visits are needed.

Surveillance during vaccination campaigns is another process indicator for surveillance performance monitoring. If vaccination teams systematically ask households if they have seen any cases of AFP then even cases that did not report to a health facility can be detected. In some cases vaccination teams may reach areas

that surveillance officers are not able to go to. By monitoring the areas covered by vaccination teams during a campaign, the areas that are not being reached at all for surveillance (those not reached by vaccination teams) can be identified and prioritized.

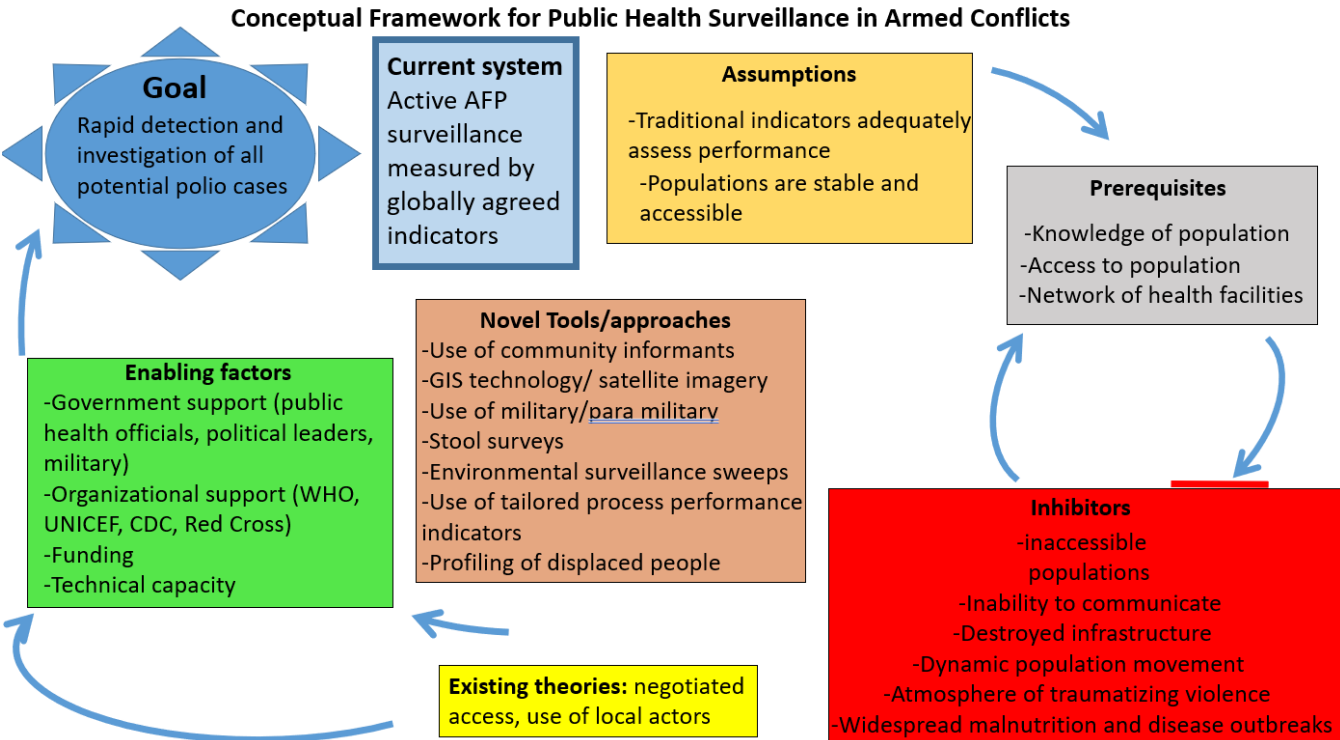
Reports from community informants is another potentially valuable process indicator. The community informants could report regularly on the areas they have visited for surveillance. These data would also help the program understand which areas are being visited for surveillance including areas that may be missed by surveillance officers conducting active surveillance as well as surveillance reports by health facility surveillance focal persons. For settlements that are remote from health facilities and in insecure areas, data from community informants can help ensure that no cases are being missed and prioritize areas that are not covered for surveillance. This level of monitoring would provide a more granular awareness of the extent and quality of surveillance activities in conflict-affected areas. Challenges to this monitoring include the difficulty of communicating with informants in inaccessible areas, and challenges in accurately mapping activities in inaccessible areas.

Data collection on displaced people can also provide more information on remaining trapped populations and indicate whether services and surveillance activities are reaching these high-risk groups. Some research has been conducted on assessing population dynamics during conflicts. The United Nations International Organization for Migration (IOM) for example manages a Displacement Tracking Matrix in which data are collected from multiple methods including key respondent interviews at the district level to obtain basic data on arrivals and departures, ward level surveys with a sample of IDPs, and IDP site assessments<sup>77</sup>. The reliability of these methods however is difficult to ascertain, and the assessments are limited to populations in accessible areas. Another limitation to the IOM approach is that it does not systematically collect information on the people left behind. Displaced people are likely to be the best source of information regarding those trapped and inaccessible populations and surveys could be developed to systematically collect such data from displaced people when they escape from inaccessible areas.

## B. Conceptual Framework

For this study I developed a conceptual framework that I continued to refine during the course of the study. The framework covers the key factors that affect the surveillance system in conflict-affected areas. It includes the systems, assumptions, barriers, theories, and opportunities regarding conducting high quality polio surveillance in conflict-affected areas. The framework seeks to identify the connections between these factors in order to focus the question on the opportunities to change the current system in ways that will make it more effective in the context of armed conflict. The framework illustrates the ways in which the current polio system is hindered in areas of armed conflict and suggests alternatives that may be effective in overcoming those barriers. The working hypothesis is that utilizing a variety of novel tools may be useful in overcoming the obstacles to conducting high quality polio surveillance in conflict-affected areas. Those methods include engagement with local communities, engagement with military and paramilitary entities, use of tailored surveillance indicators, and use of remote sensing to assess population dynamics. These novel approaches may be effective in improving the sensitivity of surveillance in areas that are difficult to reach due to armed conflict also and provide a clearer understanding of surveillance blind spots. The initial conceptual framework for this study is presented in Figure 9 below.

Figure 9: Initial Conceptual Framework



C. Logic Model

Figure 10 below presents a logic model of the traditional surveillance system. The inputs include human resources, funding, infrastructure (health facilities), and equipment (such as vehicles for active surveillance). As presented in the conceptual framework, the prerequisites are the existence of an adequate health infrastructure with a network of health facilities, and stable and accessible populations. As described in chapter 2, the activities include regular active surveillance visits to health facilities, passive surveillance reporting from health facilities, investigation of AFP cases, collection of environmental samples, and laboratory testing. The outputs are the completed active surveillance visits, the health facility surveillance reports, completed AFP case investigations, and laboratory results. The monitoring system is comprised of monitoring the non-polio AFP rate and stool adequacy, the timeliness and completeness of health facility passive surveillance reports, and laboratory results. The outcome is the timely detection of AFP cases and any potential poliovirus circulation. Through the process of

this study I investigated the adequacy of this logic model for implementing and monitoring polio surveillance in areas of armed conflict and inaccessible populations.

*Figure 10: Logic model of the traditional polio surveillance system*

<b>Inputs</b>	<b>Prerequisites</b>	<b>Activities</b>	<b>Outputs</b>	<b>Monitoring process</b>	<b>Outcomes</b>
Human Resources	Health infrastructure	Active surveillance visits	Active surveillance visits to health facilities	Non-polio AFP rate  Stool Adequacy rate	Timely detection of AFP cases and circulation of polioviruses
Funding	Stable and accessible populations	Passive reporting from health facilities	Health facility surveillance reports	Timeliness and completeness of reporting	
Infrastructure		AFP case investigation	Completed AFP case investigations	Laboratory results	
Equipment		Environmental sampling  Laboratory testing	Testing results		

## Chapter 3: Study Design, Data analysis, and Methods

### A. Analytical Approach

This study is a single case study to examine the AFP surveillance system in inaccessible areas of Borno State, Nigeria. A case study approach allows for an in-depth analysis of the impact of armed conflict on Borno State on public health surveillance with integration of evidence from multiple data types and data sources including document reviews and interviews with a wide range of stakeholders familiar with the situation in Borno. Case studies are a valid and valuable study design for descriptive, exploratory, and explanatory studies. This study is exploratory in nature in that it seeks to explore the issues of how to conduct effective surveillance in areas of armed conflict. Elements of case study research include corroboration of findings from different types of evidence, use of a conceptual framework to guide the research design, and use of appropriate data collection and data analysis techniques to address issues of validity and reliability<sup>78</sup>. There is considerable documentation available on the Borno conflict and also a large workforce in Borno working on AFP surveillance and the overall humanitarian response. Therefore there are ample sources of evidence available for this case study including interviews of key informants who are familiar with the efforts to improve surveillance and the humanitarian response in Borno as well as reviews of publicly accessible documents describing the situation and efforts made to improve AFP surveillance in the conflict-affected areas of Borno. The case study design includes articulation of research questions, development of a conceptual framework, development of data collection methods and tools, and development of a data analysis plan. Implementing a case study is an iterative process and during the course of the study the research questions, tools, and analysis methods can be refined as additional information is learned from the initial phases of data collection and analysis. The rationale for this design is that inaccessibility due to armed conflict in Borno State is arguably the most severe in the world with almost no opportunity to negotiate with the terrorists to access the local communities. Therefore this conflict presents one of the most challenging situations for achieving high surveillance quality. Approaches that are effective in Borno state consequently will likely have applicability in other conflicts of similar or less severe levels of

inaccessibility. In addition, a great deal of effort has been made to improve AFP surveillance in Borno State which makes it a productive place to collect data on the challenges and effective strategies for AFP surveillance in areas of armed conflict. Finally, CDC has invested heavily in polio eradication in Nigeria and Borno State and therefore it will be easier to conduct field data collection in Borno compared to other areas.

As stated in the introduction section of this proposal, this study seeks to answer the question of how AFP surveillance can be effectively conducted in areas with populations that are inaccessible due to armed conflict.

The study questions are as follows:

Overarching question: How can the conventional polio surveillance system and strategies be modified to address areas of conflict and inaccessible populations?

Sub-questions:

1. What are the inhibitors of effective surveillance in the context of the armed conflict in Borno State, Nigeria? Effective surveillance is defined as surveillance that is capable of detecting and investigating any cases of acute flaccid paralysis within two weeks of the onset of paralysis. While surveillance quality may never be optimal in areas with security constraints to access, the goal is to ensure that polio transmission is not missed.
2. What are the opportunities for effective surveillance in these settings? What strategies and field methods would enable effective surveillance in these settings?
3. What monitoring systems and indicators may be useful in monitoring surveillance performance in inaccessible areas?
4. What systems are in place for collaboration and information sharing for polio surveillance between the various actors (governmental, non-governmental, and multinational) that are supporting the humanitarian response in Borno?

The study describes the current AFP surveillance system in Borno to better understand what is working and what is not working and why. Particular focus is placed on whether the system is suitable to the situation in Borno. It then examines the inhibitors and potential innovative strategies for overcoming them to strengthen surveillance in inaccessible areas.

For this study, information is needed on the inhibitors of effective surveillance; current and potential approaches, mechanisms and structures; and potential opportunities for increasing surveillance sensitivity in the inaccessible areas. Sources of information and data include existing reports and datasets, and data collection among key stakeholders in the polio program.

## B. Data Sources, Data Collection, and Management

Key documents were reviewed to obtain detailed information on the polio program, the humanitarian response efforts in Borno, the armed conflict in Borno, and efforts to estimate the size and location of the displaced and trapped populations in Borno. These documents included published reports, journal articles, program plans, and news media articles. Annex 2 provides a list of these key documents and their relationship to the research questions and constructs. A measurement table (Table 3) was used to map out the data sources for each of the questions in the study. The documents were analyzed to extract data related to the study questions. Data were extracted for each of these questions and listed by data source. The documents were analyzed to assess consistency of information between reports. This provided a measure of the reliability of the available data. Analysis was done using key words and issues, a-priori terms, and emerging themes. Both a-priori and emerging codes were used for the analysis.

Primary data was collected from key stakeholders in the AFP surveillance system and humanitarian response in Borno. The data were collected using semi structured interviews guides (Annex 3). The interview guides were pre-tested for clarity and relevance with relevant stakeholders and refined prior to data collection.

Reflective memos were produced immediately after each interview. Data analysis was conducted concurrently with data collection and initial findings from the key stakeholder interviews were used to fine tune the semi-structured interview tools for later interviews. A maximum of 30 interviews were planned.

### Interviews of key stakeholders

I purposively sampled staff that are most relevant to the study topic. The primary aim of these interviews was to gain a deeper understanding of the inhibitors of surveillance, the opportunities for effective surveillance, and the monitoring and collaboration systems. In particular, the interviews served to gain a deeper understanding of how the polio program obtains information about where people in need are living; what systems and methods the program uses to conduct surveillance; how reliable the data are; what challenges they are facing; what strategies have been effective; and views on the utility of various novel approaches for conducting surveillance in inaccessible areas. The sample included relevant sectors that are important for the surveillance system.

A total of 16 personnel engaged in surveillance or humanitarian response in Borno were interviewed. Over half of these came from the state-level polio program including field surveillance officers, data managers and epidemiologists. The remainder were local key stakeholders involved in surveillance in selected districts with areas of armed conflict and inaccessibility. The staff were interviewed using semi-structured interview tools (Annex 3). The sample was purposively selected to include key officers involved in AFP field surveillance and data management and the humanitarian response. The sampling frame included government officials and partner agencies. Interviews were conducted in English which is widely spoken among these stakeholders. The interviews were conducted by phone and were recorded and transcribed. Key topics for the interview included understanding accessibility, surveillance challenges, surveillance monitoring, and new surveillance approaches. I obtained verbal consent for the interviews. No identifying information was retained.

## Description of Sample

The sample was a convenience sample with a purposive sampling strategy designed to obtain a range of perspectives and experiences and to encapsulate both the field level (district and community) and the higher levels (state and national). The strategy also entailed reaching out to various organizations to understand the issues related to collaboration and information sharing. Finally, the strategy involved selecting various cadres of staff who are familiar with various aspects of surveillance including oversight functions, field surveillance, and data analysis. The list of potential staff to interview included 17 staff at the state and national level and 30 staff at the field level (Annex 4). I limited the interviews to a maximum of 30 people to ensure feasibility of the data collection. I purposively chose from among the staff in the sample to obtain a range of perspectives. In order to ensure a diversity of respondents, the sample included at least 3 staff from the district level and staff from at least 3 different agencies. I continued sampling until I reached a point of saturation in which I was hearing the same information and not gaining new insights from subsequent interviews.

The organizations in the sampling frame included the Centers for Disease Control and Prevention (CDC), Nigeria Nation Stop Transmission of Polio program (NSTOP), The World Health Organization (WHO), the Core Group, Borno State's State Primary Health Care Development Agency (SPHCDA), the United Nations Office of Coordination of Humanitarian Affairs (OCHA), the United Nations Children's Fund (Unicef), Ehealth, Solina, the United Nations International Office on Migration (IOM), Medicins Sans Frontiers (MSF), and the Nigerian Red Cross.

CDC is a founding partner in the Global Polio Eradication Initiative. CDC staff in the sample have been providing field support for strengthening surveillance and supplemental immunization activities in Borno for several years. They have deep understanding of the issues and strategies being employed.

The National Stop Transmission of Polio program (NSTOP) is a CDC-funded polio program that was created in 2012 to support polio eradication activities in northern Nigeria. They have over 245 staff across the country working at both the state and district levels including 27 staff in Borno. NSTOP provides support for

strengthening AFP surveillance, supplemental immunization activity (SIA) quality, and routine immunization strengthening. They have a focus on vulnerable and hard-to-reach populations such as nomadic groups and displaced populations. One of their responsibilities is to conduct active surveillance visits for AFP.

The World Health Organization provides support for all aspects of the immunization program in Nigeria. They have over 2,500 staff across the country including over 30 staff in Borno state. They have officers working at the sub-district level, the district level, and the state level. They perform functions including active surveillance and verifying cases of AFP detected by district surveillance officers.

The Core Group is a USAID funded program that supports community-based AFP surveillance among hard to reach and conflict-affected communities. They have almost 2000 staff in Nigeria including community mobilizers. Core Group works through local NGOs that recruit community mobilizers for raising awareness on the need for vaccination and community informants for community level detection and reporting of AFP cases.

Borno State's State Primary Health Care Development Agency (SPHCDA) is charged with overseeing primary health care, including polio eradication activities. SPHCDA has a state level surveillance officer and assistant surveillance officer and surveillance officers and assistant surveillance officer in each of the 27 districts of Borno. The surveillance officers at the district level are responsible for conducting active surveillance for AFP and for conducting case investigation of AFP cases.

OCHA is the UN office responsible for the coordination of humanitarian emergencies. In Borno State they hold coordination meetings and support a coordination forum composed of different sectors including health. OCHA has been producing useful bulletins on the emergency response efforts in Borno.

Unicef support for polio eradication is primarily focused on vaccine logistics and health communication. In Nigeria they also recruited many thousands of community level mobilizers who are responsible for line-listing all children under five years of age, promoting vaccination, and reporting AFP cases. They have almost 18,000 staff in Nigeria including the community mobilizers and have a substantial presence in Borno State.

Ehealth Africa is an NGO focused on providing technological support for public health initiatives. They have been supporting the polio in Nigeria since 2012. Ehealth has a team of data management staff in Borno that are supporting mapping and data analysis needs. One of their projects that is relevant for this research is the analysis of data on the reach of the vaccination program in Borno state. Vaccination teams are provided with smart phones that can track the areas they visit for vaccination and provide evidence of vaccination and surveillance activities in areas of armed conflict.

Solina Health is a consulting firm based in Abuja, Nigeria that provides consulting services for the design and management of health care programs including child health and immunization. They are one of the partner agencies that are supporting data management for the polio program in Borno State.

IOM is responsible for supporting the safety of migrants including internally displaced people and refugees. They have a presence in Borno and manage estimations of displacement through the displacement tracking matrix (DTM). DTM is a major source of data on population displacement in Borno.

Medecins Sans Frontiers (MSF) is a medical humanitarian organization that provides health care to populations affected by emergencies including armed conflict. They have a presence in Borno to provide medical care to the populations affected by the conflict in Borno.

Nigerian Red Cross Society is an organization dedicated to supporting vulnerable populations in Nigeria including those affected by armed conflict. They have around 10,000 volunteers in Borno state and provide many services including health outreach, first aid training, and ambulance services.

## Data collection

Between April and August 2020 I conducted and recorded a total of 16 interviews by phone, including staff from 7 different organizations and 5 district staff from 4 different districts (Table 2). I pretested the data collection instruments with 3 project staff from states neighboring Borno state and modified the interview guides following the pretest to make them easier to understand for the respondents. I engaged a CDC colleague

to take notes for 3 of the interviews to ensure that I was not missing important issues during my note taking. The notes were very similar. I used a professional transcription service in Nigeria to transcribe the interviews and reviewed them each several times to ensure accuracy of the transcription. One issue that arose was that the quality of the phone connection sometimes faltered (most interviewees were in Borno State) and there were occasional words that could not be deciphered. These were very sporadic and the vast majority of the interview data was clear. I included one interview that was not part of the original sampling plan, a GIS specialist from CDC. This was because I felt a need for more detailed information in what was being learned from the GIS analyses. This individual played a leading role in developing and conducting the GIS analyses for Borno and, as a result, had unique experience and insights to share.

*Table 2: Interviews conducted*

<b>Number</b>	<b>Level</b>	<b>Organization</b>	<b>Position type</b>
1	State	CDC	Surveillance
2	State	CDC	Surveillance
3	State	NSTOP	Surveillance
4	State	NSTOP	Surveillance
5	State	NSTOP	Surveillance
6	State	NSTOP	Data analysis
7	State	WHO	Surveillance
8	State	Ehealth	Data analysis
9	State	Solina	Data analysis

10	State	IOM	Humanitarian Support
11	District	NSTOP	Surveillance
12	District	NSTOP	Surveillance
13	District	NSTOP	Surveillance
14	District	NSTOP	Surveillance
15	District	MoH	Surveillance
16	International	CDC	GIS Specialist

### Ethical considerations

This study posed very little risk to the participants. The study did not include any biological sample collection or biometric measurements. Only program staff who are already deeply involved in the issues are include in the sample. All responses were kept confidential and no identifying information was retained electronically. Ethical approval was obtained from the University of Illinois Ethical Review Board, the Government of Borno State Ethical Review Board, and the CDC Ethical Review Board. Informed consent was obtained from each participant prior to conducting the interviews.

### C. Data management and analysis

Document data were skimmed for relevance and relevant information was extracted from documents that primarily provided background or guidance information. For documents with rich information about the Borno context the data were extracted using an Excel based document extraction tool. The document data

were examined for themes and compared with the interview data for corroboration and establishment of patterns. I completed a review of 14 key documents as planned. My analysis plan called for coding of document data using MaxQDA, however, based on guidance from my committee chair, I used a data extraction tool in excel to summarize and analyze the document data. The document extraction instrument ensured a systematic approach to the document analysis.

Interview data were transcribed and analyzed using MaxQDA qualitative analysis software. Data were reviewed and cleaned for data entry errors and coded based on a-priori and emerging themes. The a-priori codes (constructs listed in the measurement table 3 below) were derived from the conceptual framework. These a-priori codes were revised as the data were collected to take account of additional themes and constructs and further sub groupings of concepts that arose from the data. Two stages of coding were conducted. The first cycle of coding focused on the a-priori codes from the conceptual framework.<sup>79</sup> Subcodes and themes were developed to assist in organizing the data as needed. A codebook of code definitions (Annex 1) was refined during this process. A second cycle of coding was then conducted to include emergent codes and to categorize the codes created in the first cycle based on the patterns observed. Using qualitative methods, the data were analyzed to describe the inhibitors of surveillance, the opportunities for effective surveillance, the monitoring systems, and issues of collaboration. Analysis was done using key words and issues, a-priori terms, and emerging themes. Analytic memos, matrix displays, and narrative descriptions were used as tools to analyze the data. Interview data were analyzed by groups including agency type and level of position (state level or field level) to look for consistencies and disparities in findings. Short reflective memos were written up after each interview. Primary data were compared to available published data to triangulate the findings and assess the extent to which the primary data aligns with the available data. Results were compared and contrasted between respondents and also triangulated with data from the reviewed documents to look for areas of convergence or divergence. The analysis helped identify the key promoters and inhibitors that support a surveillance system for inaccessible people and examined the utility of various novel approaches.

I added emergent codes on nomadic communities because these came up several times as both a challenge for surveillance as well as an opportunity for surveillance. The challenge as seen by some of the respondents is that the nomadic communities move in and out of the inaccessible areas and therefore may bring the polio virus either in to the inaccessible areas or out of the inaccessible areas and infect new populations that would not otherwise have been exposed. It is also a challenge because they move frequently and are difficult to find and track. They often travel through farmland or wilderness areas rather than on roads. The opportunity is that they have better access to the inaccessible areas because Boko Haram generally do not attack them and therefore they can serve as a source of information about the inaccessible areas and also can serve as community informants for the inaccessible areas.

Table 3: Measurement table

Overarching question: How can the conventional polio surveillance system and strategies be modified to address areas of conflict and inaccessible populations?							
Sub question	Construct	Sub-constructs/variables	Measures (key words)	Sources/ Data Collection	Sampling Plan	Measurement/ Analysis Plan	Triangulation & Integration [further notes on analysis]
1. What are the inhibitors (barriers) of effective surveillance?	Accessibility of populations	<ul style="list-style-type: none"> <li>Who has access,</li> <li>how do they go in and out,</li> <li>how often do they have access,</li> <li>geographic area of access,</li> <li>opportunities for access,</li> <li>limits and levels of accessibility,</li> <li>restriction in movement of local residents (within BH areas and out of BH areas).</li> </ul>	<ul style="list-style-type: none"> <li>groups with access,</li> <li>types of access (totally open,</li> <li>accessible with security escort,</li> <li>cjtf,</li> <li>military only,</li> <li>active fighting, bh</li> <li>controlled and no military access,</li> <li>full military unit needed,</li> <li>only active soldiers for active duty (no health missions)),</li> <li>geographic areas of access,</li> <li>frequency of access,</li> </ul>	Key stakeholder interviews: field officers, data users; documents 4 and 6	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

			<ul style="list-style-type: none"> <li>limits to movement of local residents</li> </ul>				
	Communication	<ul style="list-style-type: none"> <li>Mail,</li> <li>Phone,</li> <li>Email,</li> <li>Cell Phone call,</li> <li>Cell Phone Text,</li> <li>satellite phones,</li> <li>informal communication channels.</li> <li>Transmission of medical information,</li> <li>radio communication.</li> </ul>	<p>Geographic area of cell phone coverage, # and geographic area of destroyed cell phone towers, geographic areas with functional landlines, times of cell phone blackouts, geographic area of internet access, geographic area of physical mail delivery, modes and geographic area of information communication channels, availability of cell phones and charging stations, geographic area of radio coverage in inaccessible areas</p>	Key stakeholder interviews: field officers, data users; documents 4 and 6	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

	Health infrastructure	<ul style="list-style-type: none"> <li>• Status of health facilities (fully operational, partially operational (describe what services are provided),</li> <li>• destroyed,</li> <li>• partially destroyed, closed),</li> <li>• health care access,</li> <li>• distribution of clinics</li> </ul>	Geographic areas without functional health facilities, numbers of non functional health facilities, populations living in areas with non functional health facilities, level of services available in non function facilities (no services, some limited services (list types of services), availability of alternate medical care (informal health care, traditional health care, informal medicine sellers).	Key stakeholder interviews: field officers, data users; document 12	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.
	overall infrastructure	<ul style="list-style-type: none"> <li>• Roads,</li> <li>• electricity,</li> <li>• gas stations,</li> <li>• computers,</li> <li>• refrigeration capacity,</li> <li>• vehicles,</li> </ul>	Geographic areas without available infrastructure for surveillance by type of infrastructure (electricity, generators, passible roads, vehicles, motorcycles,	Annex 2: Key stakeholder interviews: field officers, data users,	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

			computers, printers)				
	population movement	<ul style="list-style-type: none"> <li>• Changes in population,</li> <li>• displaced population,</li> <li>• returning population,</li> <li>• timing of movement,</li> <li>• place of movement,</li> <li>• new settlements,</li> <li>• abandoned settlements,</li> <li>• destroyed settlements.</li> </ul>	Geographic areas with internally displaced populations (IDP), IDP camps, host communities, screening centers, nomadic groups, resettlement, returnees, abandoned settlements, destroyed settlements, new settlements, displaced populations within host communities (rather than camps), informal camps, holding centers.	Key stakeholder interviews: field officers, data users; documents 1, 11, 13	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.
	traumatizing violence	<ul style="list-style-type: none"> <li>• Attacks,</li> <li>• bombs,</li> <li>• rapes,</li> <li>• slaves,</li> <li>• hostages,</li> <li>• killings,</li> <li>• fleeing,</li> </ul>	Numbers and geographic areas with attacks, bombs, rapes, slaves, hostages, killings, fleeing, roadside bombs, terrorists, terror	Key stakeholder interviews: field officers, data users; documents 2, 3, 7	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-	Primary data compared to each other and secondary data to triangulate the findings.

		<ul style="list-style-type: none"> <li>• roadside bombs,</li> <li>• terrorists,</li> <li>• terror attacks,</li> <li>• injured people,</li> <li>• traumatized people,</li> <li>• people with conflict related mental health problems</li> </ul>	attacks, injured people, traumatized people, people with conflict related mental health problems			priori and emerging codes thematic analysis	
	Malnutrition and disease outbreaks	<ul style="list-style-type: none"> <li>• Severe malnutrition,</li> <li>• famine,</li> <li>• diarrhea,</li> <li>• measles,</li> <li>• cholera,</li> <li>• malaria,</li> <li>• meningitis,</li> <li>• outbreak response,</li> <li>• feeding center,</li> <li>• competing priorities</li> </ul>	Numbers and geographic areas with severe malnutrition, famine, diarrhea, measles, cholera, malaria, meningitis. Scope and geographic areas of outbreak response activities and feeding centers	Key stakeholder interviews: field officers, data users; documents 2, 3, 7, 12, 13	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.
	Rainy season	<ul style="list-style-type: none"> <li>• Access</li> <li>• Mud</li> <li>• Flooding</li> <li>• passable roads</li> </ul>	Ability to travel in inaccessible areas in the rainy season (by various means of transportation including vehicle, truck, wagon, bicycle, and by foot).	Key stakeholder interviews: field officers, data users; documents 2, 3, 7, 12, 13	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

	Nomadic populations	<ul style="list-style-type: none"> <li>• Movement of nomadic populations</li> <li>• Movement routes</li> <li>• Movement patterns</li> <li>• Mixing of nomadic and non-nomadic populations</li> <li>• Surveillance among nomadic groups</li> </ul>	<ul style="list-style-type: none"> <li>• Numbers of nomadic groups in inaccessible areas.</li> <li>• Access of nomadic population to travel between accessible and inaccessible areas.</li> <li>• Pastoralists</li> <li>• Fulanis</li> <li>• Nomadic migration</li> </ul>	Key stakeholder interviews: field officers, data users; documents 2, 3, 7, 12, 13	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.
2. What opportunities (strategies and field methods) would enable effective surveillance in these settings?	Community informants	<ul style="list-style-type: none"> <li>• Traditional leader,</li> <li>• village health volunteer,</li> <li>• informant,</li> <li>• surveillance focal person,</li> <li>• patent medicine vendor,</li> <li>• traditional healer,</li> <li>• nurse, traditional birth attendant,</li> <li>• barber,</li> <li>• religious leader,</li> <li>• village chief</li> </ul>	Numbers and geographic areas with community informants. Ability of community informants to conduct quality and effective surveillance. Ability of community informants to bring patients to safe areas for collection of case information and specimens, ability of community informants to bring patients to	Key stakeholder interviews: field officers, data users; documents 4 and 6	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

			safe areas for 60-day follow up examination.				
	GIS technology	<ul style="list-style-type: none"> <li>• satellite imagery,</li> <li>• settlement inhabitation status,</li> <li>• vaccination tracking,</li> <li>• surveillance tracking,</li> <li>• case verification,</li> <li>• open data kit (ODK),</li> <li>• integrated supportive supervision (ISS),</li> <li>• audio visual AFP detection and reporting (AVADAR),</li> <li>• electronic surveillance (eSURV),</li> <li>• population estimates</li> </ul>	Frequency of GIS satellite imagery assessments, reliable of assessments, geographic areas with collection of GPS coordinates of vaccination activities and surveillance activities.	Key stakeholder interviews: field officers, data users; document 8	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.
	Collection and testing of specimens beyond AFP cases	<ul style="list-style-type: none"> <li>• Environmental surveillance,</li> <li>• ad-hoc environmental surveillance,</li> <li>• healthy children stool surveys,</li> <li>• specimen collection from contacts of AFP cases,</li> <li>• specimen collection from recent escapees</li> </ul>	Geographic location of environmental specimen collection, location of healthy children survey, location of contact specimen collection, location and amount of time since arrival of	Key stakeholder interviews: field officers, data users; documents 4, 6, and 10	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

		from inaccessible areas.	recent exapees from inaccessible areas.				
	Collaboration with security forces	<ul style="list-style-type: none"> <li>• Civilian joint task force,</li> <li>• military,</li> <li>• reaching every settlement strategy (RES),</li> <li>• reaching inaccessible children strategy (RIC)</li> </ul>	Geographic area covered by RES and RIC. Number of times areas were reached, number of AFP cases identified by security forces, accuracy of information provided by security forces, quality of training of security forces, skills and capacity of surveillance forces to carry out surveillance, motivation of security forces to carry out surveillance.	Key stakeholder interviews: field officers, data users; documents 4 and 6	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

	Profiling of displaced people	<ul style="list-style-type: none"> <li>• Data collection from displaced persons including</li> <li>• location of home,</li> <li>• time of displacement,</li> <li>• route taken out of inaccessible area,</li> <li>• vaccination status of children,</li> <li>• existence of AFP cases,</li> <li>• information on populations left behind in inaccessible areas.</li> </ul>	Area profiling (Transit points, IDP camps, checkpoints), geography of origin of profiled population, percentage of children under five years of age that were never vaccinated, number of missed AFP cases identified, route taken when leaving inaccessible areas, size of remaining population in inaccessible areas.	Key stakeholder interviews: field officers, data users; documents 4 and 6	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.
	Evacuation	<ul style="list-style-type: none"> <li>• AFP case</li> <li>• AFP contact</li> <li>• Timely stool collection</li> <li>• 60-day follow up</li> </ul>	Systems for transporting AFP cases and contacts of AFP cases from inaccessible areas to accessible areas for clinical investigation and specimen collection.	Key stakeholder interviews: field officers, data users; documents 4 and 6	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

	Nomadic populations	<ul style="list-style-type: none"> <li>• Movement of nomadic populations</li> <li>• Movement routes</li> <li>• Movement patterns</li> <li>• Mixing of nomadic and non-nomadic populations</li> <li>• Surveillance among nomadic groups</li> </ul>	Use of nomadic populations for surveillance, sharing information and communicating in inaccessible areas. Systems to conduct surveillance among nomadic populations that pass through inaccessible areas.	Key stakeholder interviews: field officers, data users; documents 4 and 6	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.
3. What monitoring systems and indicators may be useful in monitoring surveillance performance in inaccessible areas?	Tailored surveillance performance indicators for inaccessible areas	<ul style="list-style-type: none"> <li>• Frequency of active surveillance,</li> <li>• documentation of active surveillance,</li> <li>• areas covered by active surveillance,</li> <li>• active surveillance reports,</li> <li>• level of accuracy of reported AFP cases (true AFP cases, correct date of onset, correct number of vaccine doses received),</li> <li>• number of late cases reported from previously unreachable areas (cases reported &gt;14 days after paralysis onset),</li> </ul>	Percent of geographical area with active surveillance, frequency of active surveillance, ability to evacuate and investigate cases in accessible areas, documentation of active surveillance (photographs, GPS coordinates), ability to evacuate cases for 60 day follow up investigations, ability to evacuate contacts for stool collection	Key stakeholder interviews: field officers, data users; documents 10 and 11	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

		<ul style="list-style-type: none"> <li>• methods of active surveillance.</li> </ul>					
	Tailored surveillance quality assessment tools for areas that supervisors cannot reach	<ul style="list-style-type: none"> <li>• Cross verification of areas reported to be visited with assessments of settlement inhabitation (are surveillance activities reported from uninhabited areas),</li> <li>• number of AFP cases reported (are unexpected numbers of cases reported),</li> <li>• detailed interviews with surveillance informants (community or military) to understand in more detail the extent and quality of the activities they conducted,</li> <li>• mapping of areas reached for surveillance.</li> </ul>	Extent and location of abandoned areas with reported surveillance, extent and location of areas with unexpected numbers of AFP cases, extent and location of areas with irregular surveillance, extent and location of areas with no surveillance, population in areas with no surveillance, population in contiguous areas with no surveillance, extent and location of areas	Key stakeholder interviews: field officers, data users; documents 10 and 11	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

			with good quality surveillance, extent and location of areas with low quality or incomplete surveillance based on detailed interviews, major data discrepancies, inability to investigate AFP cases.				
4. What systems are in place for collaboration and information sharing for polio surveillance between the various actors (governmental, non-governmental, and multinational) that are supporting the humanitarian response in Borno?	Collaboration and information sharing systems	<ul style="list-style-type: none"> <li>Agencies involved in the humanitarian response</li> <li>Information sharing systems in between agencies involved in the Borno humanitarian response</li> <li>Systems for collaboration between agencies</li> <li>Benefits of systems for AFP surveillance</li> </ul>	Emergency response, Humanitarian response, NGO, MSF, Red Cross, OCHA, IOM	Key stakeholder interviews: field officers, data users;	Purposive sample of 16 key stakeholders	Data extraction related to key questions. Mapping and descriptive statistics of existing datasets. A-priori and emerging codes thematic analysis	Primary data compared to each other and secondary data to triangulate the findings.

Table notes:

- Quality of active surveillance - how likely is it that no case would be missed in an area with surveillance - this includes frequency of active case searches, areas covered during active case searches (house to house searches or other system), level of knowledge of surveillance informants, motivation of surveillance informants, safety of surveillance informants. One possible indicator is reporting of old cases (more than 60 days old) in areas that have recently been added for surveillance.

**Accuracy of active surveillance:** how accurate is the information collected on detected AFP cases (date of onset, symptoms, true AFP, vaccination status, date of specimen collection, location of case)

**Quality of specimen collection:** were the specimens collected according to protocol and kept in the required conditions?

**Quality of follow up:** if needed, was a 60-day follow up conducted and if yes who conducted it and is the information collected accurate?

**Reach of surveillance:** which areas are covered by surveillance informants and which areas are not covered (by village)

**Regularity of reporting:** how can we know which areas have regular surveillance activities?

#### D. Validity concerns

Validity of findings was addressed through several methods. Construct validity was addressed by using multiple sources of evidence including documents and interviews and also by requesting that a select group of informants review the findings to ensure accuracy (member checking). Internal validity and reliability was addressed through development of a study database, careful analysis including pattern matching, and also by engaging a secondary note taker for 3 of the interviews to compare notes for consistency and discuss any areas of inconsistency. I used standard interview tools to ensure consistency of data collection across the sample. I used a standardized code book for the coding process to ensure consistency of coding across the data collected. I engaged a secondary coder for 2 of the interviews to compare consistency of coding and discuss and address any areas of inconsistency. I used the secondary coding to strengthen the quality of the primary coding. I used available data to triangulate findings to the extent possible. I referred back to the respondents as needed to verify findings and clarify the information provided. I convened a group of 6 number of respondents for a member checking exercise to ensure that I did not misrepresent any of the information provided. I also conducted a peer debriefing with a group of 6 peers with experience in polio surveillance in areas of armed conflict to review the findings and provide feedback.

I engaged a second coder from the UIC DrPH program to code two of the interviews to compare coding. I held a series of calls with the secondary coder to describe the study and the codes. I also shared the codebook and a summary of the study with the secondary coder. The secondary coder

analyzed 2 transcripts (13%) and reviewed my codes for those transcripts. The secondary coder agreed with all of my coding and did not suggest any other segment to code. We discussed the coding comparison at length, especially given the surprising level of agreement, and realized that we both had a similar backgrounds in international health which may have led to similar thinking about the coding process. In addition, the codes were arranged in the order of the questions asked during the interviews which made it easier to code the transcripts. The process of using a secondary coder was a useful exercise. I also reviewed preliminary coding with my committee chair which strengthen my skills in coding including coding segments with multiple codes when relevant. I coded each of the interviews in MaxQDA and created summary grids of the interviews and also organized the summary grids by respondent type (organization and position) and respondent level (field or state level).

Validity may also be impacted by the characteristics of the researcher. I have been working on polio eradication as a staff member of the CDC for over 10 years. I spent several years working on polio eradication in Nigeria and visited Borno state twice in this capacity. I also helped to establish the NSTOP program in Nigeria and therefore have strong relationships with the NSTOP program. I have met and worked with many of the respondents in this study. I believe that this familiarity with the program and the people in the program helped me to develop a relevant problem statement and also helped facilitate the interviews that I conducted. I believe that, because many of the respondents knew me or knew of me, they were more willing to participate in the study. I did not attempt to bias or sway them in any way from providing their own perspectives on the questions I asked. Similarly, I did not receive any guidance or pressure from CDC or any other agency that would bias my analysis and findings in any way.

## E. Limitations

This study is subject to several limitations. First, the sample of 16 respondents is relatively small and cannot fully represent the spectrum of perspectives from polio and humanitarian staff in Borno. To limit the impact of this limitation, I continued conducting interviews until I reached a point of saturation where I was hearing the same issues and gaining little new information from additional interviews. I was only able to interview a handful of staff from several organizations and was unable to reach staff from some organizations that were included in the sample design. Because of the difficulties I anticipated in reaching program staff, I intentionally added flexibility in the sampling design and the final sample met the objectives of the sampling design in that I included over three staff from the district level and over 3 different agencies in the final sample. I interviewed staff from 5 districts and 6 different organizations. I also included perspectives from the humanitarian response, the Ministry of Health, the data analysts, management staff, and a GIS specialist. In addition, my sample did not include any community level respondents. While it would have added depth to the study to hear directly from community members (including community informants), this was not included in the study to avoid the ethical and logistical issues involved in interviewing community members. Because most of the staff I interviewed had firsthand knowledge of the community informants and attended numerous meetings with them, I felt that I was still getting good information on the community perspective despite this limitation. Finally, the document review was limited to publicly available documents. There may have been other internal documents with more detailed information that would have added value to this study if I had been able to access them. Some respondents however shared examples of program analyses with me that were very helpful in understanding what the program was doing and these additional resources helped offset this limitation.

#### F. Conflicts of interest

There are no conflicts of interest to report.

#### G. Funding

This was almost completely an unfunded study. CDC was flexible in allowing me to conduct some of the study during my work hours. In addition, CDC paid for the cost of transcribing the interviews.

## Chapter 4: Findings

The findings chapter presents the findings from the document review and the interviews. The document review findings are described by document type and also by construct from the conceptual framework. The interview findings are presented overall by construct and are also compared and contrasted by respondent group. An additional analysis on collaboration for GIS data analysis and use is presented and discussed. Several analyses using MaxQDA software are illustrated including the code relations browser, a code map, and a code matrix. Finally, the data are triangulated between the document review and the interviews.

### **A. Document review findings**

#### Analysis of Key Documents:

Key documents included reports, plans, guidelines, and news articles. In general, there was good agreement across the documents and document types on the status of the problem in Borno. Most of the information focused on population movement and malnutrition. Overall, the document review provided useful information on the status of the conflict in Borno, the strategies being used for AFP surveillance in inaccessible areas, and guidance on conducting surveillance. A table of the reviewed documents is provided below (Table 4).

Table 4: List of Documents Reviewed

Type of Document	Document names	Date of Publication	URL
Report	Displacement Tracking Matrix	December 2017	<a href="https://www.humanitarianresponse.info/en/operations/nigeria/assessment/displacement-tracking-matrix-dtm-round-xx-i-december-2017">https://www.humanitarianresponse.info/en/operations/nigeria/assessment/displacement-tracking-matrix-dtm-round-xx-i-december-2017</a>
Report	Nigeria Emergency Response. Borno State Early Warning Alert and Response System	October 2016	<a href="https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/orno state weekly epidemiological bulletin - w41 2016 - 10 - 16 october.pdf">https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/orno state weekly epidemiological bulletin - w41 2016 - 10 - 16 october.pdf</a>
Report	Northeast Nigeria Humanitarian Response bulletin. Borno State Government.	October 2016	<a href="https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/orno health sector bulletin issue number 1 sept 2016.pdf">https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/orno health sector bulletin issue number 1 sept 2016.pdf</a>
Report	Northeast Nigeria Humanitarian Response bulletin. Borno State Government.	July 2019	<a href="https://reliefweb.int/sites/reliefweb.int/files/resources/health sector bulletin july 19 ne nigeria.pdf">https://reliefweb.int/sites/reliefweb.int/files/resources/health sector bulletin july 19 ne nigeria.pdf</a>
Report	Lake Chad Basin Crisis Overview	February 2016	<a href="https://reliefweb.int/report/nigeria/lake-chad-basin-crisis-overview-29-february-2016">https://reliefweb.int/report/nigeria/lake-chad-basin-crisis-overview-29-february-2016</a>
Report	Global Polio Eradication Initiative (GPEI) polio updates for Borno 20016-2019	March 2020	<a href="http://polioeradication.org/">http://polioeradication.org/</a>
Report	33 <sup>rd</sup> Nigeria Polio Expert Review Committee Report	January 2017	<a href="http://polioeradication.org/wp-content/uploads/2017/03/finalreport-33ERCmeeting-012017.pdf">http://polioeradication.org/wp-content/uploads/2017/03/finalreport-33ERCmeeting-012017.pdf</a>
Report	Article on finding inhabited settlements and tracking vaccination in Borno	May 2019	<a href="https://pubmed.ncbi.nlm.nih.gov/31096971/">https://pubmed.ncbi.nlm.nih.gov/31096971/</a>
Report	Polio Independent Monitoring Board Report	October 2018	<a href="http://polioeradication.org/wp-content/uploads/2018/11/20181105-16th-IMB-Report-FINAL.pdf">http://polioeradication.org/wp-content/uploads/2018/11/20181105-16th-IMB-Report-FINAL.pdf</a>
Report	USAID Lake Chad Basin Complex Emergency Fact Sheet	May 2017	<a href="https://www.usaid.gov/sites/default/files/documents/1866/05.12.17 - USAID-DCHA Lake Chad Basin Complex Emergency Fact Sheet 15.pdf">https://www.usaid.gov/sites/default/files/documents/1866/05.12.17 - USAID-DCHA Lake Chad Basin Complex Emergency Fact Sheet 15.pdf</a>

Plan	National Primary Health Care Development Agency National Polio Eradication Emergency Plan	2018	<a href="http://polioeradication.org/wp-content/uploads/2018/04/Nigeria-National-Polio-Emergency-Plan-2018.pdf">http://polioeradication.org/wp-content/uploads/2018/04/Nigeria-National-Polio-Emergency-Plan-2018.pdf</a>
News Article	New York Times article on Boko Haram: “Boko Haram is Back. With Better Drones.”	September 2019	<a href="https://www.nytimes.com/2019/09/13/world/africa/nigeria-boko-haram.html">https://www.nytimes.com/2019/09/13/world/africa/nigeria-boko-haram.html</a>
News Article	Washington Post article on Borno conflict: “Nigerian children who escaped Boko Haram say they faced another ‘prison’: Military detention”	September 2019	<a href="https://www.washingtonpost.com/world/africa/nigerian-children-who-escaped-boko-haram-say-they-faced-another-prison-military-detention/2019/09/14/e30a0da2-d40c-11e9-8924-1db7dac797fb_story.html">https://www.washingtonpost.com/world/africa/nigerian-children-who-escaped-boko-haram-say-they-faced-another-prison-military-detention/2019/09/14/e30a0da2-d40c-11e9-8924-1db7dac797fb_story.html</a>
Guidelines	WHO—recommended standards for surveillance of selected vaccine-preventable diseases*- polio	2018	<a href="https://www.who.int/immunization/monitoring_surveillance/burden/vpd/WHO_SurveillanceVaccinePreventable_18_Polio_R2.pdf?ua=1">https://www.who.int/immunization/monitoring_surveillance/burden/vpd/WHO_SurveillanceVaccinePreventable_18_Polio_R2.pdf?ua=1</a>
Guidelines	Analyzing disrupted health sectors, a modular manual 2009. (Modules 2 and 4)	2009	<a href="https://www.who.int/hac/techguidance/tools/disrupted_sectors/en/">https://www.who.int/hac/techguidance/tools/disrupted_sectors/en/</a>

## 1. Reports

I reviewed 10 reports that covered the humanitarian emergency in Borno state between 2016 and 2019. They also included information on the status of the polio program in Nigeria and AFP surveillance in Borno state. The reports demonstrated that the conflict in Borno state led to mass displacement of the population and high levels of malnutrition and disease outbreaks. For example, it was reported that, as of February 2016, 2.6 million people were displaced in the Lake Chad Basin as a result of the crisis and 4.5 million people had severe food insecurity<sup>80</sup>. They also demonstrated the impact of the conflict on the polio program including limited AFP surveillance in Borno state and thousands of children and settlements inaccessible for polio vaccination or surveillance. For example, in September of 2016 it was reported that 52% of the settlements in Borno state were inaccessible

and 334/632 (52%) of health facilities were non-functional (destroyed, looted, or closed)<sup>81</sup>. While some improvements in access were reported between 2016 and 2018, there remained a sufficient number of inaccessible children to sustain polio transmission according to the Polio Independent Monitoring Board report of 2018. In December 2017 there were 8,062 inhabited settlements in the inaccessible areas with 157,256 children under five years of age<sup>82</sup>. Use of satellite imagery, security forces, and sampling of healthy children were discussed as strategies for improving AFP surveillance in the inaccessible areas.

## 2. Plans

I reviewed one plan, the 2018 National Polio Eradication Emergency Plan. This plan gave detailed information on the challenges Nigeria was facing for achieving polio eradication, and the strategies being used to overcome those challenges. The plan discussed the challenge of having over 44% of settlements in Borno completely inaccessible at the end of 2016. It also discussed the utility of satellite imagery to estimate populations living in the inaccessible areas. The utility of collecting stool samples from healthy children and conducting ad-hoc sampling of sewage for assessing polio transmission was presented in the plan. The use of security forces for polio vaccination and AFP surveillance in inaccessible areas was also described. It also discussed the use of data collection of people fleeing from inaccessible areas as a strategy for strengthening AFP surveillance. This strategy, dubbed “profiling”, involved collecting systematic data on the area the family fled, vaccination status of the children, and any AFP cases detected. The profiling was conducted in markets, transportation hubs, IDP camps, and feeding centers. The plan did not discuss the use of community informants for surveillance in inaccessible areas.

## 3. News articles

I reviewed two news articles that described the horrors of the Borno armed conflict from the perspective of local inhabitants who lived through them. A Washington Post article from 2019 describes horrific attacks on civilians and villagers being forced to join Boko Haram<sup>83</sup>. A woman, for example, was accosted by Boko Haram fighters who beat her, burned her face, and forced her to marry a Boko Haram Fighter. Another man was forced to join Boko Haram and shoot at villagers or be killed by Boko Haram. “He said he closed his eyes and fired at random”<sup>83</sup>. Another article from 2019 describes a child with large scar from a recent suicide bombing attack that killed 8 other children<sup>84</sup>. The article stated that attacks were occurring almost daily. The article also described how soldiers were burning villages and bringing villagers to “super camps” as part of their strategy to defeat Boko Haram. It stated the military were leaving the rural areas to Boko Haram. It also described how Boko Haram looted and destroyed a military hospital.

#### 4. Guidelines

I reviewed two guidelines documents. The first, the WHO guidelines for polio surveillance, did not include specific information on how to conduct polio surveillance in areas of armed conflict. The guidelines provided an overview of the general strategies for polio surveillance including active and passive surveillance, community surveillance, environmental surveillance and standard indicators and targets. The second guidelines, the WHO guidelines for analyzing disrupted health sectors, did not focus on polio specifically and discussed many of the challenges to analyzing health data during armed conflicts, and strategies for overcoming those challenges. The guidelines stated that the routine health surveillance system often breaks down during conflicts and the data gathered is often incomplete, disorganized, and inaccurate. The little data that exist are focused on the most accessible areas of the conflict such as IDP camps. In fact, the guidelines state that the absence of data is the strongest indication of a health sector disrupted by crisis. The guidelines also discuss the challenge of accurately estimating populations during wartime and that populations estimates may be biased to advance a particular political agenda. Furthermore, the guidelines discuss the increase in mortality from disease outbreaks that results from widespread

malnutrition in times of armed conflict. They suggest some strategies for overcoming these challenges including using informal networks of experts to estimate levels of disease, ground truthing the information with locals, be suspect of data that are not in alignment with the general understanding of the situation, use information from the media, and conduct field visits if possible. Finally, they caution against using data for action if the data do not seem plausible.

## **Constructs discussed in the key documents**

### **Inhibitors**

#### **1. Inaccessible populations**

The construct on inaccessible populations was discussed in 6 of the documents. While the exact numbers varied by document, there was general agreement across sources that there are many thousands of inaccessible people in many thousands of inaccessible settlements In Borno. There was also agreement that there was a considerable decrease in the inaccessible population from 2016-2018. This highlights the challenge of conducting surveillance when a large population cannot be accessed.

#### **2. Communication**

The construct on communication was only referenced in one of the documents. One media source mentioned the destruction of the communication towers and lack of cell phone coverage in the conflict areas.

#### **3. Health infrastructure**

The construct on health infrastructure was discussed in 3 of the documents. There was agreement that many health facilities were destroyed and therefore passive surveillance is unfeasible in those areas because the health facilities cannot conduct regular disease reporting. The humanitarian response bulletin from 2016 reported that 50% of the 755 health facilities in Borno were not functional and that 297 were fully or partially destroyed. The Northeast Nigeria Health Sector report from 2016 reported similar figures: 41% health facilities completely damaged, 10% partially damaged, 80% of districts without sufficient functioning health facilities. One article discussed the breakdown of health systems in wartime and the challenge this presents to collect reliable health data.

#### 4. Overall infrastructure

There was very little information was available on the construct of overall infrastructure which was only discussed in 1 of the documents. Higgins et al (2019) discussed thousands of destroyed settlements. The article stated that in the inaccessible areas in 2017, 3,203/11,297 (27%) settlements were partially or completely destroyed, 662 (6%) were partially abandoned, and 8,062 (71%) were fully inhabited.

#### 5. Population movement

The construct on population movement was discussed in 5 of the documents. There was general agreement among the documents that a very large number of people are displaced. The estimated ranged from 1.7 to 2.6 million. This presents a major challenge to determining the true denominator for calculating rates.

#### 6. Traumatizing violence

The construct on traumatizing violence was discussed in 3 of the documents. There were some media reports of violence including bombings, children with physical scars from violence, thousands of civilians killed, and abducted women and girls. There was also a report of 82 abducted girls who were released after government negotiations. These reports suggest that there is a climate of fear in the conflict areas.

#### 7. Malnutrition and disease outbreaks

The construct on malnutrition and disease outbreaks was discussed in 6 of the documents. There was considerable information pointing to severe malnutrition and large disease outbreaks in the conflict areas. The numbers of severely malnourished were estimated to be in the hundreds of thousands with millions in need of food support. Thousands of cases of malaria, diarrhea, and cholera were reported. The actual numbers may not be accurate given the challenges of collecting health data from the inaccessible areas but they give an overall picture of a population that is suffering from malnutrition and disease outbreaks.

### **Strategies**

#### 8. GIS technology

The construct on the use of GIS technology was discussed in three of the documents. This included one document that provided an in-depth analysis of the use of satellite imagery for estimating populations in inaccessible areas (Higgins et al 2019). The other two documents discussed the utility of the satellite imagery methodology for targeting polio surveillance efforts in Borno. This demonstrates a recognition of the value of this approach.

#### 9. Collection of specimens beyond AFP cases

The construct on collection of specimens beyond AFP cases was discussed in two of the documents. The National Polio Eradication Emergency Plan of 2017 discussed collecting stool specimens from health children fleeing from inaccessible areas and conduct ad hoc collection of sewage samples for testing in security compromised areas. The Expert Review Committee of 2018 recommended continuing these strategies to supplement testing of specimens from AFP cases to avoid missing any polio transmission. The likelihood of detecting polio with this strategy was not discussed.

#### 10. Collaboration with security forces

The construct on collaboration with security forces was only discussed in the National Polio Eradication Emergency Plan of 2017. The plan indicated that 2,698 settlements in Borno were reached using the RIC (Reaching Inaccessible Children) strategy (use of military forces to conduct vaccination and surveillance) and 48,673 children were vaccinated. 4,286 settlements were reached and 251,000 children were vaccinated using the reaching every settlement strategy (RES) using civilian joint task force (CJTF) security. CJTF is an informal group of armed community members who have play a role in protecting communities. These strategies seem promising for areas that cannot be reached by unarmed civilians.

#### 11. Profiling of displaced people

The construct on profiling of displaced people was only mentioned in the National Polio Eradication Emergency Plan. The plan explained that children coming out of inaccessible areas were profiled at transportation hubs, markets, IDP camps, nutrition centers and asked of their district and ward of origin. 375,706 from Borno were profiled and vaccinated including 14,341 coming from completely inaccessible districts of Abadam and Marte. This strategy seems useful for quantifying and vaccinating children leaving inaccessible areas. It could be used to gather more information on the population left behind including possible AFP cases.

## 12. Community informants

None of the documents discussed the use of community informants for surveillance in inaccessible areas.

### **Tailored surveillance quality assessment tools**

## 13. Tailored surveillance performance indicators

None of the documents discussed the use of tailored surveillance performance indicators for surveillance in inaccessible areas.

## 14. Tailored surveillance assessment tools

None of the documents discussed the use of tailored surveillance assessment tools for surveillance in inaccessible areas.

### **Collaboration and information sharing systems**

Two of the documents discussed collaboration and information sharing systems. The Northeast Nigeria Humanitarian Response bulletin listed many agencies that were providing humanitarian assistance in Borno, including the type of assistance they were providing and the areas where they were working. The Polio Independent Monitoring Board mentioned weekly humanitarian coordination meetings in Borno hosted by the polio program. These strategies seem useful for sharing information and collaboration between agencies in humanitarian emergencies. The documents did not provide examples of how these systems were helping the polio program.

In summary, the documents confirmed many of the proposed pathways in the conceptual framework for this study. The issue of inaccessibility was discussed in 6 of the documents with consistent information on the size and importance of this barrier. The problem of the destruction of the health infrastructure was discussed in 3 of the documents with agreement that around 50% of health facilities in 2016 were nonfunctional due to the conflict. Population movement was also discussed in 5 of the documents with a range in estimates of the displaced population from 1.7 to 2.6 million people. Traumatizing violence was discussed in 3 documents with reports on the violence and climate of fear. Malnutrition was discussed in 6 documents describing large scale malnutrition with millions in need of food and large disease outbreaks. GIS technology was discussed in 3 documents with a focus on the utility of satellite imagery as a method for estimating populations in inaccessible areas. Collaboration and information sharing systems were discussed in two of the documents.

The document review confirmed the importance of the barriers proposed in the conceptual framework although the breakdown of the communication network and the overall infrastructure were each only discussed in one document. Only two documents were directly related to the polio response in Borno and most of the other documents were not expected to detail the strategies for public health surveillance in Borno but rather provided context and background on the conflict. These two documents, the National Polio Emergency Action Plan and the Polio Expert Review Committee report, both reported on the utility of GIS technology and collection of stool specimens beyond AFP cases. The National Polio Emergency Action Plan also discussed the utility of collaborating with security forces and profiling displaced populations. Both of these documents were written while there were large gaps in AFP surveillance due to the armed conflict.

Several constructs were either not discussed or only mentioned in passing in the documents. These were the use of tailored surveillance quality assessment tools and use of community informants for surveillance strengthening. It is likely that these systems are newer and have not yet been documented in publicly accessible documents.

## B. Interview Findings

I summarized the data for each respondent in a summary grid and summarize the overall findings below. Not all respondents provided information on all the constructs. The findings were fairly consistent across respondents although each respondent provided some different details that enriched the overall understanding of the challenges and steps being taken to address them. Table 5 below gives a breakdown of the number of times I coded a segment and the number of respondents who provided information by construct for each code. For some respondents I coded multiple segments for the same code. The code frequency table demonstrates that the most frequently discussed inhibitor was inaccessibility and the most frequently discussed strategy was community informants.

*Table 5: Number of coded segments and respondents who provided information per code*

Code	Number of coded segments	Number of respondents who provided information
Inhibitor/Accessibility of populations	75	16

Inhibitor/Communication	26	11
Inhibitor/Health infrastructure	16	11
Inhibitor/Overall infrastructure	20	10
Inhibitor/Population movement	34	13
Inhibitor/Traumatizing violence	32	14
Inhibitor/Malnutrition and disease outbreaks	11	10
Inhibitor/Rainy season	11	10
Inhibitor/Nomadic population	10	7
Inhibitor/Other	9	6
Strategies/Community informants	126	15
Strategies/GIS technology	65	16
Strategies/Collection and testing of specimens beyond AFP cases	17	11
Strategies/Collaboration with security forces	54	15
Strategies/Profiling of displaced people	13	8
Strategies/Evacuation	42	13
Strategies/Nomadic population	13	6

Strategies/Other	8	4
Monitoring systems/Tailored surveillance performance indicators for inaccessible areas	104	15
Monitoring systems/ Tailored surveillance quality assessment tools indicators for inaccessible areas	5	4
Collaboration and information sharing systems	19	11

### **Inhibitors**

The first part of the interviews consisted of questions regarding the main inhibitors to polio surveillance in areas of armed conflict in Borno State. I asked respondents about the proposed challenges that I included in my conceptual framework and measurement table and also asked participants to list other challenges that they encountered. The purpose of this section was to understand the importance of the challenges from the perspective of the various respondents, who are involved in polio surveillance or the humanitarian response in Borno, and also to gain more details, insights, and examples of how these challenges play out in practice. I also used this section to set the stage for the second section which focused on strategies to address the challenges.

### **Accessibility**

The main inhibitor discussed by the respondents was the issue of accessibility (Table 5). This was discussed by all the respondents, often at great length. All the respondents discussed the fact that no one from the polio program can go to the inaccessible areas and that there is great risk in those

areas. Many respondents complained that this inaccessibility makes it impossible for polio program staff to conduct surveillance or investigate AFP cases in these inaccessible areas. One respondent reported that there were 6,821 inaccessible settlements in Borno. While several respondents reported that the government has regained control of some areas over the years since 2015 and that in many districts the district capital is now accessible, many respondents indicated that the conflict is still very active and has even escalated in 2020. One respondent stated that there was less accessibility on the eastern side of Borno (Bama, Dikwa districts) compared to the western side (Magumeri and Gubio districts). Several respondents stated that two districts of 27 districts in Borno are fully inaccessible (Abadam and Marte) and one respondent reported that only 6 of 27 districts are fully accessible as of July 2020. Respondents mentioned the dangers of explosive devices and land mines on the roads and the inability of health workers to reach the inaccessible areas. Several respondents talked of the fear of going to those areas because of the dangers. One mentioned that someone working for the polio effort was killed while on duty. One respondent said that 45% of the state is geographically inaccessible. Several mentioned that the conflict is still ongoing and one said it was getting worse. Another informant mentioned that motorcycles, which are an important form of transportation to rural areas in Nigeria, are banned on Borno state because they are often used by terrorists.

Several respondents gave quantifications of the inaccessibility. As stated above, one respondent stated that 6,821 settlements are inaccessible. The estimated size of the trapped population was 720,462 people with 440,651 children under 15 years of age (the target age group for polio surveillance) according to one respondent who is responsible for program data. At the district level several respondents reported that most wards are inaccessible (10/15 in Kukawa district, 6/11 in Ngala district, 11/14 in Bama district). Other organizations take a more cautious approach to accessibility and have not attempted to reach many of the places that the polio program has reached.

*Respondent 1: "the conflict is continuing right now as we speak and it is not slowing down. At some point it comes down, but since December last year the conflict situation has gotten worst."*

*Respondent 3: "Up to 45% of the state geographic area remain inaccessible. Take for example, there are 27 local governments in the state, only 6 are fully accessible" ... "populations living in those areas cannot be reached by the regular teams that conduct AFP surveillance and surveillance for other vaccines preventable diseases. So, some populations are trapped there"*

*Respondent 5: "Like at this point in time the LGAs (districts) are now... most of the LGAs are partially accessible with two of the LGAs totally inaccessible at this point in time. These two LGAs are Abadam and Marte. And as far as we are concerned, the only people you can find in Marte and Abadam at this point in time are either insurgents or the military personnel. You hardly find a civilian population there, except an individual is being trapped, being held by the insurgents."*

*Respondent 6: "So, I know Abadam and Marte are, you know, considered completely inaccessible." "So, and then we have about.... So, in total the whole settlements in Borno is just over 15,000. We have about 5,696 for accessible. We have 3,092 for partially accessible. And we have 6,821 settlements for inaccessible. But it's also note to... it is also important to note that these numbers are fluid and they change."*

*Respondent 15: "Insecurity is an all-encompassing challenge."*

In summary, accessibility was viewed as the paramount challenge by the respondents. Accessibility is better in 2020 than it was in 2016 because the military was able to regain control of district capitals in most districts. However, while these are important gains, most of the rural areas in the middle and northern parts of Borno is still inaccessible and unreachable by the polio program. The danger involved in trying to reach these areas was heavily emphasized by the respondents. For someone to try to go to an inaccessible area is still completely unthinkable with a highly likelihood of that person being killed. There is still a sizeable population trapped in these areas and the inability of the program to go in to conduct surveillance is an overriding problem for the polio program.

Most respondents stated that all of the health facilities in inaccessible areas are destroyed. Two respondents said that Boko Haram would steal the drugs and vaccines in the health facilities and even abduct health workers. This was seen by one respondent as an indication that Boko Haram understands the value of vaccines and may be covertly vaccinating their members. Several also stated that health workers could not go to the inaccessible areas. Several explained that without health facilities it is difficult to detect and report AFP cases. Some respondents reported that residents of the inaccessible areas can sometimes access health care in health facilities just outside the border of the inaccessible areas, including across the border in Cameroon. This presents an opportunity to conduct surveillance in these areas to possibly report some of the AFP cases occurring in the inaccessible areas. The lack of health facilities and health workers means that the passive surveillance system cannot function. It also means that the normal system of active surveillance, which is focused on visits to health facilities, cannot function. One respondent stated that some settlements are more than 50 kilometers away from the nearest functioning health facility.

*Respondent 1: "So, all those health facilities in those trapped communities have been destroyed."*

*Respondent 3: "when the insurgents take over a location they destroy these health facilities."*

*Respondent 5: "anytime the insurgents come for an attack, the health facility happens to be one of their major targets where they attack and they cart away drugs and vaccines to their base."*

*Respondent 7: "Yes, no functional health facility....Yes, no any place in Kukawa (district)"*

### Communication

Most respondents stated that there were no means of communication with people in the inaccessible areas and that the cell phone networks had been destroyed. One respondent mentioned that this includes internet and email because it is all based on the cellular network. Other respondents

mentioned that other apps used for surveillance in Nigeria can't be used in inaccessible areas because they require cell phone reception. Several said that Boko Haram destroyed the cell phone towers but one respondent suggested it was the military that stopped the cell phones from working to limit Boko Haram's ability to communicate. Most discussed the challenge that the lack of communication posed in reporting AFP cases and active case searches. One respondent also mentioned that Boko Haram does not allow satellite phones in the areas they control. Satellite phones operate based on satellites rather than cellular towers and therefore can be used in areas without cellular phone reception. Some respondents thought that the military uses some form of satellite communication and, possibly, also some Boko Haram members but this may have been speculation. Some respondents mentioned that in areas along the border with Cameroon, Chad, and Niger the cell phone network from the neighboring countries could be used to communicate. They reported however that the residents in the inaccessible areas are not comfortable using phones to communicate while in the inaccessible areas even if they have cell phone reception because they could be seen as informers against Boko Haram. Some respondents reported that the cell phone network is gradually returning in some of the districts but that the reception is limited to the main accessible town in those districts because only the cell phone towers in the main towns were rebuilt. Several respondents mentioned that nomadic herdsmen could sometimes pass messages when they reach a town because they still go in and out of the inaccessible areas.

*Respondent 3: "one of the most prominent activities of the insurgency is destroying government properties and any property that they feel in their own thinking depicts some western knowledge. Take for example, when they get to a place and they conquer the place, they destroy GSM network in that area. So, communication came down completely."*

*Respondent 4: "in those inaccessible areas, communication structures has been destroyed, so GSM networks (cell phone networks) are not available. You won't be able to communicate on phone in those areas."*

*Respondent 5: "in the whole of the northern part of Borno State, there was no network. Because, the military felt that the insurgents use the network a lot for their own communication. So, for the military to be able to succeed in their operations, they need to put down the network services, so that this will hinder communication between the insurgents."*

## Overall infrastructure

The challenges for the overall infrastructure that were mentioned included poor condition of roads, lack of electricity, and the inability to travel by vehicle or motorcycle. One mentioned that people were going back to live in a “primitive, native lifestyle”. While I did not obtain information on the availability of electricity in the rural areas prior to the conflict, respondents reported that the roads were useable and cell phone coverage was good prior to the conflict. One respondent stated that the conflict-affected areas of Borno were always poorly developed relative to other areas of Borno. Several respondents mentioned that in some areas people use carts pulled by cows or donkeys as transportation. One mentioned that the inability to charge phones and laptops was a problem. Another mentioned the inability to freeze ice packs for shipping specimens to the laboratory. Another mentioned that the challenges in travelling in the inaccessible areas made it impossible for the community informants to attend regular monthly meetings. Several respondents discussed the problem of landmines and IEDs on the roads that make most roads in the inaccessible areas unusable. While the status of overall infrastructure was not the overriding challenge, the issue of insecurity on the roads was seen as a serious obstacle.

Respondent 1: *“the infrastructure generally, not just healthcare, in these inaccessible areas have degraded seriously.”*

Respondent 3: *“In some location they could use vehicle, particularly around Magumeri area. In some places like Nganzai they have used horses. Motorcycles are not allowed” ... “... major roads that should have been tarred or have been tarred in the past and they got bad and they remained bad.”*

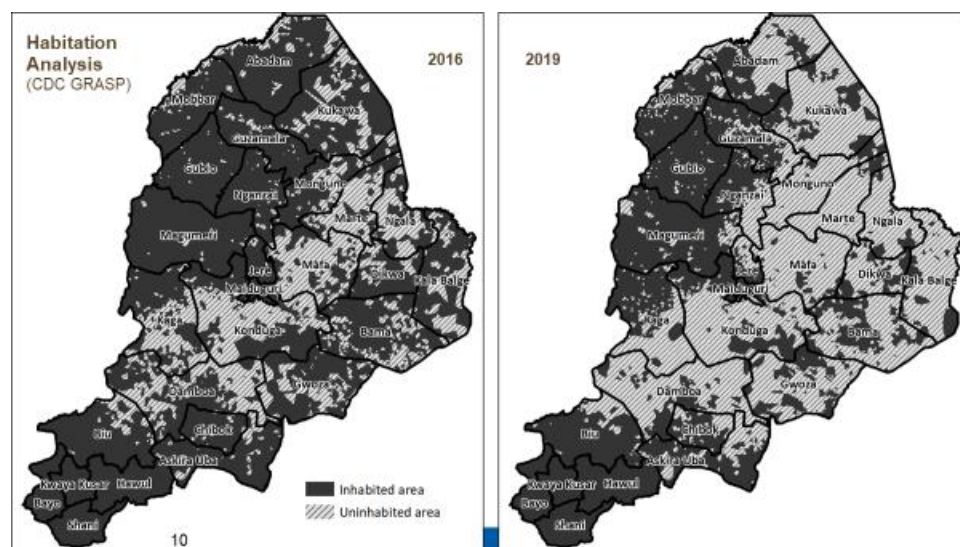
Respondent 4: *“So, yes, lack of electricity is really an issue”*

Respondent 5: *“the issue is most of the areas that are security compromised, they don't have even that power supply.” ... “There might be roads, accessible roads, but because of the security risk involved, people don't really patronize the roads in terms of moving up and down.”*

## Population Movement

Most respondents reported that there were large and dynamic movements of populations with entire settlements being abandoned en masse and that this caused challenges for conducting AFP surveillance. In one district for example, nearly 200 settlements had been abandoned. In another district a respondent reported that most of the district population are now living as IDPs in the state capital. Much of this movement is people fleeing from inaccessible areas to accessible areas (movement of internally displaced people). One respondent discussed the risk of disease transmission caused by a mixing of the populations from the inaccessible areas with the population in the accessible areas. This is particularly concerning because of the low immunity of the population in the inaccessible areas. The timing of the movement is not known and one respondent mentioned going to a settlement and then not finding anyone there when going back to the same settlement later. Some of the movement is also people who are evacuated from inaccessible areas by the military as part of the military's efforts to defeat Boko Haram. Several mentioned the challenge of not knowing the true population. They reported that this causes problems in have an accurate denominator for calculating rates and also for knowing where to go to conduct surveillance (the places that are populated). While the population movement was seen as a challenge, it was not seen as the main challenge. Also, several respondents commented that it is much easier to conduct surveillance once people flee the inaccessible areas and therefore the population movement out of the inaccessible areas is helping to improve the quality of surveillance. One respondent stated that the number of uninhabited settlements increased from year to year since 2016 and that there are currently over 4,000 uninhabited settlements and that over a quarter of the state population is living in IDP camps. I was provided with the map below (Figure 11) that visualized the reduction in inhabited areas from 2016 to 2019. This map, based on satellite imagery analysis, demonstrates the substantial decrease in inhabited areas from 2016 to 2019.

Figure 11: Change in inhabitation in Borno from 2016 to 2019



Respondent 1: “there has been massive... there has been population movement from inaccessible to accessible” ... “So, sometimes these people come out, maybe we are unable to ascertain which direction they go. That is a possibility. So, to have a very correct or exact estimate of the population is challenging.”

Respondent 3: “some populations are trapped there and some have moved out to areas of... where the security is not threatened. And they have formed IDP camps and they are living in those IDP camps in secured areas.”

Respondent 4: “in a situation whereby you have let's say a particular population in a location and you are able to conduct one or three surveillance activities and then after sometime they are either displaced or a new population comes in, so it really gives you like very, very unstable denominator.”

Respondent 5: “So, the population is dynamic. There is a lot of movement, a lot of evacuation, some were being evacuated to camps in their LGA headquarters, some can even be evacuated to an LGA other than theirs. It depends on whether the LGA has an IDP camp or not.”

Respondent 7: “if you look at the habitation, the number of people living there (in Kukawa district) as 2017, it is more than the number of people living there by now.”

## Traumatizing violence

Most respondents reported that the population was very traumatized and that this impacted the ability to do surveillance. This included both a reticence of community members to cooperate when being asked about AFP cases and also reductions in the quality of work by surveillance officers. Several respondents discussed the fear of health workers of going to the inaccessible areas. Death and the risk of a violent death are everyday occurrences in Borno. There is an atmosphere of fear that permeates everyday existence. Families living in inaccessible areas are deeply afraid of cooperating with anyone seen as associated with the government or the secular modern world. People are focused on basic safety and survival and do not see issues of disease surveillance as important. Local surveillance informants are scared to use phones with GIS tracking for fear of being found out by Boko Haram. Work is often interrupted because of fear and danger. Several respondents reported that, despite the trauma, the community informants were still able to do surveillance and that they were highly motivated by the incentives provided to them for doing surveillance work. Respondents reported that there is a desperate need for money and food in the inaccessible areas and this need often overrides the fear and trauma that might otherwise hamper the willingness and ability of locals to carry out surveillance activities.

*Respondent 1: "In Borno State, there is hardly a family that has not suffered the consequences of the armed conflict in Borno State. So, these people are psychological already traumatized." ... "what strategy do we use? How to interact with the people, to interact with the person who is already shattered." ... "You know, with this armed conflict, there is poverty in the land. So, people can beat their trauma with financial inducement. So, this financial... I will strongly believe that this community informants go there not because they like the job but because of the financial implications."*

*Respondent 4: "a common example is you have a health worker whose parents were slaughtered right in his presence and you want him to go back to that same location and conduct surveillance. So, definitely, you will have issues with him going back. Or even if he goes back that quality of service that is expected of him might not be possible. And then, also, a community that has been devastated by insurgency, if you go in to conduct AFP surveillance, most especially you want to ask about whether they have children that are paralyzed by poliovirus or so, they seem not to give in because of that psychological trauma."*

## Malnutrition and disease outbreaks

While respondents discussed the challenges of malnutrition and disease outbreaks for conducting AFP surveillance, they did not place a major emphasis on this as an overwhelming impediment to conducting AFP surveillance in the areas of armed conflict. The main issue related to malnutrition and disease outbreaks raised by most respondents was that some children developed weakness due to malnutrition and that this was confused for AFP by community informants. It is tragic that some children are malnourished to the point of being confused with paralysis and this demonstrates the devastating nature of the conflict in Borno state. Another issue raised by several respondents was that the communities are focused on getting food and are not cooperative with disease surveillance because of their need for food. One respondent mentioned that surveillance officers often wait until after food distribution before conducting AFP surveillance in IDP camps. Another issue raised was that some families would not bring their malnourished children out of the house for surveillance officers to observe because it was not traditionally acceptable to let others see a malnourished child and therefore they were not accessible for surveillance. One respondent mentioned that disease outbreaks can have a positive impact on AFP surveillance because the communities will be more open to disease surveillance when there is an outbreak of a disease that is affecting them.

*Respondent 1: "We have gone to communities where we have seen children who are malnourished and almost dying. They have some tradition somewhere; they don't even bring them out because they are malnourished."*

*Respondent 3: "So, conducting AFP surveillance and surveillance for diseases is impacted by the fact that people will not want to give information directly when you come to them and say OK I am conducting a surveillance of diseases. What they will ask from you is, can you give us food, can you give us other needs that we have, immediate needs before that information is given."*

*Respondent 4: "if they have an outbreak of disease like measles, because of the way measles devastates and kill their children, and if you come to them pertaining other intervention, they seem to agree and allow you to continue to do their activity. So, that's some positive part of it. But also some negative part of it, like malnutrition, sometimes community informant that you sent to identify children with weakness or paralysis, they end up picking a lot of non-true AFP, maybe because of the nutrition status of the kid."*

### Other – rainy season

Several respondents discussed the challenges of movement during the rainy season. This was not in the original conceptual framework and list of constructs but arose as an important topic during the interviews. This was especially pronounced in the eastern part of Borno (Kala Balge and Ngala districts in particular). While the ability of the military to move around and the ability for vehicles to move is severely limited in those areas during the rainy season, community informants are still able to move around on foot or by animal. In other areas travel during the rains was actually reported to be easier such as in the Lake Chad islands or very sandy areas. Some strategies such as use of the military for surveillance were reported to be impacted by the rainy season. The work of the community informants is especially important given that other strategies cannot function in the rainy season. Even for community informants the rainy season leads to reduced active surveillance, slower evacuation of cases, less participation in meetings, and slower feedback on surveillance activities.

*Respondent 3: “during the rainy season the state becomes waterlogged and some locations are muddy. So, that closely reduced mobility around the state. Specifically, even the insurgence mobility is reduced. Even the military operations are reduced during the rainy season, because the geographic area could not allow for vehicular movement during the rainy season. But dry season activities is a little bit easier to move across the state.”*

*Respondent 4: “Our major strategy for reaching those inaccessible areas is using the military or community informants. But during rainy season some of these places, especially places like Ngala, Dikwa, Marte axis and Damboa or maybe some part of Bama and Gwoza, those places become waterlogged and vehicular movement becomes restricted, because heavy vehicles easily sink and they won't be able to access those areas to conduct their regular activities.”*

*Respondent 5: “So, commencement of rainy season affects... it affects... I mean, the effect of the rainy season depends on the location. There are areas where the rainy season is a blessing to them in terms of movement and then there are areas where it's a problem to them in terms of movement because they will be cut off completely, nobody can be able to reach them and they cannot reach other people.”*

### Other – Nomadic population

While the nomadic community was not one of the barriers included in the conceptual framework and constructs for this study, several respondents mentioned that there are nomadic groups that move back and forth between accessible and inaccessible areas as part of their cyclical movements with their cattle and are difficult to track. This was not in the original conceptual framework and list of constructs but arose as an important topic during the interviews. There are many nomadic groups in Northern Nigeria, including Borno State and they move seasonally in search of green pastures for their cattle. Several respondents reported that nomadic groups are generally not targeted by Boko Haram and can still continue their traditional migratory routes even when they pass through inaccessible areas. The respondents mentioned that their movement poses a risk of spread of polio either into the inaccessible areas or out of the inaccessible areas. Because of their movement and their time spent in inaccessible areas these groups are particularly difficult to reach for surveillance.

Respondent 1: *"Because we know sometimes they (the nomads) do pass through inaccessible areas, maybe they may give them a cow and they pass or something."*

### **Strategies**

The second section of the interview focused on strategies for conducting polio surveillance in areas of armed conflict in Borno. The strategies are directly connected to the challenges and are attempts to overcome the barriers described above. I asked the respondents to discuss the strategies that they were using and probed them on other strategies from the conceptual framework. The purpose of this section was to understand the relative value of each strategy and learn more details on how it is being implemented including examples from the field. I also used this section to glean information about other strategies that are being implemented that were not part of the conceptual framework for this study.

### **Community Informants**

The strategy most discussed by the respondents was the use of community informants for inaccessible areas. This strategy involves recruiting lay persons who have access to inaccessible areas and asking them to search for and report AFP cases in the inaccessible areas. The timing of the introduction of this strategy, called Community Informants for Inaccessible Areas (CIAs) was not completely clear but most respondents stated that the strategy was started in 2019. The strategy was made possible by the fact that, despite the inaccessibility of the Boko Haram controlled areas, in some cases some people were occasionally able to go out from the inaccessible areas to visit relatives or go to markets. In 2016 very little was known about this type of access but gradually more was learned about this. Also, as the military regained some territory since 2016 it has become more common that some of the trapped population could occasionally come out to accessible areas to go to the market. The respondents stressed that this is still fraught with danger and that Boko Haram holds family members hostage when they allow people to go out to ensure that they come back. It is a bit murky how the CIAs are able to go in and out of the inaccessible areas. Some were reported to be nomads or hunters or firewood gatherers and that these groups were given permission by Boko Haram to move in and out of the inaccessible areas. Several respondents reported that CIAs negotiate with local Boko Haram members to be able to go in and out for surveillance. Others reported that the CIAs had to sneak out without Boko Haram knowing. Several people mentioned that the informants could be members of Boko Haram but that their affiliation was not questioned. One respondent reported that there are fewer CIAs on the eastern side of Borno state because the conflict is more violent there.

The CIA program was deliberately kept apart from the polio program to minimize the risk to the informants, and special supervisors were recruited from outside the program to manage the informants. The use of community informants was already a strategy being used by the program in accessible areas and this new program was a modification of the strategy to fit the needs of the inaccessible areas. For example, whereas in accessible areas informants with a health background were recruited, the main criteria for selection as a community informant in the inaccessible areas was simply the ability to go to the inaccessible areas and a willingness to do the work. Informants are initially recruited by asking traders in the markets in

inaccessible areas if there are some customers or traders who are coming from the inaccessible areas. The recruitment is then expanded through a snowball approach in which, once a community informant is identified, the informant then tries to identify and recruit other informants. Some informants recruit others within the inaccessible areas to help look for AFP cases in the communities. The informants are given a briefing on AFP surveillance and the case definition for AFP cases and monthly meetings were arranged for the informants to give reports of their surveillance activities. One respondent reported that the CIAs are trained on other reported conditions in addition to AFP. No regular salary or stipend is provided to the informants but they are given an allowance for attending the monthly meetings (1,000 Naira for transportation and 500 Naira for refreshments) and additional funds are made available to them to bring AFP cases that they detect to accessible areas for clinical examination and sample collection. The informants look for AFP cases although the exact activities they do to look for cases are not very clear and depend on the level of security risk in the areas they go to. Sometimes they simply observe the community and other times they directly ask households if they have any paralyzed people in their household. Once they identify an AFP case, they attempt to evacuate the case to an accessible area for investigation (the strategy of evacuation will be described in another section below). The area covered by each informant is also not perfectly clear but most respondents said that the informants often cover 2-3 settlements each. A recent innovation with this strategy is that most informants are now given phones with GPS tracking enabled in order to track the settlements they visit for surveillance (the phones do not need network reception to take GPS coordinates). Several respondents stated that the phones are used because they did not trust the information that the CIAs were reporting on the areas that they visited. The phones can be kept discreetly in their pockets and do not have to be manipulated to capture the GPS coordinates. Still, several respondents reported that some CIAs are not comfortable using the phones because of the danger involved.

A parallel structure of community informant coordinators (not regular polio program staff) was developed to coordinate the work of the CIAs. For each ward a ward level coordinator is recruited and at the district level a district coordinator is recruited who serves as the go-between for sharing

information between the CIAs and the polio program staff (including Ministry of Health staff). Regular meetings are held at the district level (weekly or monthly) but attendance is often low because of the difficulties in getting out of the inaccessible areas to attend the meeting. In some districts the meetings have to be held in neighboring districts because there is no accessible place available within the district. This limits the attendance at the meetings because the distances are longer for the CIAs to attend. Also, monthly meetings of the district coordinators are held in the state capital to review the progress. While the number of CIAs seems a bit fluid, with CIAs dropping out or being added regularly, one respondent reported there is a state database of CIAs and shared an example from the database which seemed well kept and organized. Some informants recruit other people within the inaccessible areas to help them even though they are not listed as official CIAs and do not attend the monthly meetings. The informants share some of their funding with the other people that they recruit to help them.

As of August 2020 it was reported that there were over 1,700 CIAs in Borno State, and increase from 1241 in 2019. There was general consensus that the CIAs were finding AFP cases and reaching most, but not all the settlements in the inaccessible areas. Data provided by one respondent indicated that the CIAs have reached 764 settlements that were not reached by any other surveillance strategy and that there are still 901 settlements that have not been reached with any intervention including the CIAs as of April 2020. A key aspect of the work of the informants is to bring AFP cases out of the inaccessible areas for investigation. This is a challenging and risky process given the danger involved in leaving the inaccessible areas and the lack of transportation. It often required negotiating with Boko Haram for permission to temporarily bring the patient out, paying bribes, and using carts pulled by horsed or donkeys as the means of transportation. One challenge mentioned with this strategy was that the informants would often report AFP cases that did not meet the case definition of AFP. It is likely that they were overzealous in reporting due to the financial benefits of reporting cases. Another challenge was that it was difficult for the CIAs to come out regularly to attend the monthly meetings due to security challenges and also transportation challenges.

Respondent 3: *"So, the first thing is, because of the security situation you wouldn't want to associate the community informant in inaccessible directly to the government. So, persons who are community persons are engaged at the local government level who supervises a ward level community informant supervisors. And then these community informants supervisors at the ward level are the ones who identify these community informants."*

Respondent 4: *"So, once he is engaged his responsibility would be to identify AFP cases and then report to his ward. He has a ward leader for that particular activity. And one of the advantages they we are also taking is that if you are able to identify one community informant let's say from one ward, and he is also tasked with the responsibility of identifying additional community informants within that ward."*

Respondent 5: *"the major strength really lies on the ability of the informants to be able to navigate into these inaccessible areas, to be able to interact with the caregivers without any problem." "It's not all inaccessible settlements has an informant. ... There are some areas where... a particular informant ... cannot be able to visit. So, invariably, there are a lot of settlements in Borno at this point in time that we cannot locate an informant that can be able to work and that can be able to give us information about what is happening in that location."*

Respondent 7: *"even with the community informants some of the settlements were still inaccessible."*

Respondent 12: *"even if you are a terrorist you don't want your child to have polio; you will still allow these guys to carry out vaccination, you will still allow them to do their health work, to carry out their surveillance activities; because, eventually, it is for your advantage."*

This system of community-based surveillance is much more resource-intensive than the regular facility-based surveillance system. It requires recruiting community members to look for AFP cases in all settlements and report their findings. Respondents reported the existence of over 16,000 settlements in Borno, compared to approximately 458 functional health facilities in the state. Given the lack of health facilities in the inaccessible areas however, the community informant system is logical one to implement to ensure that all AFP cases are reported. Based on the responses it is clear that this system has made the surveillance system much more sensitive than it otherwise was. There are several important limitations of this system that were discussed by the respondents, however. One is that the CIAs are usually not trained health workers and may not fully understand how to identify an AFP case. Several respondents discussed the issue of CIAs reporting cases that did not meet the case definition for an AFP case. Related to this is the

financial incentive that the CIAs receive for reporting cases. They may report cases that do not meet the AFP case definition because of the incentives they receive for reporting cases. Another limitation is that there is no way to directly supervise the work of the informants and therefore no way to confirm that they are reporting all AFP cases in the settlements they cover. If there are AFP cases that are not possible to evacuate for example, the CIAs may neglect to report them. Most respondents reported that the CIAs are not able to reach all settlements and therefore there are still some communities that are not included in this surveillance system, resulting in a risk of missed polio cases. It seems that there are currently an insufficient number of CIAs to cover all settlements. For example, in one district a respondent reported that there were 95 CIAs to cover 545 settlements and a respondent from another district reported 45 CIAs to cover 678 settlements.

This strategy was described as a major breakthrough that has greatly improved the surveillance in Borno State. Cases of vaccine derived polio (a form of polio that occurs when the vaccine virus mutates back to a virulent form) were detected through this strategy which gave reassurance to some respondents that cases of wild polio virus would also have been detected had they occurred. Some respondents explained that this strategy would not have been possible to implement at the height of the conflict in 2014-2016 because there was too much violence and because there were no accessible areas in most districts.

### GIS Technology

Almost all respondents enthusiastically discussed the benefits of GIS technology for improving surveillance in inaccessible areas. The two uses of GIS technology that were discussed were the use of satellite imagery to estimate the size and location of the populations in the inaccessible areas and the use of GPS-enabled phones to track the places visited by CIAs for surveillance. Many respondents reported that the use of satellite imagery for estimating the trapped population was extremely helpful. This system is done by analyzing high resolution satellite images of settlements in inaccessible areas of Borno and estimating the inhabitation status based on the pattern of vegetation growth as well as the status of the structures. The method was

developed by comparing images of abandoned settlements and destroyed settlements with images of inhabited settlements and intact settlements in the same areas to identify the visual traits of uninhabited and destroyed settlements. If paths and compounds are covered in vegetation this is evidence that the settlement is abandoned (since paths and compounds are generally free of vegetation because people walk on them frequently). If the structures are visibly burnt or destroyed this is evidence that the settlement is partially or completely destroyed and uninhabited. A GIS specialist respondent reported that over 12,000 settlements are being routinely analyzed using satellite imagery (all the settlements in the inaccessible districts). This strategy was used to estimate the inaccessible population and track progress in reaching the population. It was also used to prioritize areas for implementation of surveillance and vaccination interventions such as the CIAs and the use of military personnel for surveillance. It was helpful in advocating with the military for support in reaching inaccessible populations. One respondent explained that before the use of satellite imagery there was a poor understanding of the population living in inaccessible areas and conflicting information about the remaining population which made planning difficult. Satellite imagery data provided by one respondent indicated that, in 2019, there were 96,000 children under fifteen years of age that were unreached by surveillance in the two largest blocks of inaccessible settlements in northern and eastern Borno.

Most respondents also discussed the use of the GPS-enabled phones for tracking the places visited by the CIAs as well as the RIC and RES teams. One respondent explained that the phones are programmed to automatically record the GPS coordinates every two minutes. A 200 meter buffer is applied to the location of the visit so if a CIA is within 200 meters of the settlement then that settlement is considered reached for surveillance. This system allows the polio program to systematically track the areas covered by the CIAs and prioritize those areas not yet covered. Another system, using a cell phone application, was also provided to the CIAs and allows for collection of additional information including data on AFP cases detected. I was not able to ascertain what percentage of the CIAs were using the application, which is more visible and therefore more risky and also requires a level of

literacy that not all CIAs possess. The advantage of this additional information is that it allows the program to pinpoint the location of detected AFP cases and remove any doubt that AFP cases are being detected from inaccessible areas.

Respondents reported that maps of the surveillance reach based on the phone GPS data are produced at the state level and shared with the districts. It is interesting to note that the districts rely on the state level to inform them of their progress, but the system seems to be working. Some respondents shared examples of the maps (figure 12-14) that are developed by the Borno polio Emergency Operations Center (EOC) data team (comprised of staff from various UN and non profit organizations and the Ministry of Health). The maps provide clear geographic visualization of the reach of the surveillance system and highlight clusters of unreached settlements in Abadam and Bama districts. They also show that, overall, there is a much higher reach in the western part of Borno and much less reach in the eastern part. Furthermore, the maps display the high level of abandoned settlements in eastern Borno.

Many respondents discussed the value of the phones as an accountability tool to ensure that the CIAs are truly reaching the places that they claim to reach. One respondent explained that before the use of the phones some of the places that the CIAs said they were reaching were completely uninhabited which did not make sense. The Nigeria polio program places a strong emphasis on collecting evidence of the activities conducted as proof. It was not evident however that the program is tracking the regularity of surveillance visits and this is an area of the monitoring that could still be refined. The use of the phones, which collect GPS coordinates through satellites and do not require cellular network, was gradually introduced starting in 2019. A new application was launched in April 2020 which is a lighter version of the tracking system. One of the issues with this system that was raised by several respondents is that not all CIAs are comfortable bringing phones into the inaccessible areas because of the security risk. They explained that Boko Haram may consider the person to be a traitor or intruder if they are discovered to be using the phone and that taking in phones is dangerous. None of the CIAs are taking photos for this reason although this would also be very helpful. The reason for the passive system that

automatically records GPS coordinates is that it does not require the CIAs to manipulate the phone and therefore is easier to hide (they can keep it in their pocket or bag without touching it and it will still collect the GPS coordinates). I was not able to get a good estimate of the percentage of CIAs that are using the phones but several respondents said that most or almost all CIAs are now using the phones.

Several respondents also reported on the logistical challenges of providing phones to the CIAs. There are over 1,700 CIAs as of August 2020 and the goal is to provide phones for all of them. Phones also need to be replaced when they are lost or damaged. The phones are kept at the ward level and distributed to the CIAs as they go out for surveillance visits (after attending a surveillance meeting). They need to be charged before providing them to the CIAs and they need to be collected from the CIAs to download the data and recharge the phone after each use when the informants come out of the inaccessible areas. While some solar chargers were procured, problems with keeping the phones charged were reported. There have been times when the GPS coordinates of the CIAs could not be tracked because the phones were inadvertently switched off or the battery had run out. For districts without cell phone network the downloading of the data requires bringing the phones to the state capital which is costly and time consuming. Because CIAs have challenges with transportation and movement, there is often a lag in receiving the phones and downloading the data.

One respondent reported that they have documented surveillance activities in 4,095 inaccessible settlements including 621 settlements that were not previously reached for surveillance since the height of the insurgency in 2014. The respondent also reported that there are still around 1,000 settlements that have not been reached for surveillance since 2014. Recently the program has also started analyzing the number of times each settlement is visited although this is not yet being reported as a performance tool. They also use the GPS tracking data to estimate the size of the population that has not been reached for surveillance by combining it with the satellite imagery estimates of population size per settlement. As stated above, in 2019 there were over 97,000 children under fifteen years of age still unreached for surveillance in the two areas with the largest number of unreached settlements.

Respondent 1: *"We use satellite imagery to estimate population, population usually in trapped areas. They use geographic structures on ground or structures on movements and, how do you call it, the pattern of the growth of the grass in the areas, house destruction and movement, pass and others to determine population and they estimate this population based on the type of housing in those areas and the movement around there in areas where they have maybe too much of tall grasses and all that. It means movement has not been taking place. So, that is what they use. It is just an estimate of the population in trapped areas. And that has really been helpful in the programme."*

Respondent 4: *"And so, in some of the places we have been able to use... to give them smart phones in those areas, to be able to track their movement. But in other areas the Community Informant in Inaccessible Area will tell you that they will not be able to carry any mobile device on them, because if they are caught they will be penalized with that."*

Respondent 5: *"And then the GIS, we use the GIS map for our advocacy to the military and to the informants in the form of training. When we are sensitizing them, we now display the map before them asking them of... showing them the habitation status of the communities around them, then probing further to know whether they know about the existence of such communities."*

Respondent 7: *"there is VTS that tracks the movement of this surveillance reach by settlements. And that is the reason why... that's how we knew that there are settlements that are left for surveillance."*

Respondent 16: *"so being able to use the tracking phones, uh, to add another layer of accountability, I think has been extremely valuable. Um, So you can make sure that if somebody says they reach, they reached a settlement and did vaccination there. Well, you can see. Alright. Did you actually go there? Did you actually spend enough time to do what you said you did?"*

Figure 12: Map of settlement reach by CIAs in Bama district, April 2020

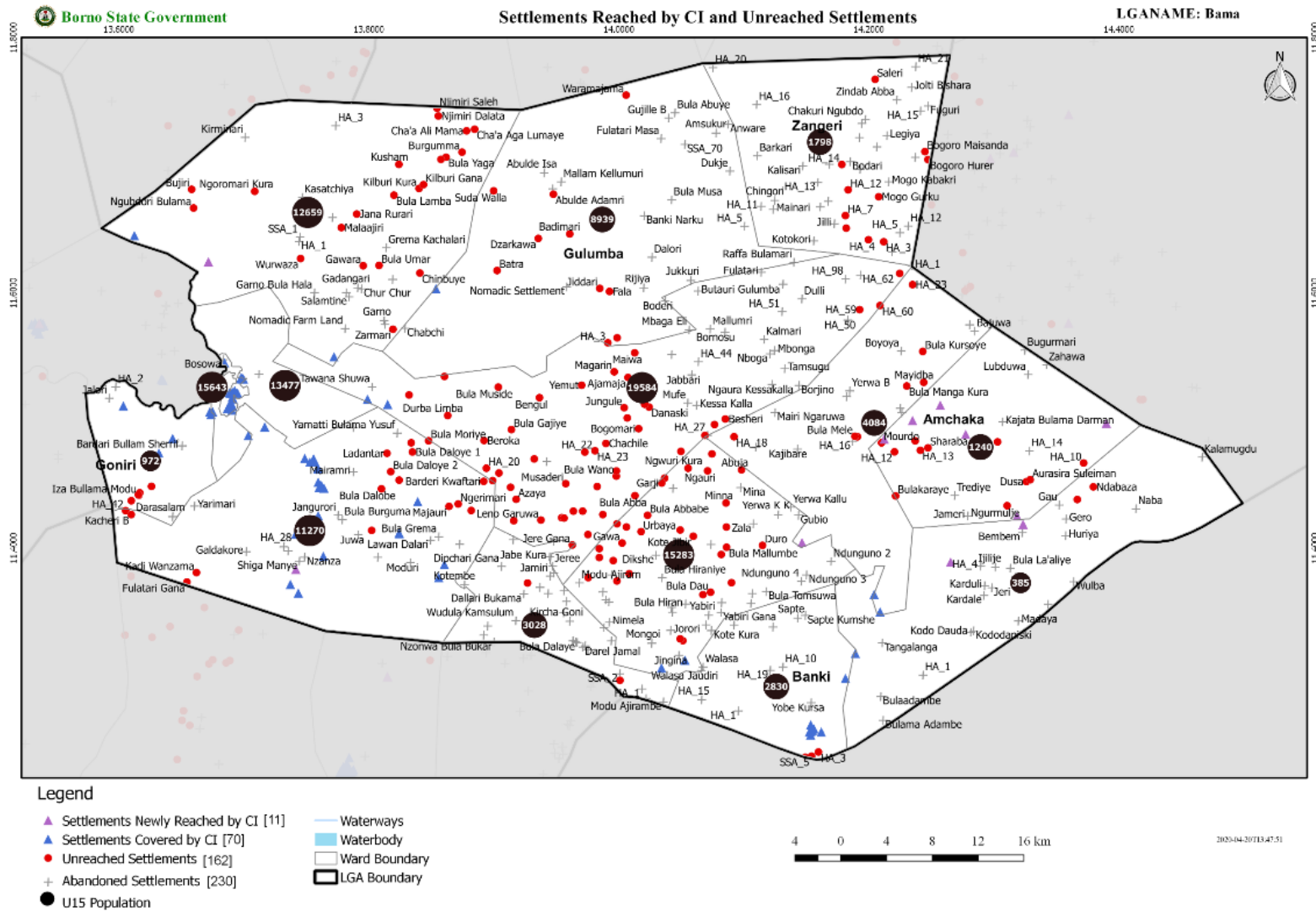


Figure 13: Map of settlement reach by CIAs in Abadam district, April 2020

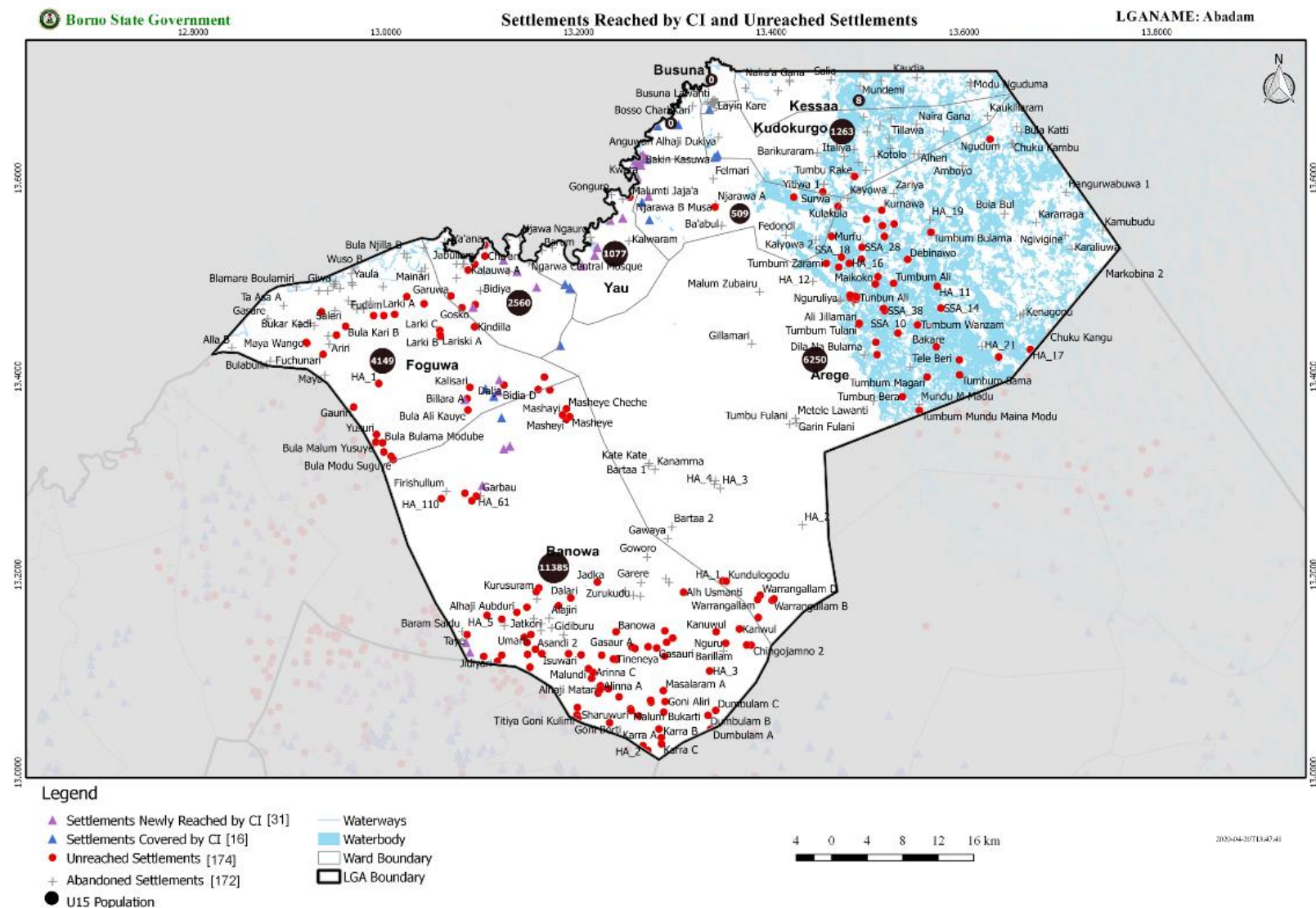
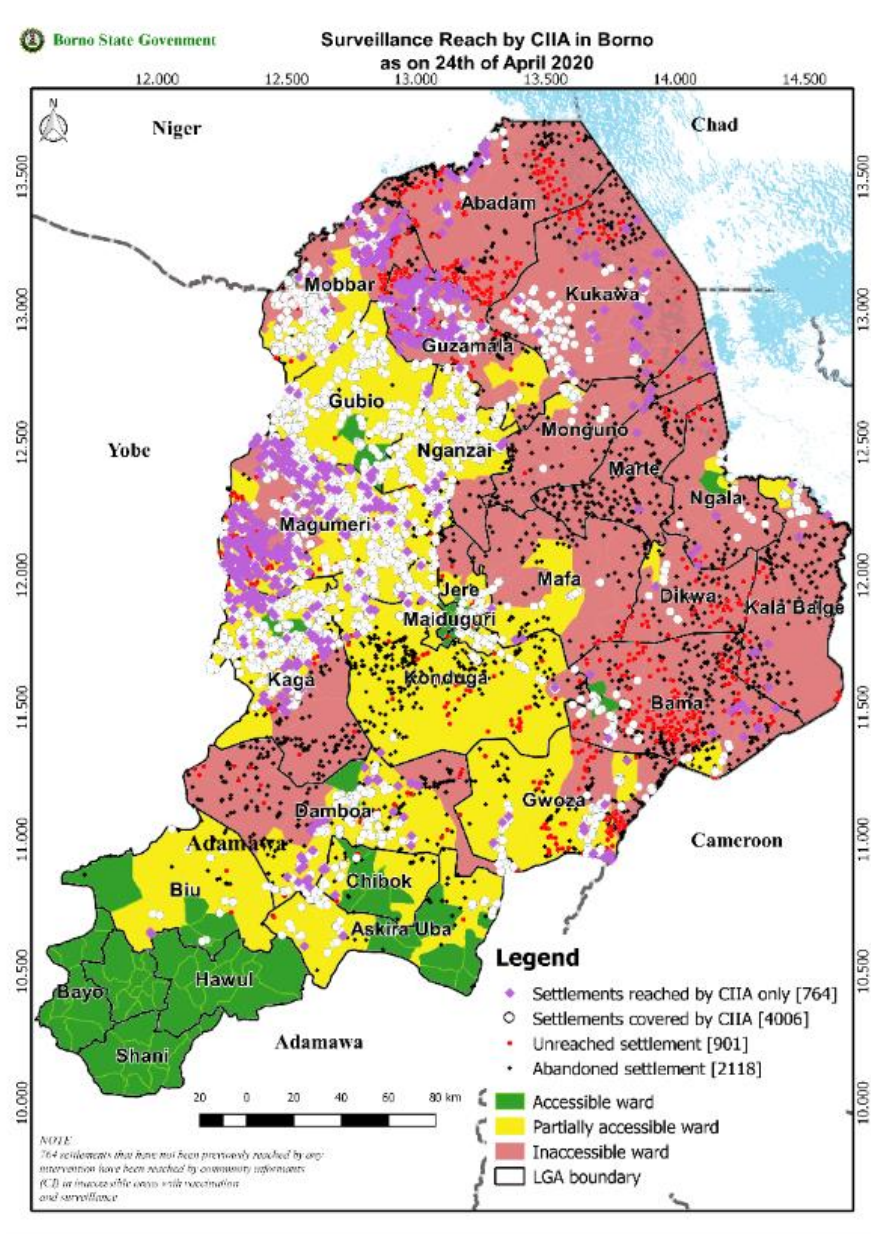


Figure 14: Overall map of surveillance reach by CIAs, April 2020



### Collection and testing of specimens beyond AFP cases

In 2016 cVDPV was detected from a healthy child who was a contact of a wild polio virus case in a conflict-affected district of Borno. This provides evidence that the strategy of collecting specimens from healthy children can detect polio viruses in the context of the Borno conflict. Because the healthy children do not have any symptoms of polio however, it is something akin to looking for a needle in a haystack. Nevertheless, respondents felt that this strategy was important and useful for improving surveillance quality. Most respondents reported that stool specimens are collected from healthy children from inaccessible areas. This includes collection of specimens from children who recently arrived in IDP camps from inaccessible settlements. Most respondents did not give details of this, but one respondent reported that 10% of newly arrived healthy children are sampled. Some respondents reported that this strategy is very helpful in ruling out the presence of polio, but others did not think that it added much value since there is a low likelihood of detecting polio in healthy children even if it is circulating. Respondents also reported that samples from children who were identified by CIAs as AFP cases and brought out of inaccessible areas but then determined not to meet the case definition for AFP were still collected and tested as healthy children samples. Respondents also reported the policy of collecting stool specimens from 3 healthy contacts of each AFP case detected in the inaccessible areas. In practice however, respondents reported that it is difficult to do this, and many families are not willing to consent for specimens to be collected from their healthy children. This is understandable given the risks involved in bringing these children to an accessible area for the specimens to be collected. Several respondents reported that cases of vaccine derived polio virus have been detected from samples of healthy children in inaccessible areas, and therefore this strategy is useful in ensuring that there is no undetected polio in the inaccessible areas. One respondent reported that environmental samples were once collected from areas near inaccessible areas. Environmental sampling is a key component of polio surveillance in places where it can be implemented. It requires a location with running water that is contaminated with sewage and, because of the low population density and the lack of a central drainage system in the towns and villages, the program was not able to identify suitable environmental surveillance sites

outside of the state capital in Borno state. Two respondents reported that RES and RIC teams also collect healthy children samples in areas that have not reported cases. One respondent also reported that healthy children stool samples are collected from 10% of the children of nomadic groups within 10 days of arrival in an accessible area from an inaccessible area. Two respondents reported that vaccine derived polio was detected through healthy children stool sampling and that therefore the strategy is helpful in detecting polio. They believed that if wild polio was still circulating it would have been detected through the healthy child sampling.

*Respondent 3: “when the plans were made after the outbreak in 2016, the surveillance group in the state looked at it and said, we had some healthy children who were contact of the cases that turned out to be positive were circulating virus and then even for a WPV. And so from that point on the design to collect healthy stool sample from children arising in the IDP camp was initiated.”*

*Respondent 4: “So, you see, through the healthy child stool sampling sometimes you will be able to find cases of VDPV in those inaccessible areas.”*

#### Collaboration with security forces

Collaboration with security forces was discussed in detail by most respondents. The two strategies described were called Reaching Every Settlement (RES) and Reaching Inaccessible Children (RIC). RES is a strategy in which civilian security forces either accompany surveillance officers or go out on their own to look for AFP cases and vaccinate children against polio in partially accessible areas. These are areas that are still very dangerous but are not completely under Boko Haram control and possible to visit with civilian security support. The civilian security force is called the Civilian Joint Task Force (CJTF) and is comprised of community members who have volunteered to protect the local communities. Figure 15 displays a photo of a CJTF team. They are typically armed but with inferior weapons to Boko Haram or the military such as inefficient locally made rifles or pump action rifles rather than automatic rifles. RIC is a strategy in which military personnel are trained to vaccinate and look for AFP cases when they go to inaccessible areas. This strategy is done exclusively by the military without any polio staff accompanying them. Respondents report that both these strategies were

helpful in expanding the reach of the AFP surveillance system in the areas of armed conflict. The RES system is helpful in reaching some security compromised areas but cannot be used to reach the fully inaccessible areas controlled by Boko Haram. Respondents reported that RES is not operating in Bama, Guzamala, Ngala, and Kukawa districts because it is too dangerous. One respondent reported that a CJTF was killed while working on polio. Respondents indicated that neither of these strategies were able to reach most settlements in the inaccessible areas. Challenges with the RIC system included that the polio program has little influence over the movement of the military, the lack of regularity of the visits, frequent changes in commanding officers which requires fresh advocacy to convince the military to cooperate with the polio program, the difficulty in monitoring the work of the military, and the reduction in military operations during the rainy season. One respondent reported that cases detected by RES and RIC were often detected late (over 14 from the date of paralysis onset) because the visits are not regular. Several respondents reported that reporting of AFP cases by the military was minimal because the visits are infrequent and they don't spend much time in each settlement when they conduct their operations. The military often evacuate everyone from settlements they reach and relocate them in IDP camps. While it is unclear if this is done voluntarily, it makes it easier for the polio program to conduct AFP surveillance. Several respondents reported that the population often flees when they see the military coming, which would make it ineffective for the military to conduct AFP surveillance once they reached the settlement. The military also inform the program when they evacuate populations so that surveillance can be conducted among the new arrivals in the IDP camps.

Figure 15: A Reaching Every Settlement (RES) civilian Joint Taskforce (cJTF) security team



Respondent 1: *"This is a kind of military intervention where the military they visit a settlement sometimes to evacuate and to vaccinate people who live there and also to actively look for AFP cases." ... "So, they may go to one area and they may.... There is*

*no clear consistency as I mentioned to you earlier. They would prioritize security situation over AFP surveillance and polio vaccination."*

*Respondent 3: "So, we don't have direct influence on where they will go. We know they will go out, we know they will conduct operations, we know they will regain some communities, but where these communities, the location and what will happen is not in our control. However, the military is provided with list of locations that have been prioritized based on the habitation status of the settlements in the insecure area. So, it's not regular. It happens irregularly."*

*Respondent 5: "And once a military personnel is sighted from a distance all the population will disperse and run away, you will not be able to get their attention and then talk to them."*

*Respondent 12: "The community informants have been able to gain the trust of the community. So, even if a child of a terrorist needs to be evacuated, these guys can still go ahead and do the vaccination, because they have been trusted, they cannot be attacked. But if a soldier, a military man approaches those communities, the terrorists or the bad boys can engage them in a fight."*

#### Profiling of displaced persons

The strategy of profiling displaced persons was described in the National Polio Eradication Emergency plan which described this as a system to collect systematic information on children coming out of inaccessible areas as displaced persons. Around half of the respondents (8/15) discussed efforts to gather information on recent arrivals from inaccessible areas. These efforts to "profile" the inaccessible population are done by polio program staff in IDP camps and transit areas near inaccessible areas. The respondents reported that this system helps learn about people leaving the inaccessible areas and helps in estimating the size of the population remaining in the inaccessible areas. The recent arrivals are asked where they came from and whether they saw any AFP cases. The International Organization on Migration (IOM) is also profiling new arrivals from inaccessible areas and sharing their data with the polio program but they are not asking about AFP or vaccination status. One respondent mentioned that surveillance among the

newly displaced population has been helpful in detected AFP and polio cases that occurred in the inaccessible areas and, because of the high level of displacement, it provides some level of assurance that circulation in the inaccessible areas is not being missed.

Respondent 1: *“So, we setup this profiling centers that assess the health condition and vaccination history of people coming from inaccessible areas.”*

Respondent 3: *“So, when a person is coming out of an inaccessible area or with their children, when a family is coming out with children, these teams are the first contact with the person coming out of the inaccessible areas. So, they conduct surveillance.”*

### Evacuation

Most respondents (12/15) discussed the strategy of evacuating AFP cases for investigation. The AFP surveillance system requires that a clinical examination be conducted on each AFP case and that 2 stool specimens be collected within 14 days of the onset of paralysis. The clinical examination must be conducted by a qualified health worker and the collection of stools specimens must also be done according to the required procedure including filling of forms and ensuring that the specimens are kept at a cool temperature (2-8 degrees Celsius). Given that the CIAs are typically not health workers and often not literate and that there is no electricity in the inaccessible areas, the most feasible approach for conducting the investigation is to attempt to bring the patient out to an accessible area. To this end, the program has pre-positioned funds at the district level to cover the costs of evacuating AFP cases and paying for their meals, lodging, and medical care. Often the cases are brought out of the inaccessible areas on foot or in a cart drawn by a horse or donkey. Some parents are not willing to have their child evacuated. The CIAs need to overcome resistance and fear from families of the AFP cases of the risk and danger involved and the CIAs offer food and medical care as an incentive to the families to motivate the families to allow their child to be evacuated. Generally a family member accompanies the AFP case when they are evacuated. Generally there is some negotiation with Boko Haram to allow the case to be evacuated and family members are held hostage to ensure that they return. The respondents reported that it can

take a number of days or weeks to evacuate a patient for the investigation and this can result in some of the investigations being done beyond 14 days from the onset of paralysis have passed. In this case, a follow-up examination of the patient is needed after 60 days to rule out residual paralysis (which may indicate a polio compatible case). The follow-up examination requires the patient to be evacuated a second time and respondents reported that the AFP cases were often difficult to find and bring out again. Respondents reported that it is often difficult to evacuate AFP cases and that it is sometimes not possible to evacuate them either because Boko Haram will not let them leave or because the family of the patient won't let the patient leave. One respondent mentioned 4 cases that were not evacuated. It was difficult to get definitive information on the number of AFP cases that were not evacuated and reported and there does not seem to be functioning system to record these cases. The CIAs also attempt to bring 3 contacts of the AFP case out for stool collection at the same time as the AFP patient. This is to increase the likelihood of detecting the poliovirus even if it is not detected in the AFP patient. Several respondents mentioned however that it is very difficult to convince parents to allow their healthy child to be evacuated for stool specimen collection. One respondent reported that for cases that cannot be evacuated the CIAs attempt to collect specimens and bring them out for testing. This strategy has some limitations in that it means that a qualified health worker is not able to do the clinical examination of the case and fill in the case investigation form. It is also challenging to bring in a stool specimen carrier and ice packs and ensure that the samples are in good condition and viable when they are brought out of the inaccessible area.

In summary, the strategy of evacuating AFP cases from inaccessible areas for clinical investigation and specimen collection is vital to the surveillance efforts in the inaccessible areas. Without this it would be very difficult to collect specimens from AFP cases and the quality of clinical information about the cases would be very poor (including many cases that did not meet the case definition for AFP). This strategy is fraught with danger given the risks of travel in the inaccessible areas and the incentives provided to the families of the AFP cases including lodging, meals, and

medical care, likely play a large role in convincing the families to agree to the evacuation. Nevertheless, it is not clear if all cases are evacuated and there does not seem to be a good system for recording information about AFP cases that could not be evacuated.

*Respondent 1: "we have had pocket of cases as you described where it has been difficult, that we know there are cases but we are unable to reach." ... "some of them may refuse to come out"*

*Respondent 3: "I have heard of a case in Kala/Balge and um... it's best for my memory that I can remember it, that Kala/Balge case. The case could not be evacuated. And that case I think it was lost to follow-up." ... "the cases evacuated is kept for 48 hours before samples were collected. Once you leave the case to go out, to go back to the inaccessible locations, once you come back you'll want to do the 60-day follow-up you have to go back to evacuate the 60-day follow-up report. So, there are issues with 60-day follow-up in cases that turn out to require 60-day follow up."*

*Respondent 4: "So, sometimes it's easier for them to come out and being that it may not take long time, maybe a day or two they will be able to come out, they will be able to evacuate and then the activity be conducted. But sometimes it lasts longer than that. Because sometimes the insurgents themselves would have to give them like an authorization saying that OK you can now go and treat your children until you are fine and then come back. So, if the negotiation took longer they may not likely come out immediately. And in such situation you will sometime see some of them reporting late and resulting to inadequate cases."*

*Respondent 5: "the same informant that identified the case is being given transport money to transport the patient to the LGA headquarters which is accessible and safer for people to come from outside for the investigation. So, he is being supported by given transport money, some token for his logistics. And at the end of the day, the caregivers that arrive, they are normally being given accommodation and then they are being fed in the LGA headquarters pending when the investigation is over then they go back."*

### Nomadic Population

While the nomadic population was not part of the conceptual framework and constructs for this study, 6/15 respondents discussed working with nomadic communities as a strategy for improving surveillance in the inaccessible areas. They explained that there are nomadic groups that pass between inaccessible and accessible areas and that the nomadic population is generally left alone by Boko Haram. Several respondents mentioned that work is being done to track the nomadic population. Traditional nomadic groups in Borno state move seasonally with their herds in search of pasture.

Despite the dangers, some of them still pass through inaccessible areas during their nomadic cycles. One respondent mentioned working with veterinarians to access the nomadic population. The same respondent however felt there is a need for a better system for reaching the nomadic population that passes through inaccessible areas. Another respondent mentioned that a system exists to identify nomadic populations with access to inaccessible areas. Several respondents mentioned using nomads to gather information about the inaccessible areas and as CIAs because they are able to go in and out of the inaccessible areas and can access some areas near Lake Chad that other CIAs cannot reach. A third respondent in a district with a large nomadic community (Kukawa) said that nomadic people (or people disguised as nomads) were engaged as community informants because Boko Haram generally does not attack the nomads. He also said that they use nomadic Fulani leaders (Ardos) as coordinators of the community informants. He said that these nomadic leaders naturally learn about health problems within their communities such as paralysis and are therefore in a good position to report AFP cases.

*Respondent 1: "The only thing I might like to add is the nomadic population. You know, the involvement of nomadic population in inaccessible areas. Because we know sometimes they do pass through inaccessible areas, maybe they may give them a cow and they pass or something. So, it's to involve them or build surveillance system using nomadic population who pass through inaccessible areas. Yes, I think that would be something we need to build right now. That is not functioning now, but something we need to build."*

*Respondent 7: "we do meet on monthly basis in Monguno LGA, where these community informants will come. And they are mostly nomadic. So, they do come from market on Saturdays, so we use this opportunity for us to meet with them. So, because of the distance not all the community informants will come for the meeting. You know, because of the security situation in our... they just took themselves as nomadic. And most at times the armed conflict groups will not attack those who are nomadic, mostly."*

#### Other

Some other strategies came up during the interviews. Two respondents discussed the potential utility of conducting surveillance in health facilities that are near the inaccessible areas because some of the inaccessible population may seek services there. This includes health facilities in

neighboring countries including Niger and Cameroon. One respondent discussed conducting regular meetings with health workers from Cameroon to share information on disease surveillance and reported AFP cases. One respondent mentioned that funds are positioned with the district surveillance officer to enable rapid payment of the costs associated with evacuating patients from inaccessible areas.

*Respondent 1: “For instance, in Abadam, for example, there is a health facility in Bosso. Bosso is in Niger Republic, but it's very, very close to Abadam. So, we know for sure that sometimes these insurgents go to those clinics for help.” ... “I have witnessed a case actually where a Boko Haram member came out with the wife and the child to seek medical help in a clinic in Jere local government. So, they come, yes, and they come out sometimes with the civilian population. They are all civilian, but they come out with the normal civil population.”*

*Respondent 3: “the health facilities across the borders of Niger Republic, Chad, and Cameroon became useful to some of the trapped populations. So, they go across the borders and access healthcare on that side. But that also is something that the surveillance system try to explore to see if cross border collaboration could impact on the surveillance system itself.”*

*Respondent 5: “all the inaccessible areas, WHO give them a fund that is called a basket fund, that is purely for surveillance for inaccessible area. And the rationale behind giving them that fund at the LGA level is to ensure that cases are attended promptly, so that they don't fall back... they shouldn't just be falling back to the state for any request. They are given the power to utilize that fund for activities in inaccessible areas and then give retirement after the work. So that it will save time. So that because if the funds are not ready, in case if the sample needs. I mean, some money needs to be paid for the sample to be transported from a very longer distance. So that that is not being delayed. The money is in the custody of the DSNO (district surveillance officer). The DSNO gives out the money instantly to the team to now collect the samples.”*

### **Monitoring systems**

The next section of the interview tool focused on systems for monitoring surveillance performance in the inaccessible areas. For several reasons, the monitoring systems traditionally used for polio surveillance are not well suited to the areas that are inaccessible due to conflict. One reason is that program supervisors cannot physically go to supervise the work in those areas. Another reason is that the destruction of the health infrastructure means that regular reporting of surveillance data from health facilities is not possible. A third reason is that the small populations and the continuous population movement make it difficult to use the traditional indicators in a meaningful way for the inaccessible areas. For example, the non-polio AFP

rate is expected to be above 3 per 100,000 children under the age of 15 years in Nigeria. However most of the wards in the inaccessible areas have small populations and therefore cannot be expected to achieve this rate. In addition, an assumption behind the rate is that AFP surveillance is taking place uniformly. In the context of Borno, where certain areas are not accessible, this assumption is not valid. Therefore, if the rate is achieved for a particular district, the program may come to an incorrect conclusion that this means that polio transmission can be ruled out in the district. The purpose of this section of the interview guide was to gather more information about how the program is being monitored and what innovative systems have been put into place to overcome the limitations of the traditional monitoring system for the inaccessible areas.

#### Tailored surveillance performance indicators

The main indicator mentioned by all the respondents was the GPS tracking of the movement of the CIAs. This is the main system being used to monitor the progress in reaching inaccessible settlements with surveillance activities. There was a great deal of enthusiasm for this indicator among the respondents. Some respondents also discussed the limitations of the indicator in that it does not monitor the quality of the work the CIAs are doing in the inaccessible areas and only provides evidence of where they have been. Respondents explained that this GPS tracking system allows the tracking of the number and location of the settlements being reached by the surveillance system (including CIAs) and the number and location of the unreached settlements. Coupled with the population estimates from the satellite imagery, it also allows the program to track the size of the population that is not covered by surveillance. Several respondents also mentioned that the number of times that settlements are reached for surveillance is being tracked. Because the assumption that surveillance is conducted uniformly across a district is not valid, this level of information about where searches are carried out for AFP cases is a very effective way of documenting the sensitivity of the system and the areas of continued risk. One respondent mentioned that a limitation of this indicator is that there is often a lag in receiving and uploading the data from the phones. Several respondents mentioned that the number of inaccessible settlements reached by CIAs that were not reached by any other strategy is being tracked. The major challenge with this

system, as reported by several respondents, is that the GPS data does not provide information on what the CIAs did when they reached the communities and it is possible that, despite going there, they still missed AFP cases or chose not to report some cases because of the risks involved. One respondent also mentioned that attendance at the monthly CIA meetings is tracked and that attendance is used to assess whether some of the CIAs are inactive.

Many respondents also mentioned tracking the number of AFP cases reported and investigated as a main indicator for the inaccessible areas. One respondent mentioned that the proportion of notified cases that are investigated is monitored. This seems very useful in monitoring the frequency of cases that are identified but not investigated but I was not able to find concrete information about the implementation of this system. One respondent also explained that this system allows for precise mapping of where AFP cases were detected which provides evidence of which areas have detected cases and which areas have not detected cases. This was a problem before the collection of geocoordinates in the inaccessible areas when it was not possible to precisely identify where the case occurred.

Several informants mentioned that the state polio emergency operations center regularly reviews the data on surveillance in the inaccessible areas. The GPS data are being mapped and district level maps are produced for each district to track their progress in reaching the inaccessible settlements and to prioritize settlements for surveillance. The maps include surveillance reach at the settlement level based on all strategies (CIA, RES, and RIC). The reach by settlement is analyzed according to whether it is sustained reach (regular and continuous) or sporadic and irregular. Surveillance by CIAs is considered sustained whereas surveillance by RIC is considered sporadic. Two respondents mentioned that the AFP data are grouped by clusters of districts in the inaccessible areas for analysis of districts with larger populations so that the non-polio AFP rate will be more meaningful (the rate expected is 3 cases per 100,000 population under 15 years and many of these districts have very small populations). Several also mentioned that the data from inaccessible areas are analyzed separately from the data from accessible areas to be able to more closely track the progress in the

inaccessible areas. The stool adequacy rate is being monitored for the inaccessible areas to determine what percentage of cases had stool specimens collected in good condition within 14 days of paralysis onset. Several respondents gave detailed data on the total number of inaccessible settlements, the number reached for surveillance, and the number of CIAs and also shared examples of the maps and analyses being produced (Figure 16). One respondent also mentioned that the inaccessible population estimate is produced every two months to account for changes in population based on movement. Another respondent reported that IOM produces a weekly reported on population movement called the Emergency Tracking Tool and that this report is shared with the polio program. Several respondents mentioned that the identification of VDPV is a useful indicator that surveillance is effective and capable of detecting polio virus, and that wild polio would have been detected if it had been circulating. Respondents also mentioned categorizing unreached settlements according to the likelihood of reaching them for surveillance in the near future.

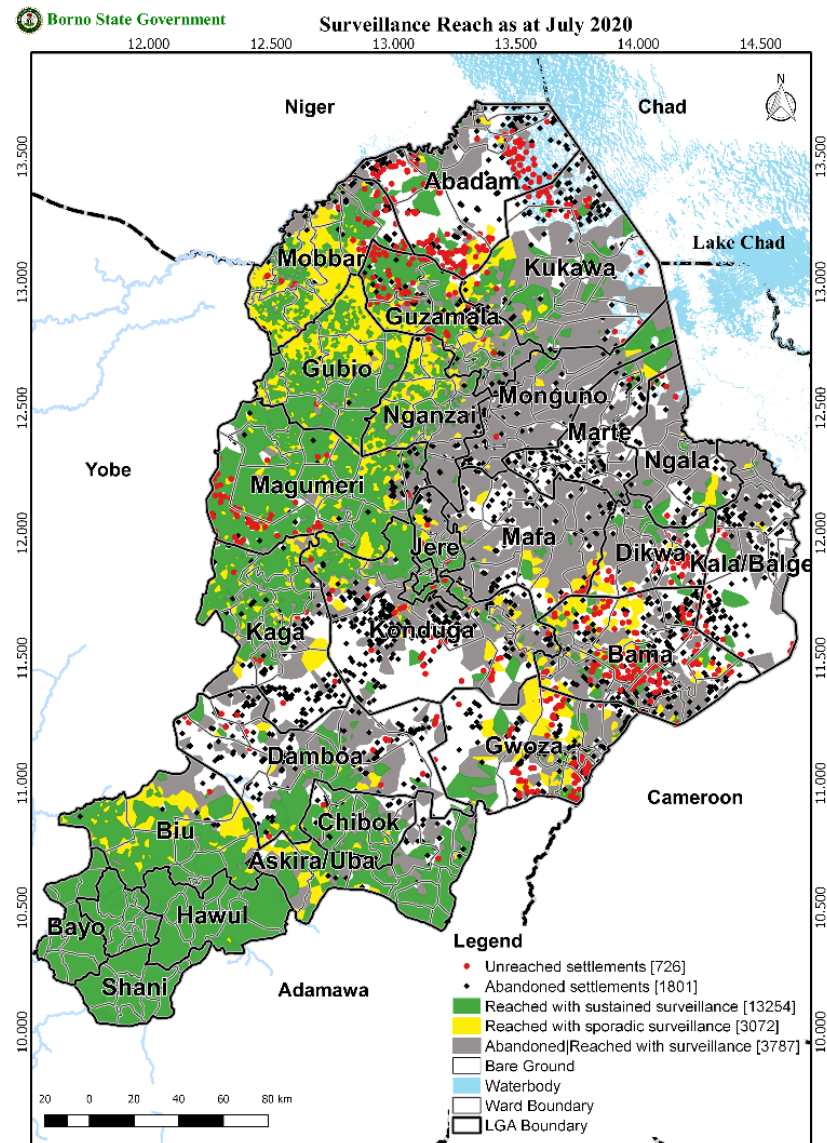
*Respondent 1: "Let's say we have different unreached population, we grouped the different unreached population by where we think there will be greatest impacts and where we think to reach this area is also better to reach this entire area as a whole. So, this clustering is basically a type of grouping, grouping of of inaccessible population for intervention."*

*Respondent 3: "The most important tool is the Geo-Location Tracking Systems, which I call the GTS. That shows that the person has been to a settlement. He cannot be somewhere else and then the geo-location system would show somewhere else. So, the next monitoring system is the geo-location monitoring system that is being used to show that they have visited the community itself."*

*Respondent 4: "So, the major challenge is most of the monitoring is not physical monitoring where a supervisor can go with his checklist in the settlement to conduct monitoring"*

*Respondent 6: "So, as at while we were analyzing this data, that was in February (2020), we had community informants, they had visited 4,094 settlements to carry out surveillance and vaccination activities. So... And I am also... the call out here was only 621 of these settlements have never been reached by any intervention."*

Figure 16: Map of surveillance reach produced by the Borno EOC, July 2020



### Tailored surveillance quality assessment tools

In addition to regular monitoring of performance indicators, periodic quality assessments or evaluations are also very useful for understanding the quality of a surveillance system. A minority of respondents discussed the quality assessment tools (4/15). This may be because, generally, only higher-level staff are engaged and fully aware of these types of assessments. They all mentioned that the program periodically conducts reviews or assessments in which outside groups come in to do the assessment. Some examples are outbreak response evaluations, surveillance assessments, and a review by members of the African Regional Certification Commission for polio eradication. The reviews included interviews with staff, reviews of tools and data, field visits, and in-depth analyses. One respondent gave his own assessment that, after looking for wild polio virus using all the strategies described here and not finding any wild polio virus, he felt confident that there wild polio no longer exists in Borno state. Indeed, the African Regional Certification Commission for polio eradication recently came to the same conclusion when they declared Nigeria and the entire African Region wild polio virus free in August of 2020.

*Respondent 3: "Yes, the evaluations, like outbreak response evaluations or assessments has been conducted, surveillance systems evaluations and assessments has been conducted, the ARCC visit has been conducted. Basically, they come around and listen to what people involved directly, staff involved directly in the surveillance system have to say about the surveillance in the inaccessible areas. They look at the tools, they look at how data is collected, how it is being shown to improve the surveillance system and then provide recommendations for the state on how to improve on surveillance system itself."*

*Respondent 4: ""So, I think most of the things we do is we do those in-depth analysis to understand the surveillance in the inaccessible areas. And that is why most of the time you see the information from surveillance in inaccessible areas are treated as disaggregated information not combined with the larger state, so that in-depthly we can sit down and assess and then evaluate the performance of surveillance in those inaccessible areas. "*

### **Collaboration and information sharing systems**

The last section of the interview tool focused on collaboration and information sharing. The reason for this was to better understand what mechanisms are in place for sharing information and collaborating both between polio partners and also between the polio program and the larger humanitarian response effort in Borno State. This is to explore whether there are opportunities that could be capitalized on to benefit from information or programs that other agencies are implementing. 11/15 respondents discussed collaboration and information sharing systems. They all mentioned the polio emergency operations center (EOC) as a place for collaboration and information sharing and said that other agencies outside of polio attend these meetings, including the International Organization for Migration (IOM). The EOC meetings are attended by the Ministry of Health and all partners involved in the polio response. Some examples of collaboration reported include training clinicians from other agencies in AFP surveillance and reporting, working with food distribution agencies such as the Food and Agriculture Organization, the World Food Program, and Action Against Hunger to conduct surveillance during food distribution, working with veterinarians, and sharing polio data on inaccessible populations with other organizations. The collaboration efforts were focused on displaced populations living in accessible areas rather than inaccessible populations. Several respondents reported that there is a regular partner coordination meeting called the Health Partners Coordination Meeting that polio staff also attend. At the district level 3 respondents reported that there is good collaboration between different agencies working on polio eradication including WHO and NSTOP but that there are no other humanitarian organizations that are working in the inaccessible areas. One respondent stated that there is sometimes a problem of collaboration and that the polio program is not always aware of the work of other sectors. Several respondents discussed the benefits of collaboration including AFP cases reported by other organizations, sharing information on population movement, and conducting surveillance and vaccination during food distribution. Only one respondent stated that there is another organization that has some access in inaccessible areas but when

pressed for details it seems that the organization (Red Cross) did not actually have the ability to work in the inaccessible areas. Several respondents reported that data from the polio program is being shared with other agencies is being used by them in their assessments.

*Respondent 1: "Yes, there have been tremendous amount of benefits working with different organization. Like, we did a program with this organization with vet where we vaccinated animals and nomadic population. It has a benefit to the program. And then with these guys who provide food. You know, as I mentioned earlier! These guys who provide food, we now program our activities together in such a way that it looks like one activity."*

*Respondent 3: "Yes, so there are some organizations directly we have been able to collaborate with. Like when food is distributed by organizations, the polio program team are stationed in those locations and they are able to conduct AFP surveillance and other polio program."*

*Respondent 4: "So, the state have... they have a group that... health emergencies group that meet on regularly basis, twice in a month. So, that platform serves as the primary platform where information is disseminated to other partners that provide services to those populations. And then during that time the polio program also take advantage to integrate some of its activities with other collaborative partners."*

### **C. Comparison of Interview Findings Across Groups**

I compiled the summary data by groups of respondents and compared the responses to look for similarities and differences between groups in the information provided. The groups were as follows: state level respondents, district level respondents, data managers, nonprofit organizations, Ministry of Health, NSTOP, CDC, WHO, and other UN organizations. Table 6 below gives a breakdown of the number of coded segments by group. Different groups of respondents provided different insights but generally did not contradict information provided by other groups. The district level respondents generally provided more granular information about the conditions in the field which helped to better understand the situation as well as the differences between districts. For example, some districts are completely inaccessible, and some have one or two accessible towns. Also, some districts have large numbers of settlements that cannot be reached by CIAs while others have much fewer settlements that CIAs cannot reach. It was

difficult to get clear information on some topics such as whether there were AFP cases detected in inaccessible areas that could not be investigated. Some groups stated that this did happen, but others stated that, while it is a challenge, there were no cases that were not investigated. It was also difficult to get clear information on whether some CIAs were not able to use phones to track their movement. Most groups discussed this as a challenge, but some said that all CIAs were now using phones and others said that not all CIAs were using phones. It was also difficult to ascertain whether anyone working for the polio program had been killed in the line of duty and the responses to this varied by group although no group reported more than 1-2 deaths.

*Table 6: Number of Coded Segments by Group*

<b>Group</b>	<b>Number of Coded Segments</b>
CDC	164
Ministry of Health	27
NSTOP	373
WHO	61
Other non-profit organizations working on polio	71
Other UN organizations	19
Data Managers	109
District Level	264

State Level	379
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## **Inhibitors**

### **Accessibility:**

There was overall agreement between the information provided across groups and levels. There was no discordant information and there were some differences in the details and specifics provided by different group and levels. District level respondents reported that the majority of wards were inaccessible and that it is difficult to know the population in the inaccessible areas. They also reported that some areas were not reachable by CIAs and that accessibility varied by district with Bama having less accessibility than other conflict-affected districts. State level staff reported that there are many people trapped in inaccessible areas and that the conflict is getting worse in some areas. They also reported that inaccessibility is the main overriding challenge facing the polio program in Borno State. Data managers gave some quantification of the size of the problem and provided some examples of analyses of accessibility. Overall they reported that there are around 7,000 inaccessible settlements, of which almost 1,000 have not been reached for surveillance since the height of the conflict in 2014. The respondent from the Ministry of Health corroborated the findings from other staff including another program staff from the same district and reported that CIAs reached 300 out of 736 settlements in the district and that some areas are too dangerous for CIAs to reach. Other non-profit agencies provided similar information. WHO, CDC, and NSTOP also provided similar information. Other UN agencies reported that they do not work in the inaccessible areas because it is too dangerous.

**Communication:**

Respondents in most groups reported that there is no phone network in the inaccessible areas and no group reported contrasting information. There was no discordant information. District level respondents explained that the phone network has returned to some district headquarters but not to the rural areas of the district. Some district level respondents also mentioned that phone network from neighboring countries (Cameroon and Niger) can be accessed in some inaccessible settlements near the international borders. They explained however that the residents are not willing to call polio program staff for fear of retribution by Boko Haram. Several field level respondents discussed that communication is only possible in person and that nomadic populations can pass messages and information when they go to markets in the accessible areas. State level respondents also mentioned that there is some phone coverage along international borders and also that satellite phones are not being used in the inaccessible areas. Data management respondents discussed the fact that mobile apps that are used for surveillance in other parts of the state are not usable in the inaccessible areas because there is no phone network.

**Health Infrastructure:**

There was agreement by all respondents that there is no health infrastructure remaining in the inaccessible areas. Field level respondents reported that some residents of the inaccessible areas were able to access health services in health facilities along the border in neighboring countries such as Cameroon. State level respondents reported that there are no health workers remaining in the inaccessible areas and therefore no passive surveillance is possible. They also mentioned that Boko Haram steals drugs and vaccines when they attack health facilities. The WHO respondent also mentioned that Boko Haram steals vaccines and may be vaccinating their own children.

**Overall infrastructure:**

Most groups of respondents reported that the roads in the inaccessible areas were in very bad condition and also unsafe because of IEDs. There was no discordant information. District level respondents also mentioned the lack of electricity and the fact that AFP specimens cannot be kept cold if collected in the inaccessible areas. State level respondents mentioned that motorcycles, which are a major source of transportation in the rural areas, are banned in Borno State because they are often used by the terrorists for attacks. They also mentioned that horses or cows are used for transportation in the inaccessible areas. They explained that the lack of electricity in the inaccessible areas is a problem for charging phones and laptops as well as keeping AFP specimens cold.

**Population movement:**

Almost all groups discussed the issue of population movement and reported that there are many abandoned settlements and a very large number of displaced persons who have left the inaccessible areas. Field level staff reported that the population in the inaccessible areas is decreasing as people flee and that this is leading to a decrease in reporting of AFP cases in the inaccessible areas. State level staff reported that there has been massive movement from inaccessible to accessible areas and that it is difficult to know the precise population size in the inaccessible areas. The data management respondents also discussed the large numbers of abandoned settlements in the inaccessible areas and provided some data on this. One document provided reported over 2,000 abandoned settlements in the inaccessible areas. The Ministry of Health respondent reported that most people in one ward of the district had fled to neighboring districts. The respondent from another UN organization (IOM) reported that they track displaced persons through various systems and share the reports with the polio program.

## **Traumatizing violence**

Almost all groups discussed the issue of traumatizing violence and that this makes surveillance more challenging because people are afraid to do things that may put them at risk and communities are not interested in cooperating with disease surveillance efforts. While this was discussed as a challenge no group stated that it made surveillance impossible. The field level respondents reported that CIAs are still able to do their work despite the trauma and that the financial incentives provided to them are a strong motivation for them to do the work. They also discussed the strong hesitancy of families to allow their children to be evacuated for specimen collection due to the danger involved. Data manager respondents reported that some CIAs have been kidnapped and others killed. Other groups of respondents did not state that any CIAs had been kidnapped or killed although the WHO respondent later stated that a CIA was recently killed and another wounded by an IED.

## **Malnutrition and disease outbreaks**

Four of the nine groups discussed how malnutrition and disease outbreaks is affecting surveillance. The main concern was that children with weakness due to malnutrition were being reported as AFP cases even though they do not meet the case definition. The other concern was that IDPs and residents in the inaccessible areas are hungry and focused on meeting their immediate need for food and therefore are not cooperative with efforts to conduct AFP surveillance. Field level staff also reported that families of AFP cases often cooperate with efforts to evacuate the AFP case because medical care and food is provided when AFP cases are evacuated. The NSTOP group reported that large disease outbreaks (such as measles) can make communities more cooperative with disease surveillance activities including AFP surveillance because the community is concerned about the outbreak. The CDC group also reported that some families hide their malnourished children which can hamper disease surveillance efforts.

## **Rainy season**

Four of the nine groups discussed how the rainy season affects surveillance. All groups reported that movement is much more difficult in the rainy season and that surveillance activities slow down. Field level respondents reported that the ability to travel during the rainy season varies by district with drier northern districts generally less affected by the rainy season compared to districts in the middle part of Borno and along the Cameroon border. They reported that some districts become flooded and extremely muddy which makes travel very difficult and sometimes impossible. Respondents agreed however that CIAs could still work during the rainy season because they generally move by foot. The field level respondents reported that the existence of nomadic populations varies by districts with some districts reporting very few nomadic people and other districts reporting high numbers of nomads.

## **Nomadic population**

Five of the nine groups discussed how the nomadic population affects surveillance. All groups agreed that the challenge is that the nomadic groups move between inaccessible and accessible areas and therefore could serve as conduits for the virus to circulate between accessible and inaccessible areas. The groups also discussed the challenge of reaching nomadic groups for surveillance because of their frequent movement and their routes which are often off of the roads.

## **Other challenges**

Four of the nine groups discussed how the other challenges affect surveillance. Each of those groups discussed funding and the high cost of conducting surveillance in inaccessible areas as a major challenge. Two groups also discussed the fact that the polio program cannot supervise the work in the inaccessible areas as a challenge. One group also discussed the challenges of competing priorities and the current Covid19 lockdown.

## **Strategies**

### **Community informants:**

All groups that work on polio (8/9 groups) discussed the strategy of engaging community informants in the inaccessible areas. All groups enthusiastically discussed the importance of this strategy in improving surveillance in the inaccessible areas. Some different details were reported by the different groups but no inconsistencies or contradictions were reported between groups. The district level respondents had more details about the community informants including their payments, how they are recruited, and how they carry out their work. State level respondents were able to describe the coordination structure for the community informants including ward level coordinators and district level coordinators. The data management respondents provided the numbers of CIAs that are working and the numbers of settlements that they have reached and most other groups did not have these details. While most groups talked about the CIAs working with tacit or overt permission from Boko Haram, the Ministry of Health respondent reported that the CIAs were sneaking in and out of the inaccessible areas covertly.

### **GIS technology:**

All nine groups discussed the use of GIS technology to improve AFP surveillance in the conflict-affected areas of Borno. The use of phones to track the GPS coordinates of the CIA visits in the inaccessible areas was the GIS strategy reported. Six of the groups also reported the use of satellite imagery to estimate the inhabitation status of settlements in the inaccessible areas and the size of the trapped population. The Ministry of Health respondent also discussed the collection of GPS coordinates of AFP cases.

**Collection and testing of specimens beyond AFP cases:**

Seven of the nine groups discussed the collection and testing of specimens beyond AFP cases as a strategy for surveillance in the inaccessible areas. All discussed the collection of stool specimens for testing from healthy children. District level respondents discussed the collection of specimens from contacts of AFP cases. They mentioned however that it is hard to convince parents of health children in the inaccessible areas to allow their children to be evacuated for specimen collection. State level respondents also discussed collection of specimens from children who recently arrived in IDP camps from the inaccessible areas, from children from nomadic groups, and by RES and RIC teams when they reach inaccessible areas. They did not provide details on how the children were selected or the number of samples collected. Two groups also discussed collecting specimens from children who were evacuated as AFP cases by CIAs but, upon investigation by a clinician, were determined not to meet the case definition for AFP.

**Collaboration with security forces:**

All nine groups discussed collaboration with security forces as a strategy for AFP surveillance in the conflict-affected areas. All groups that work on polio (8/9 groups) reported on the two strategies of RES and RIC. There was no contradictory information provided but different groups provided different details. The district level group reported that the RES strategy was not being implemented in some districts because it was too dangerous for civilian security forces to work there. Several groups reported that residents of inaccessible area often flee with the military comes, which makes it impossible for the military to conduct surveillance. Several groups also reported that the surveillance work by the military is only sporadic and cases that are detected are often late (beyond 14 from paralysis onset). Several groups also reported that it is hard to coordinate with the military and that the military prioritizes their operations over the needs of the polio program.

**Profiling of displaced people:**

Seven of the nine groups discussed the strategy of profiling displaced people. The district level staff discussed this strategy less than most other groups, perhaps because they are focused on reaching children in the inaccessible areas. The information provided was very similar across groups. There was little emphasis on the importance of this strategy from any of the groups.

**Evacuation:**

Seven of the nine groups discussed the evacuation of AFP cases from inaccessible areas for clinical investigation and specimen collection. The information was fairly consistent across groups. All groups discussed the challenges of evacuating the cases and that it is time consuming and can lead to late investigation of some cases. They also discussed the risk involved in evacuating the cases. Most groups also discussed the re-evacuation of cases for a 60-day follow-up for those cases that were investigated late (beyond 14 from the start of the paralysis). Most groups reported that all cases could be evacuated and re-evacuated if needed but two groups reported that a small number of cases could not be evacuated and others could not be re-evacuated because of the risk involved.

**Nomadic population:**

Five of the eight groups discussed the use of nomadic populations to enhance surveillance in the areas of conflict. The information provided by the groups was very similar and focused on the ability of the nomadic populations to travel between accessible and inaccessible areas. The groups reported that nomadic people were recruited as CIAs and ward coordinators of CIAs and also that they were contacted when they came to markets in accessible areas to learn more about the habitation status of settlements in the inaccessible areas. District level respondents also reported that nomadic groups would inform them when they planned to relocate and that they kept a database of the movement of the nomadic groups. District level

respondents also reported that nomadic groups were used to conduct surveillance near Lake Chad because they have better access to that area than others. One group reported that they conduct healthy children stool sampling among the nomadic communities.

**Other:**

Two groups discussed other strategies for improving AFP surveillance in the conflict-affected areas. Both groups discussed collaboration with health workers in areas bordering the inaccessible areas including in neighboring countries. One group reported holding meetings with health officers from Cameroon to share information jointly plan for investigation of cases as they are reported.

**Monitoring systems**

**Tailored surveillance performance indicators for inaccessible areas:**

All nine groups discussed the use of tailored surveillance performance indicators for inaccessible areas. All groups discussed process level indicators of activities conducted in the inaccessible areas. These include records of meetings with CIAs and GPS evidence of surveillance visits conducted by CIAs and security forces. District level respondents focused on the use of maps to track the progress in reaching the inaccessible populations. State level respondents provided more indicators including analyzing traditional AFP indicators by blocks of districts, monitoring the size of the population unreached for surveillance, monitoring detection of VDPV as an indication of a functioning surveillance system, and analyzing areas with sporadic versus sustained surveillance. The data management group provided more details on the process of collecting and analyzing the data and on the analyses they produce including maps and lists of unreached settlements. The data management group was more knowledgeable on the data and the numbers of inaccessible children. The WHO respondent also reported that the number of AFP cases from inaccessible areas is being tracked as well

as the healthy children stool specimens from inaccessible areas. The Respondent from IOM discussed the production of an Emergency Tracking Tool (ETT) that reports the weekly population movement in and out of the inaccessible areas.

#### **Tailored surveillance quality assessment tools for inaccessible areas:**

Four of the nine groups discussed the use of tailored surveillance quality assessment tools for inaccessible areas. Most mentioned independent assessments by outside groups such as the Africa Regional Certification Committee for Polio (ARCC). The methods mentioned include speaking to project staff, reviewing project tools, reviewing data collection systems, and field visits.

#### **Collaboration and information sharing systems**

Six of the nine groups discussed collaboration and information sharing systems. Information varied between groups of respondents more for this construct than the other constructs. District level respondents reported that all groups working on polio are collaborating with each other and that there is also collaboration with the International Organization on Migration (IOM). Respondents at the district and state levels reported that there were no other groups working in the inaccessible areas besides the polio program. Respondents at the state level reported that there is a coordination mechanism at the state level called the Health Partners Coordination Meeting and that this coordination includes organizations involved in the humanitarian response including representatives from the polio program. They reported that other programs are benefiting from the work of the polio program in terms of understanding the situation in the inaccessible areas. State level respondents also reported that the polio Emergency Operations Center is the main mechanism for coordination. The IOM representative reported that the COVID19 pandemic has made coordination much harder and that there have not been recent coordination meetings because of the COVID19 lockdown. NSTOP respondents reported that the polio program is collaborating with the World Food Program and Action Against Hunger to conduct surveillance activities during food distribution. NSTOP respondents

also reported that the polio program is training clinicians from other organizations on polio surveillance and that some other organizations report AFP cases from IDP camps.

#### **D. Tables and MaxQDA visualizations**

##### **Memos**

Throughout the data collection and data analysis process I wrote memos to help remind me of questions, key points, areas to probe further, and inconsistencies in the data. These memos were very useful during the analysis process. These included free memos (unattached to particular segments of text) and in-document memos (attached to text segments). I wrote memos immediately after completing each interview and also while coding the data. I referred to the memos while summarizing and analyzing the data. In total I wrote 180 memos (excluding code memos, which in MaxQDA are code definitions). Annex 5 provides an excerpt of the list of memos that I wrote.

Sample memo 1:

Memo 50 from respondent 3 line 164: “34,000 children under 5 years of age still not being reached even with the CIAs. Unsure of the number of under 15 children unreached.” This memo was regarding information that the respondent provided on the construct of the challenge of inaccessible populations. I made a memo because it including the number of unreached children and I was having a hard time getting actual numbers from most respondents. I also thought it was striking that he did not know the number of under 15 children that are unreached even though this is the target population for AFP surveillance and therefore very important to know.

Sample memo 2:

Memo 63 from respondent 4 lines 76-78: “disease outbreaks can have a positive effect on AFP surveillance because communities become more receptive to public health work.” This memo was regarding the construct of the challenge of malnutrition and disease outbreaks. I took this memo because most respondents had felt that disease outbreaks were a hindrance to AFP surveillance but this respondent explained that it could be an advantage as well.

### **Code relations**

The code relations browser (Annex 7) demonstrates that there is a strong relationship between accessibility of populations and community informants. Many respondents discussed these topics together with a focus on how the local community informants were helping to improve surveillance in inaccessible areas. In addition, many respondents discussed accessibility and tailored performance indicators together with a focus on how the performance of the community informants is being monitored by using phones equipped with a GPS tracking app. In addition, there was a strong relationship between tailored performance indicators and GIS technology as well as community informants. Many respondents specifically discussed the use of GIS for performance monitoring in inaccessible areas for monitoring the movement of the community informants. This is easily seen in the code relations browser for monitoring systems in Annex 7.

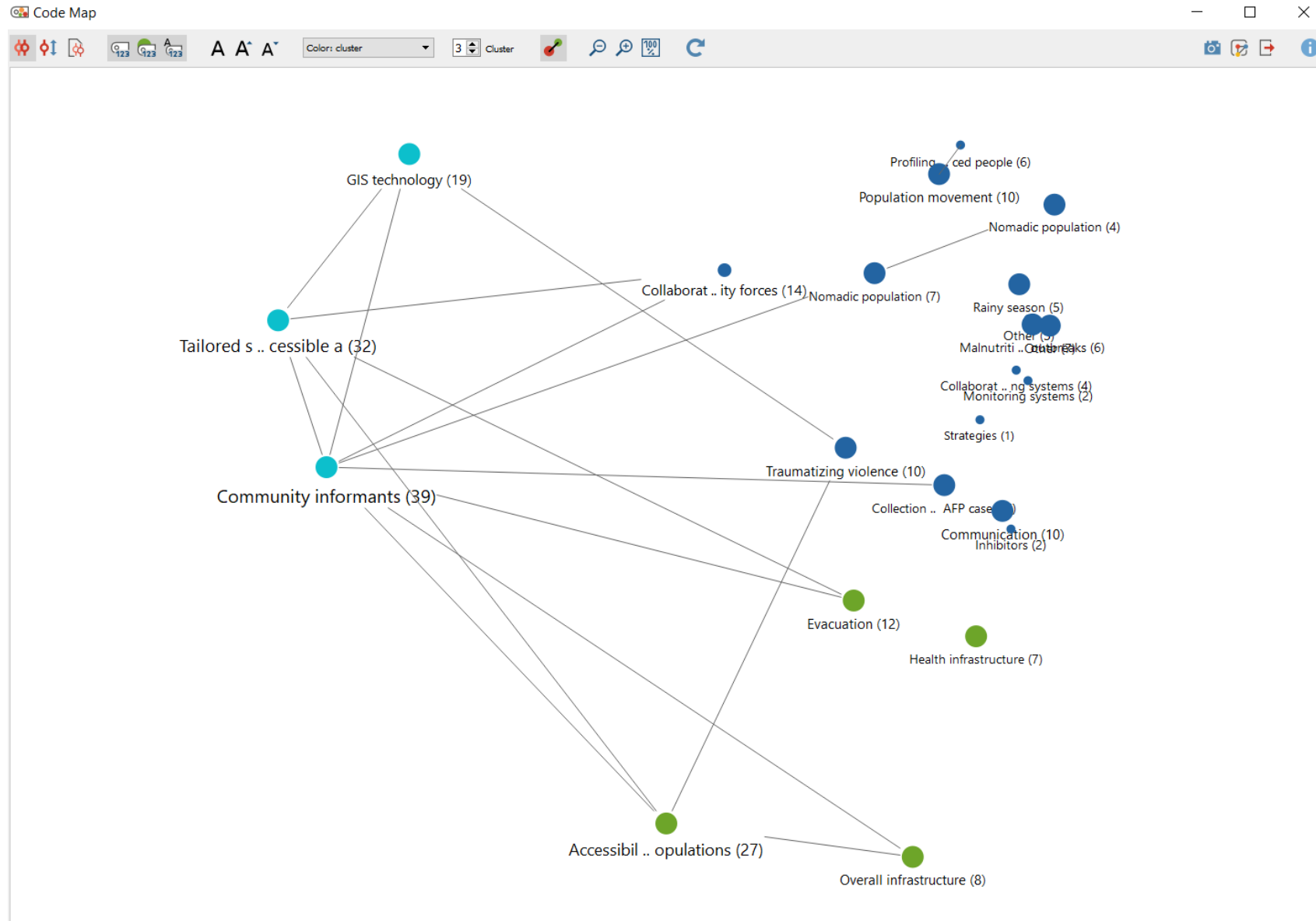
### **Code map**

The code map below (Figure 17) represents the relationships between the codes based on co-occurring codes in the interview texts. Those areas show overlap in the information provided. For example, responses regarding nomadic populations that served as community informants were coded for the nomadic population construct and also the community informant construct. This shows the linkage between the nomadic population and the

community informant strategy. The community informant code had the most links to other codes which makes sense because the community informants were often the actors that were impacted by inhibitors such as traumatizing violence and also actors who performed other strategies such as evacuating AFP cases. Some codes were not linked to other codes such as the challenge of the destroyed health infrastructure. While this strategy was not discussed in the context of other constructs, that does not diminish its importance as a barrier to a surveillance system that traditionally relies on case reporting by health facilities.

Overall, the code map visualizes the strong linkages between community informants, tailored surveillance indicators, and GIS technology. These links came out strongly in the study as a key piece of the innovative strategies to overcome the challenges of conducting surveillance in areas of armed conflict. The community informants are able to reach the inaccessible areas. Without strong monitoring tools however it is difficult to track their progress and provide evidence of which areas they are reaching. GIS technology provides that monitoring tool and the analysis of the GIS data helps inform the continued effort to reach more settlements in the inaccessible areas. These three interlinked strategies helped the program overcome the main barriers including inaccessibility, destroyed health infrastructure, and the destroyed communication infrastructure.

Figure 17: Code Map



## Code Matrix

The code matrix browser (Table 7) presents the number of times each respondent discussed each of the codes. This figure shows that community informants, tailored surveillance indicators, inaccessibility, and GIS technology were the most commonly discussed codes. The fact that the respondents had more to say about these codes suggests that they felt they were more important and had more information to share about them. Tailored quality assessment tools, malnutrition and disease outbreaks, rainy season, nomadic population, and profiling of displaced people were the least commonly discussed codes. The fact that the respondents had less to say about these codes suggests that fewer respondents thought they were important or that they had less information to share about these factors. There was some variation by respondent in which codes they discussed the most. Some of this may have to do with the position of the respondent. For example, data management respondents spoke in more depth about the performance indicators and district level respondents had more information to share about the community informants.

Table 7: Code Matrix Browser

Code	Resp. 1	Resp. 2	Resp. 3	Resp. 4	Resp. 5	Resp. 6	Resp. 7	Resp. 8	Resp. 9	Resp. 10	Resp. 11	Resp. 12	Resp. 13	Resp. 14	Resp. 15	Resp. 16	Total
<b>Inhibitors</b>	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	<b>2</b>
Inhibitors\Accessibility of populations	3	6	6	3	3	3	9	8	8	6	3	4	4	1	3	5	<b>75</b>
Inhibitors\Communication	3	1	2	1	2	1	1	5	6	1	0	0	0	0	0	3	<b>26</b>
Inhibitors\Health infrastructure	2	2	1	2	1	0	1	1	1	1	0	0	0	0	1	3	<b>16</b>
Inhibitors\Overall infrastructure	1	5	1	3	1	0	2	1	2	0	0	0	0	0	2	2	<b>20</b>
Inhibitors\Population movement	3	4	2	1	1	0	3	3	4	2	2	1	4	0	0	4	<b>34</b>
Inhibitors\Traumatizing violence	4	3	2	1	1	1	1	4	5	1	1	1	0	0	6	1	<b>32</b>
Inhibitors\Malnutrition and disease outbreaks	1	1	2	1	1	0	1	1	1	1	0	0	0	0	0	1	<b>11</b>
Inhibitors\Rainy season	1	1	1	1	1	0	1	1	2	1	0	0	0	0	0	1	<b>11</b>
Inhibitors\Nomadic population	1	0	0	1	0	0	2	1	3	1	0	0	0	0	1	0	<b>10</b>
Inhibitors\Other	2	1	2	1	2	0	0	1	0	0	0	0	0	0	0	0	<b>9</b>
<b>Strategies</b>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	<b>1</b>
Strategies\Community informants	2	5	4	2	5	6	20	18	7	13	10	8	0	3	12	11	<b>126</b>
Strategies\GIS technology	3	3	3	2	1	9	1	3	4	5	4	5	4	4	6	8	<b>65</b>
Strategies\Collection and testing of specimens beyond AFP cases	2	1	1	1	1	0	1	0	2	1	0	0	0	1	5	1	<b>17</b>
Strategies\Collaboration with security forces	7	5	3	2	1	1	0	10	2	4	1	4	1	3	5	5	<b>54</b>
Strategies\Profiling of displaced people	4	1	1	1	0	0	0	0	0	1	0	0	0	1	1	3	<b>13</b>
Strategies\Evacuation	1	5	3	2	1	1	4	9	6	4	3	0	0	0	2	1	<b>42</b>
Strategies\Nomadic population	2	1	0	1	0	0	4	0	2	0	0	0	0	0	3	0	<b>13</b>
Strategies\Other	2	0	2	0	1	0	0	0	3	0	0	0	0	0	0	0	<b>8</b>
<b>Monitoring systems</b>	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	<b>2</b>
Monitoring systems\Tailored surveillance performance indicators for inaccessible a	5	10	2	2	1	16	6	0	6	4	3	23	2	12	10	2	<b>104</b>
Monitoring systems\Tailored surveillance quality assessment tools for areas that s	0	2	1	1	0	0	0	0	0	0	0	0	0	0	1	0	<b>5</b>
Monitoring systems\Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<b>0</b>
<b>Collaboration and informations sharing systems</b>	1	2	1	1	1	0	0	1	1	2	0	0	4	0	3	2	<b>19</b>

### E. Co-occurring codes: Additional analysis on collaboration for GIS data analysis and use

As visualized in the code map, the co-occurrence of the codes on GIS technology, community informants, and tailored surveillance indicators was striking. The use of GIS technology to monitor the surveillance activities in the inaccessible areas, particularly the activities of the community

informants, was reported to be a very important tool by most of the respondents. In order to explore this further, I re-analyzed the data focusing specifically on how the organizations in the program worked together to produce, analyze, and use the GIS data on the tracking of surveillance activities in inaccessible areas. I generated a new summary grid focusing specifically on the question of what types of collaborations are needed to make effective use of GIS technology in the context of the armed conflict in Borno. I then created a summary table of the relevant codes of community informants, GIS technology, tailored surveillance indicators, and collaboration. I also analyzed this by organization to understand different perspectives by the various organizations involved in data collection, analysis, and use.

Through this analysis a consistent and cohesive story of how the data were collected, analyzed, and used emerged. The phones were provided by WHO and distributed to the CIAs by the ward coordinators. After the CIAs returned from the field, the phones were collected by the ward coordinators during the regular meetings with the CIAs and swapped for fresh phones. The used phones were transported back to Maiduguri by WHO where the data were uploaded to the server at the polio EOC. The data were then downloaded and analyzed by staff from Ehealth and maps produced. Staff from CDC provided regular updates to the Borno EOC on the estimates of settlement habitation to enable analysis of whether the inhabited settlements were being reached. Once the data were uploaded, the phones were charged and sent back to the districts by WHO staff. Staff from the Solina NGO separately analyzed the data from the RES and RIC teams and these data were combined with the CIA data to produce overall maps of surveillance reach from all interventions. These maps were produced for the state overall, for each district, and for each ward. A data team comprised of NSTOP, MoH, WHO, Ehealth, and Solina collectively worked together to conduct the analyses and produce reports that were presented each week at the EOC and also shared with the districts. A weekly review meeting was held at the polio EOC for all partners to review the weekly analyses. A monthly meeting was held at the polio EOC with ward and district CIA coordinators. The district and ward maps were sent to each district on a weekly basis for their review and use during their meetings with the CIAs. The polio EOC was reported to be the hub where the information was analyzed and shared.

All polio partners (CDC, WHO, NSTOP, Ehealth, and Solina) reported that they worked closely together. The data team respondents discussed more analyses than the respondents at the district level. While the data team produced many analyses, it seems that the maps were the main tool used at the district level to review surveillance reach.

All respondents and groups reported that there was good coordination for data analysis and use (Table 8). The respondents from CDC gave general feedback that the GIS data were used to monitor the reach of surveillance but did not provide specific information on how the data analysis system worked. NSTOP staff provided more details on how the system worked including how the CIAs are organized, where the data are analyzed, the types of analyses conducted and the regularity of meeting at different levels. Ehealth staff provided more details on how the data are uploaded, what analyses are conducted, and how the analyses are shared. Solina staff provided similar information as Ehealth although with less details about the analyses. WHO staff provided more information on how the CIA program is organized, regularity of meetings, and coordination mechanisms. MoH staff provided less details but discussed the collaboration including that the phones were brought from the state level.

While respondents did not specifically talk about collaboration for data management, the process they described illustrated a very strong collaboration across multiple organizations. The analysis of co-occurring codes for GIS technology, community informants, and tailored performance indicators revealed the strong collaboration between organizations that led to important advances in data analysis and use. The data management team, comprised of individuals from 5 different organizations, worked together to divide up the work of analyzing and visualizing a huge amount of data on a weekly basis. This included exploring and incorporating new data analyses on an ongoing basis. Nigeria, as the last country in the region to report wild polio virus, was the main hurdle for the region to overcome to achieve polio free certification. The existence of the polio EOC in Borno provided the platform for planning, data sharing, and collaboration. This hub created the environment for effective collaboration. The program did not have easy

answers to the problems they were facing and therefore valued the partnership and contributions across the organizations. This allowed for an open environment for coming together as partners for collective brainstorming to develop new approaches to achieve their mutual goals.

*Respondent 3: "So, in 2016 when the outbreak of 4 cases were reported in the state, the state came together to make a plan on how to approach the response to the outbreak, knowing fully-well that these cases came from inaccessible locations. So, a plan was made with partners and the state government, which I was directly involved in working out that plan. And then the next thing was what strategies can be deployed that are not... may not be fitting the regular ways of which the polio eradication has been conducting surveillance."..." But at this point in time we decided OK let's look at it, we have to leave the normal way of doing things and find strategies that will fit this situation."*

Table 8: Summary tables of GIS data collaboration

Organization	Summary
<b>CDC</b>	Good coordination, use tracking data to monitor reach of surveillance
<b>NSTOP</b>	Good coordination, use tracking data to monitor reach of surveillance, 2 levels of coordinators of CIAs: ward and district. Polio EOC as hub for coordination. Phones brought to state level for analysis. Weekly presentations of analysis at state and district levels. Send maps to districts each month. NSTOP and WHO working as a team. Ehealth produces maps.
<b>Ehealth</b>	Bring phones to Maiduguri for uploading. produces ward level maps for the district teams so they can clearly see the locations of reached and unreached settlements. Sends maps to WHO to share with the LGAs. Maps are also reviewed at the state EOC each week. Ehealth role is data analytics and mapping - showing locations reached by community informants. Provides a line list of abandoned and unreached settlements. Abandoned is based on the GRASP analysis (CDC).
<b>Solina</b>	Solina focuses on RES/RIC. Phones are brought to Maidugiri to download data and analyze. Analysis incorporated into reports that are discussed with the EOC and shared with all stakeholders as it is required.

<b>WHO</b>	3 categories in the CIIA program: informants, ward coordinators, district coordinators. Ward coordinators have twice monthly meetings with CIAs to review data and give feedback. Monthly meetings with ward and district coordinators in Maiduguri to review data and give feedback. Have WHO surveillance focal persons for inaccessible areas. All partners participate in the monthly meetings – WHO, NSTOP, CDC, Ehealth. Ehealth produces the maps.
<b>IOM</b>	collaboration with Ehealth and CDC Atlanta - review satellite imagery data. Share their ETT reports with the polio EOC
<b>MoH</b>	Borno EOC (WHO) sent the phones for them to use.

### **Triangulation between document review and interviews**

Table 9 below displays the extent to which the constructs were discussed in the documents and the interviews. Eight constructs were discussed in some or most of the documents and interviews. Eleven constructs appeared one time or less in the documents: communication, overall infrastructure, rainy season, nomadic population (challenge), community informants, collaboration with security forces, profiling of displaced people, evacuation, nomadic population (strategy), tailored surveillance indicators, and tailored quality assessment tools. Both in the document review and in the interviews the constructs of inaccessibility, population movement, and malnutrition and disease outbreaks were very prominent. The least discussed constructs across the document review and the interviews were nomadic populations (challenge), profiling of displaced people, nomadic populations (strategy), and tailored quality assessment tools.

For those constructs that were discussed in both the documents and the interviews, there was good agreement in the information provided (Table 10). For inaccessibility, there was agreement across documents that there are many thousands of inaccessible people in many thousands of inaccessible settlements and also that the size of the inaccessible population decreased considerably over time from 2016-2018. While the exact numbers differ slightly, this aligns well with the information provided by the interview respondents. Communication was only discussed in one of the documents but the information in the document, that the cellular towers had been destroyed resulting in a lack of cell phone coverage in the conflict

areas, aligned well with the information from the interviews. Health infrastructure was discussed in two documents which stated that passive surveillance is not feasible due to the destruction of health facilities in the conflict areas. This aligned with the information from the interviews. Overall infrastructure was only discussed in one document which presented information about thousands of destroyed settlements, which aligned well with the information from the interviews. Population movement was discussed extensively in both the interviews and the documents and, while exact numbers varied, there was wide agreement that a very large number of people are displaced in Borno State. Traumatizing violence and a climate of fear was highlighted in both the documents and the interviews and all the information converged on the fact that violent atrocities are ongoing leading to widespread psychological trauma among residents in the conflict areas of Borno State. Malnutrition and disease outbreaks were discussed in most of the documents and interviews and there was a convergence of information that there is severe malnutrition and many disease outbreaks. The interviews described how that is affecting AFP surveillance such as by confusing weakness from malnutrition with acute flaccid paralysis. The constructs of the rainy season and nomadic populations were not discussed in the documents reviewed.

For the strategies there was also good alignment of information between the documents and interviews, although not all the strategies were discussed in the documents. The strategies of community informants, evacuation, and nomadic populations were not discussed in the documents reviewed, perhaps because these are more recent innovations and had not started when the documents were produced. GIS technology was discussed in both the documents and the interviews. Both the documents and the interviews discussed the utility of satellite imagery for estimating populations in the inaccessible areas. The interviews also discussed the use of GPS tracking to monitor where surveillance was taking place in the inaccessible areas, but this was not mentioned in the documents reviewed. Collection of stool specimens beyond AFP cases was discussed as a useful strategy both in the documents reviewed and the interviews. Profiling of displaced people was only mentioned in one of the documents reviewed but it was discussed as a useful strategy which aligned with the information from the interviews. Collaboration with security forces was only mentioned in one of the documents

reviewed but it was similar to the information provided by the interviewees, namely that security forces can improve AFP surveillance in areas of armed conflict but there are many limitations to this strategy such as the irregularity of the visits. Monitoring systems were not discussed in the documents reviewed and there is no information about tailored surveillance indicators or tailored quality assessment tools from the document reviews.

Collaboration and information sharing were discussed in both the documents reviewed and the interviews. There was agreement that there are many agencies working in Borno and that information sharing systems are in place through coordination meetings. The interviews also discussed collaboration between the polio program and other agencies, such as training clinicians from other agencies to search for AFP cases among IDPs or conducting AFP surveillance during food distribution activities. The interviews also discussed how the polio program is helping other programs by providing information about the population living in inaccessible areas.

Table 9: Extent to which findings were discussed in document review and interviews

Construct	Sub Construct	Document Review	Interviews	Overall
Inhibitors	Inaccessibility	+++*	+++	Highest
	Communication	+*	+++	Medium
	Health Infrastructure	++*	+++	High
	Overall Infrastructure	+	+++	Medium
	Population movement	+++	+++	Highest
	Traumatizing violence	++	+++	High
	Malnutrition and disease outbreaks	+++	+++	Highest
	Rainy season	+	+++	Medium
	Nomadic population	+	++	Low
Strategies	Community informants	+	+++	Medium
	GIS technology	++	+++	High
	Collection and testing of specimens beyond AFP cases	++	+++	High
	Collaboration with security forces	+	+++	Medium
	Profiling of displaced people	+	++	Low
	Evacuation	+	+++	Medium
	Nomadic population	+	++	Low
Monitoring systems	Tailored surveillance performance indicators for inaccessible areas	+	+++	Medium
	Tailored surveillance quality assessment tools	+	++	Low
Collaboration and information sharing systems		++	+++	Medium

\* + Issue discussed by 1 or no documents/respondents

++ Issue discussed by some documents/respondents

+++ Issue discussed by most documents/respondents

Table 10: Triangulation of data from document reviews and interviews

Construct	Sub Construct	Documents	Interviews	Level of Agreement
Inhibitors	Inaccessibility	Discussed by most	Discussed by most	High
	Communication	Discussed by one	Discussed by most	High
	Health Infrastructure	Discussed by some	Discussed by most	High
	Overall Infrastructure	Discussed by one	Discussed by most	High
	Population movement	Discussed by most	Discussed by most	High
	Traumatizing violence	Discussed by some	Discussed by most	High
	Malnutrition and disease outbreaks	Discussed by most	Discussed by most	High
	Rainy season	Not discussed	Discussed by most	NA*
	Nomadic population	Not discussed	Discussed by some	NA
Strategies	Community informants	Not discussed	Discussed by most	NA
	GIS technology	Discussed by some	Discussed by most	High**
	Collection and testing of specimens beyond AFP cases	Discussed by some	Discussed by most	High
	Collaboration with security forces	Discussed by some	Discussed by most	High
	Profiling of displaced people	Discussed by some	Discussed by some	High
	Evacuation	Not discussed	Discussed by most	NA
	Nomadic population	Not discussed	Discussed by some	NA
Monitoring systems	Tailored surveillance performance indicators for inaccessible areas	Not discussed	Discussed by most	NA
	Tailored surveillance quality assessment tools	Not discussed	Discussed by some	NA
Collaboration and information sharing systems		Discussed by some	Discussed by most	High**

\* Not applicable

\*\* Interviewees provided additional information not found in the documents

## Chapter 5: Discussion and Recommendations

Chapter 5 discusses the key findings of this study in greater depth. It then reviews changes to the conceptual framework based on the findings. The chapter goes on to discuss the progress made in Borno and the remaining challenges facing the program. Furthermore, ethical issues facing the program are discussed and highlighted. Limitations of the study are presented. Reflections on the data collection and analysis, leadership implications and the standards for reported qualitative data are presented. Recommendations, lessons learned, and suggestions for future research are provided.

### A. Summary of key findings

This study delved into the challenges of conducting public health surveillance in areas of armed conflict. The overall research question was:

How can the conventional polio surveillance system and strategies be modified to address areas of conflict and inaccessible populations?.

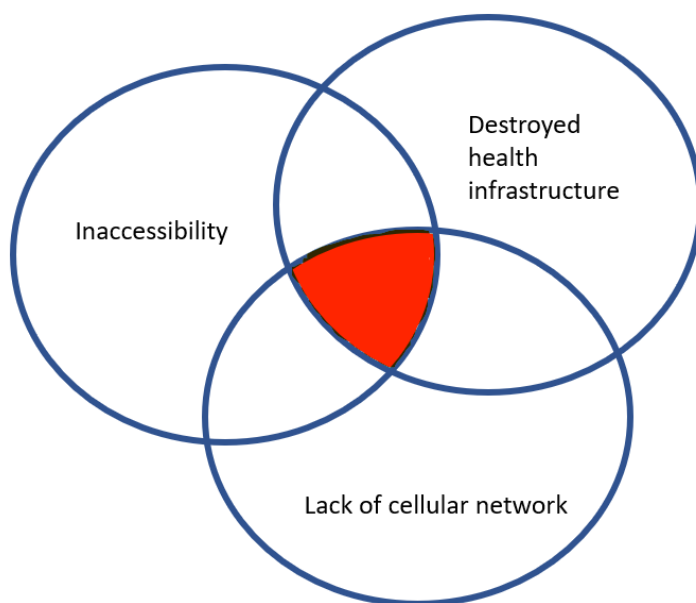
The specific sub-questions were:

1. What are the inhibitors of effective surveillance in the context of the armed conflict in Borno State, Nigeria?
2. What are the opportunities for effective surveillance in these settings? What strategies and field methods would enable effective surveillance in these settings?
3. What monitoring procedures and indicators may be useful in monitoring surveillance performance in inaccessible areas?
4. What systems are in place for collaboration and information sharing for polio surveillance between the various actors (governmental, non-governmental, and multinational) that are supporting the humanitarian response in Borno?

## Inhibitors

The main inhibitors that were highlighted were inaccessibility, lack of a cellular network, and the destruction of the health infrastructure. The combination of these three challenges resulted in a situation in which traditional public health surveillance was nearly impossible to conduct in the conflict-affected areas of Borno State. While other challenges were discussed, these three were the predominant challenges. Any one of these challenges on its own would create major problems for public health surveillance but the three combined, as depicted in Figure 18, made it nearly impossible. Without a functioning health infrastructure it could still be possible to conduct community based surveillance using local staff and using SMS or phone to communicate the surveillance activities conducted and to report AFP cases. Without access but with a functioning health facility, the passive surveillance system could still function. Without a cellular network it could still be possible to conduct surveillance and report in person. Without all three however, the options for conducting surveillance are extremely limited.

Figure 18: The intersection of three main inhibitors of public health surveillance in conflict areas of Borno State



The general consensus regarding the other challenges was that, while these are important challenges, they did not present insurmountable obstacles. A breakdown in the overall infrastructure such as degraded roads and lack of electricity makes things harder but these are challenges that the polio program has faced elsewhere and was able to overcome. For example, novel specimen carriers that can stay cold for up to a month without electricity have been developed and are in use in Borno and other areas that lack electricity.

The climate of traumatizing violence meant that people did not prioritize public health and were focused on issues of their immediate safety. While this was a challenge, the program was able to find ways to engender cooperation through integration with other services and provision of basic services for AFP cases. Community informants were motivated to conduct AFP surveillance because of the incentives that helped them meet their immediate needs. AFP surveillance was integrated with feeding programs and people were therefore more cooperative

The widespread malnutrition and disease outbreaks created challenges in that severe malnutrition causes weakness that can be confused with acute flaccid paralysis. Therefore many reported AFP cases turned out to be malnutrition. This is a truly tragic situation but, with trained medical doctors stationed in each district, it was possible for them to distinguish between weakness due to malnutrition and acute flaccid paralysis and exclude the cases that did not meet the case definition for AFP. What made this more of a barrier for surveillance was that the prevailing hunger meant that communities were not interested in public health interventions until their immediate needs for food were met. Integrating AFP surveillance with feeding programs was therefore very effective as a strategy to overcome this barrier. For evacuating AFP cases, the provision of food and lodging for the AFP case and caregiver was a major motivating factor for the family to agree to evacuate the case for investigation. While the occurrence of other disease outbreaks was a challenge, because of the parallel structure of the polio program, the polio surveillance was able to continue despite other health priorities.

The challenge of conducting surveillance during the rainy season was a challenge, particularly in some districts in eastern Borno (Bama, Ngala, Kala Balge). It was noted that this challenge has always been there but was exacerbated by the conflict because the roads were mined and getting stuck increases the risk of being attacked. Respondents also explained that the community informants were still able to move around during the rainy season because they typically travelled by foot.

Population movement was discussed as a major factor for surveillance. It was generally discussed as a challenge because it meant that it was difficult to know where the populations were located and made calculation of rates very inaccurate. However, it was also noted that the displacement of people from inaccessible areas to accessible IDP camps made it possible to conduct surveillance among those people who had fled. Indeed, this is how the wild polio cases in 2016 were detected. The fact that there was continuous displacement of populations in 2016-2020 meant that there was a possibility of detecting polio among the newly arrived displaced population if it was still circulating in the inaccessible areas. In addition, the fact that the population in the inaccessible areas in the east of Borno was decreasing rapidly meant that there were fewer people living there to sustain transmission of the virus and also that there were few populated settlements where surveillance was needed. This is visualized in Figure 15 above which shows that many of the settlements were abandoned.

The nomadic population was also discussed as a challenge to surveillance in the inaccessible areas. Because the nomadic groups relocate frequently and travel through hard-to-reach areas, it is a challenge to include nomadic groups in surveillance systems even in secure areas. In accessible areas this challenge is greatly amplified. With careful planning and close collaboration with nomadic leaders, it is possible to reach these populations when they move to accessible areas<sup>85</sup> and some respondents discussed strategies to reach the nomadic communities.

Another challenge that was discussed was the issue of the sustainability of the efforts to conduct surveillance in the inaccessible areas. This work is very resource-intensive and can only be sustained with heavy investments. The investments in polio will likely decrease in the future and it is unclear to what extent the work of reaching inaccessible areas of Borno will be able to continue. This is a prolonged conflict with no end in sight and therefore continued investments will be needed to maintain surveillance in the vulnerable conflict-affected communities.

## Strategies

Much of the time during the interviews was devoted to discussion of the strategies that have been developed to address the challenges of conducting surveillance in the conflict-affected areas of Borno. The respondents were extremely animated when discussing the strategies, particularly the use of community informants and the use of GIS technology. It was clear that a great deal of effort went into developing and refining these strategies. Perhaps the overall strategy employed in Borno was continued innovation and perseverance when facing seemingly the intractable combined challenges of inaccessibility, lack of communication network, and a destroyed health infrastructure. The problem of inaccessibility in Borno was well known at all levels of the Global Polio Eradication Initiative and it was recognized that a solution was needed to achieve polio eradication in Africa, and it took a sustained effort with support at all levels to succeed.

The use of GIS technology was pivotal to the program in two ways. The first is in estimating the size and location of the populations in the inaccessible areas through analysis of satellite imagery. Ironically, the analysis took place on a different continent and yet provided the best information on the populations in the inaccessible areas. In 2016, when the wild polio cases were detected in Borno, there was a great deal of confusion about the size and location of the trapped populations in Borno. Indeed, there was a belief that there were no people left in the Boko Haram controlled areas, a belief that was contradicted by the finding of polio cases linked to escapees from those inaccessible areas. But even if the detection of the wild polio cases proved that people were still living there, it did not answer the question of where they were living or how many or how the habitation was changing over time. That information, provided by the satellite imagery analysis, proved vital to targeting the efforts on the inhabited geographies in the conflict zones. Without this information the surveillance efforts would not have been able to focus on only the inhabited settlements and it would not

have been possible to track progress in reaching the unreached populations. The information also helped advocate with the military for their support in reaching these populations. Without the maps the military could have just insisted that there were no people remaining in those areas.

The other key contribution from GIS technology was the use of GPS enabled phones to track the surveillance visits in the inaccessible areas. This strategy was not well documented in the public domain and conducting the interviews for this study was very helpful in understanding this strategy and its value to the polio program in Borno. The use of the phone trackers enabled the program to document where surveillance was taking place, establish accountability over the work of the community informants, track progress, and plan to reach the remaining unreached areas. Without this information it would have been much more difficult to present credible evidence that the country was free of wild polio virus. The phones are not being used by all community informants and therefore the documented evidence of the surveillance likely underestimates the true extent of the surveillance by the community informants.

The strategy of collaborating with security forces predated the strategy of engaging community informants in the inaccessible areas. This was seen at the time as the only viable strategy to get into the conflict zones. While it had some level of success, it was not seen as a successful strategy on its own for conducting sensitive surveillance because it was not regular enough and it was not a priority for the military. Indeed, very few AFP cases were detected with this strategy and only a small portion of the settlements were documented as reached with this strategy. While this strategy was not enough on its own to achieve sensitive AFP surveillance, it did provide some early inroads into reaching the inaccessible population and probably was enough to rule out widespread polio transmission with large numbers of paralysis cases.

The main strategy that was discussed at length by the respondents was the use of community informants for surveillance in the inaccessible areas. This strategy, in combination with the use of GPS enabled phones to track their surveillance visits, was seen as the key strategy that really led to the strong evidence of the absence of wild polio in Borno state. At the outset of the wild polio outbreak in 2016 there were much fewer accessible areas

and the military had not yet regained control of the towns in much of the state. At that time the respondents did not believe that the strategy of engaging local community informants would have been viable. Indeed, it was a gradual process of engaging community informants in inaccessible areas (CIAs) over time and even now there are some areas that the CIAs have not been able to reach, particularly in Abadam and Bama districts, while other areas are well-covered by CIAs. It is possible that the variable success of the strategy in different areas is due to the existence of different factions of Boko Haram in different parts of the state. The faction present in the eastern part of the state is considered much more dangerous and violent than the faction present in the western side of Borno state. Nevertheless, the strategy made great inroads across Borno and provided the strongest evidence that surveillance was taking place and cases were not being missed.

The carefully crafted system of separating the community informant system from the rest of the polio program was a very deliberate effort to protect the safety of the community informants. Ward and district level coordinators were separately recruited from local community members who had access to the inaccessible areas. The entire program was run by local community members who were known and trusted in the inaccessible areas. As discussed by the respondents, building trust between the community informants and Boko Haram was key to their ability to conduct surveillance activities and evacuate AFP cases. Had the work of the community informants been directly linked to the government and the polio program (which was also working with the military), this would have jeopardized the work of the informants and put them at extreme danger of retaliatory attacks by Boko Haram. While there was a vacuum of leadership in the conflict affected areas, this carefully developed strategy created the local structure needed to coordinate this program as safely and effectively as possible.

As shown in figure 14, by April 2020, of the 7,034 settlements in the inaccessible areas, 4,006 (57%) settlements were reached by CIAs including 706 (10%) that had not been reached by any other strategy and 901 (13%) settlements remained unreachable. The map shows the location of settlements by these categories and also displays the 2118 (30%) settlements that are abandoned. Overall this shows that the CIA strategy had made very

significant inroads into strengthening surveillance in the inaccessible areas, although there are still pockets of settlements that are not being reached, particularly around Bama, Dikwa, and Abadam. The maps also shows that the success of the CIAs was much greater on the western side of Borno than the eastern side of the state. The limited access in the eastern side is offset by the large number of abandoned settlements there and the smaller population needing surveillance. The estimate provided to me of the unreached population of children under fifteen years of age in these remaining settlements is 97,000. While this is still a large number, the fact that it is spread out over two different areas of the state reduces the likelihood of sustained polio transmission. This is a massive improvement from the situation in 2017 when 58% of the settlements Borno state were inaccessible to the polio program.

This very substantial progress was driven both by increases in penetration of surveillance and also by depopulation of the inaccessible areas. Another aspect of the community informant work that respondents were enthusiastic about was its potential to be ongoing and regular. While the security forces were getting to some of the inaccessible areas, they were not getting there often and that limited the value of the collaboration with security forces as a method of ongoing surveillance. With the community informants on the other hand, they is the potential visit the same areas on an ongoing basis. This would lead to a much higher level of confidence that polio cases are not being missed because the polio virus can only be detected from infected individuals for the first two months after the onset of paralysis, with the highest chance of detecting the virus within the first 14 days after paralysis onset. I could not find examples of reports on the regularity of the surveillance by CIAs however and this is an area that seems to require better analysis and documentation. Indeed, an internal database that was shared revealed that a large percentage of the settlements visited by CIAs had only been reached once since the effort began in 2019.

An unanswered question remains about the quality of the surveillance in the inaccessible areas. The fact that they are detecting AFP cases is strong evidence that the surveillance is working. The GPS data on the locations of their visits is also strong evidence that they are actually getting to

many of the inaccessible areas. What is less clear is whether they are reporting all cases that they find or only the cases that they are able to evacuate. I was not able to get a clear answer to this question and many respondents indicated that a small number of AFP cases were detected that could not be evacuated but there did not seem to be any system for systematically recording these cases.

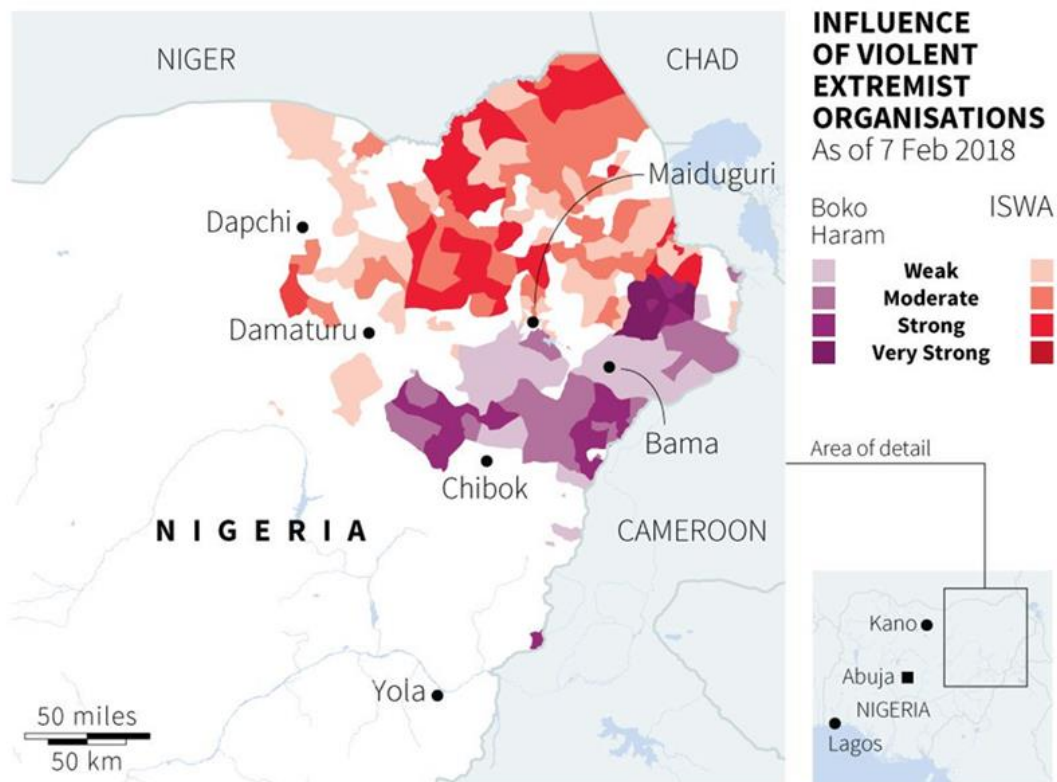
The literature highlights the importance of negotiated access as a key strategy for improving surveillance in inaccessible areas<sup>66</sup>. The insurgent groups in Borno however have not been open to negotiation and therefore this strategy was not included in the conceptual framework for this study. It was clear that negotiation with Boko Haram leadership (of any faction) was just not possible. At the lower levels however the respondents did discuss negotiations and trust between the community informants and local Boko Haram members. The fact that the community informants were able to negotiate with Boko Haram to go in and out of the inaccessible areas to conduct surveillance is a key piece of the success of this strategy. Even more critical was their ability to negotiate with Boko Haram to be able to evacuate AFP cases for investigation. Without this, the increased surveillance would have been incomplete and detected cases would have to be classified as polio compatible and could not be discarded as non-polio after laboratory testing. While some respondents said that the CIAs were “sneaking” into the inaccessible areas and others talked about negotiating access, when it came to evacuation most respondents discussed building trust with Boko Haram and negotiating with them for the evacuation of the cases. They talked about how the informants were known to Boko Haram and came from the communities. The negotiation however is clearly fraught with risk and, tragically, I was informed that some community informants have been killed. It is especially tenuous for the polio program to be collaborating with the military while at the same time engaging community members who negotiate directly with Boko Haram. The respondents explained to me that the CIAA program was intentionally disassociated with the polio program in order to protect the CIAs from suspicion. A separate structure of coordinators was put in place using local community members rather than polio staff (even at the district level where polio staff can work). Nevertheless, there is still a great deal of risk involved in this strategy.

Only one respondent discussed the impact of the different factions of Boko Haram on the surveillance strategy and penetration and provided Figure 19 of the areas of presence by the two factions. The two main factions, Boko Haram and the Islamic State of West Africa (ISWA) which splintered off from Boko Haram in 2016, are present in different areas of Borno. ISWA is putting more emphasis on becoming a government, including providing services to the population than Boko Haram<sup>86</sup>. This means that, while both factions are at war with the government of Nigeria, there is more freedom of movement in the ISWAs areas and therefore it is easier for the CIAs to operate in those areas. The areas of Bama, Marte, Dikwa, Kala Balge, Gwoza, Damboa, and Ngala are under Boko Haram whereas Magumeri, Nganzai and Mobbar are under ISWAS. The areas controlled by Boko Haram have had less penetration by CIAs but also fewer remaining inhabited settlements.

Figure 19: Areas of influence of the two factions of Boko Haram

## Islamist insurgencies in Nigeria

Boko Haram and its splinter group Islamic State in West Africa (ISWA) have influence over a large area of northeast Nigeria while government control is severely limited.



Sources: USAID; Maps4News

C. Hughes, 29/04/2018

REUTERS

The other strategies discussed as useful were profiling displaced populations, collecting and testing specimens beyond AFP cases, and working with nomadic populations. Profiling of displaced populations serves as a form of “proxy surveillance” for the inaccessible areas. Because of the high levels of displacement that continued from 2016-2019 the surveillance among the displaced population provided a certain level of assurance that polio circulation in the inaccessible areas was not being missed. Testing samples of healthy children was also seen as a useful strategy but it is unclear whether polio can be ruled out just because it is not detected in small samples of healthy children. Engaging with nomadic communities was seen as an important strategy both in conducting surveillance in inaccessible areas in general and also in improving surveillance specifically among the nomadic communities. Other research has highlighted the importance of nomadic communities as a potential reservoir for diseases such as polio<sup>87</sup> and it is important to ensure that this population is not neglected by the surveillance system. None of these strategies however were given the same level of importance as the engagement of community informants to find and evacuate cases and the use of GIS to track their work and track the remaining population in the inaccessible areas.

## Monitoring systems

There was clearly a shift away from the traditional surveillance monitoring tools in the conflict-affected areas. The main monitoring systems being used were focused largely on process level indicators. They monitored the number of settlements being reached, the number of community informants engaged, and the location of the reached and unreached settlements. They also monitored the newly reached locations. This type of process monitoring, completely different from the traditional monitoring, was uniquely adapted to the situation of the conflict in Borno. In addition to tracking the activities, there was also close monitoring of AFP reporting from the inaccessible areas. The number of AFP cases reported and the location

of the AFP cases reported was closely tracked to look for areas with no reporting as an indication that perhaps surveillance was not working well in that area. The collection of the location where AFP cases were found, as opposed to where they were investigated, was a major advancement. This provided very solid evidence that the program was truly finding AFP cases in the inaccessible areas (rather than from the displaced population living in IDP camps). There was a de-emphasis on the non-polio AFP rate as a monitoring tool even though this is the cornerstone indicator used around the world. The reason for this is that the population is quite small in the inaccessible areas and therefore few AFP cases are expected. In addition, because the health system has collapsed, one cannot assume that there is uniform surveillance over an area and therefore detecting a case in a district does not mean that surveillance is occurring uniformly across the district. The program therefore tracked reporting of AFP cases by ward (the administrative level below the district) to track which wards were reporting cases.

The focus on geographical evidence from GPS devices was another unique innovation. This allowed the program to have strong confidence that the community informants were reaching the inaccessible areas. Because no supervision of the community informants could be conducted, and because they were volunteers with very little training, the program was not comfortable relying on their reporting of their activities without some evidence. This shift from the traditional surveillance indicators required a great deal of data support and indeed there was a sizable data team in Borno (in addition to remote GIS support from CDC in Atlanta) to analyze and visualize the surveillance data on a regular basis. There was also an ongoing process of refining and introducing new systems for analyzing the data. For example, recently a new analysis was added that categorizes the unreached settlement into three categories based on the likelihood of being able to reach them in the next month. Detection of VDPV was also used as a monitoring tool in that it provides evidence that the program can detect polioviruses and therefore is unlikely to be missing wild polio cases.

## Collaboration

As described in chapter 4, the value of collaboration within the polio program for data management and analysis clearly came out as a major strength of the program. The analysis of co-occurring codes described in chapter 4 highlighted the strong web of collaboration that existed between different organizations supporting the polio program in Borno. This rich data provides very useful insights into question 4 of this study. Respondents also talked about the value of the collaboration and information sharing with other humanitarian agencies. This was most helpful in reaching the populations living in IDP camps. For the population still living in the inaccessible areas however, the polio program was at the forefront of the effort to reach those populations and did not have viable partners to collaborate with. No other agencies were working in the inaccessible areas and therefore the polio program had to “go it alone”. There were perhaps missed opportunities to provide other services to the inaccessible populations but the initiative of the CIAs was very risky and secretive and therefore efforts to collaborate with the CIA had not been initiated at the time of the interviews. Several respondents also discussed how the other agencies benefitted from the data that the polio program shared on the location and size of the populations in the inaccessible areas. No other agencies had such information and they were very grateful for it.

## B. Comments on leadership

### Meta-leadership

In emergencies there is a need for effective coordination and collaboration across agencies and sectors. However, there is a tendency for individuals to work more closely within their own organization rather than work broadly across organizations. Meta-leadership is a strategy to overcome this by connecting the goals and efforts of diverse agencies and groups<sup>88</sup>. Henderson et al<sup>88</sup> describe the strong tendency of organizations to look inwards and resist collaboration with other organizations, and indeed maintain a competitive stance towards other organizations. The current COVID-19 pandemic is the most recent example of the challenges of working across groups and the dire consequences that can result from poor collaboration across agencies. Yet leaders are often unprepared for the challenge of bringing together different organizations for a common cause. Henderson et al argue that a new type of leader is needed who can bring diverse groups together to collaborate effectively to achieve a shared goal. This requires fostering a culture of openness and connection between organizations. It relies less on organizational power and more on establishing relations and trust, even among organizations that are traditionally antagonistic. It requires moving out of one's comfort zone and bringing others together.

This concept is relevant to the situation in Borno in which the complex adaptive problem could not be solved by one agency alone and effective collaboration across groups was needed. In speaking to respondents for this study, it was striking how aligned they were on the goals they were working towards, and their strong passion and commitment to those goals. It was beyond the scope of this study to focus on how the common goal was established, but the respondents discussed the intense pressure to achieve the goal of eradicating polio. They were aware that Nigeria was the last country in Africa to have endemic wild poliovirus transmission and that Borno state was the last state in Nigeria to detect wild polio. They understand that the program failed to detect the wild polio transmission that was occurring from 2011 to 2016 and that this was a deep embarrassment to the polio program. Perhaps due to the clarity of the mission, there was a true coming together of multiple organizations to achieve a common goal, and a collective belief that this required collaboration. The depth of the challenge likely also helped create a sense of "we are in it together". No one agency felt that they could solve the problem on their own and did not want to take full responsibility for the challenge. One respondent described how, in

2016, all the partner agencies sat down together to try to plan a new system for improving surveillance in the inaccessible areas. The spirit of openness and collaboration was remarkable.

The work conducted in Borno, in particular the effective work in redefining the performance monitoring system, exemplifies the ability of the program to embody the strategy of meta-leadership. There was a true connection in purpose and goal that united all the actors from the various NGOs and organizations that were supporting the polio program in Borno. There was also the creation of the polio emergency operations center which created a hub for collaboration and coordination. While the respondents in this study provided clear evidence of the ability of the program to overcome the challenge of the tendency to work in an insular fashion within organizations, the respondents focused on the group members themselves rather than the leaders as the true champions of the effective collaboration. The approach highlighted in this study, focusing on achieving a common goal through innovation, collaboration, attention to data, and accountability, may serve as a model for how NGOs can work together without a top down coordination model. The intense pressure on the program to improve surveillance in Borno, including pressure from the African region to present robust data to the African Regional Certification Committee, meant that the Borno polio program was highly motivated to demonstrate that they were improving surveillance in Borno. The common goal and lack of a clear path to success, coupled with the establishment of the polio EOC as a hub for collaboration, allowed for collective brainstorming and coming together as partners to develop strategies to achieve the mutual goal. The intense commitment of the program to achieve the common goal, in conjunction with the extreme challenge of the situation and the lack of an effective strategy, created ripe conditions for the collaboration and cross organizational coordination to thrive. The respondents all talked about other units and organizations with a great deal of respect. While the meta-leadership strategy is focused on the qualities of the leader in charge, this study suggest that meta-leadership may surface from the bottom-up through the work of the many individuals involved in the program.

The collaboration for GIS data analysis may be the clearest example of this inter-organizational collaboration. In interviewing staff from multiple organizations I uncovered an amazingly rich web of collaboration that was able to accomplish a remarkably complex and arduous task week in and week out while all the time looking for ways to improve and introduce new analyses. I have witnessed countless examples where organizations, and even groups within the same organization, compete and even undermine one another in overt or covert ways. Yet in one of the most challenging and dangerous of circumstances, individuals from five separate organizations were working together to accomplish more than any one group could do alone. The depth and quality of the analyses shared with me by respondents, and the utility of these analyses for tracking and improving the program came out strongly from respondents from all levels and organizations. This was truly a remarkable collaboration and the analysis of the co-occurring codes from this study helped to reveal the rich intricacies of the team work involved. As mentioned above, perhaps the intense pressure to achieve results, coupled with the pervasive danger and risks in Borno, was able to bridge organizational differences and foster a feeling of togetherness.

### Logic model for polio surveillance in areas of armed conflict

In chapter 2 I presented a logic model of the traditional polio surveillance system (figure 10). As discussed in this study however, the traditional polio system is not well-suited to the challenges of areas of armed conflict. Figure 20 below presents a proposed logic model for polio surveillance in areas of armed conflict. The inputs are similar to the traditional polio surveillance system but they include GIS technology and a coordination and collaboration center. The key challenges analyzed in this study are a destroyed health infrastructure, inaccessible populations, and the lack of a functioning communication infrastructure. The key activities are surveillance visits by community informants and security forces, evacuation of detected AFP cases for case investigation, healthy children stool sampling, laboratory testing, continuous innovation of strategies and analyses, and collaboration across groups. This contrasts sharply with the key activities in the traditional polio surveillance system which focus on active surveillance to health

facilities, passive reporting by health facilities, and environmental surveillance. Whereas with the traditional system the strategies have remained fairly constant over the years, in areas of armed conflict there is constant innovation to identify new strategies to reach the inaccessible populations. The processes and systems are necessarily much more dynamic for surveillance in conflict-affected areas. The outputs are active surveillance visits to communities, collection of stool samples from healthy children from inaccessible areas, completed AFP case investigations, and laboratory test results. As with the traditional polio surveillance system, the outcome is the timely detection of AFP cases and circulation of polioviruses. While the system is quite different compared to the traditional polio surveillance system, the desired end result is the same.

As discussed in chapter 2, in the traditional polio surveillance system the primary performance monitoring indicators are the non-polio AFP rate and the stool adequacy rate. These two indicators provide a strong measure of the quality of the surveillance in normal settings. The non-polio AFP rate indicates whether sensitivity is high enough to ensure that there unlikely to be missed cases of AFP and the stool adequacy monitors whether the specimens are adequate for being able to detect polio. The non-polio AFP rate assumes however that the population is accessible and serviced by an evenly distributed network of health facilities. In a district with inaccessibility, a high non-polio AFP rate may mask gaps in surveillance in areas that do not have such as network and are not accessible. Even if those areas have small populations pockets of polio transmission could be missed, as was seen in 2016. Therefore the focus of the monitoring system in the conflict-affected areas was shifted to documentation of the settlements reached for surveillance using GPS tracking, satellite imagery to estimate the size and locations of the inaccessible populations, monitoring the absolute number of AFP cases rather than the rate, and continuous innovations to explore new methods of data analysis. These adaptations, as illustrated in the logic model below (Figure 20), allowed the program to effectively monitor performance using a surveillance performance system that was tailored to the needs of the areas of armed conflict. It should be noted that stool adequacy is still an important indicator to monitor even in areas of armed conflict. The polio surveillance analyses performed for the conflict-affected areas are more complicated and elaborate than the traditional analyses and, as described in

this study, required a very strong collaboration across multiple organizations. The sophistication of the mapping for the inaccessible areas, with multiple layers of data visualized in single maps, goes far beyond the level of mapping typically used for polio surveillance analysis and visualization.

Figure 20: Logic model for polio surveillance in areas of armed conflict and inaccessibility

Inputs	Challenges	Activities	Outputs	Monitoring process	Outcomes
Human Resources Funding GIS technology Collaboration and coordination center	Destroyed health infrastructure Inaccessible populations Lack of communication infrastructure	Surveillance by community informants and security forces Evacuation of AFP cases for case investigation Healthy children stool sampling Laboratory testing Continuous innovation in strategies to expand surveillance reach and system for monitoring progress Collaboration between partners (NGOs, CDC, WHO, etc.) in data collection and analysis of data provided by CIAs <sup>i</sup> , multiple sources of data provided by CIAs including GPS data from phones & reports of observed cases	Active surveillance visits to communities Collection of healthy children samples Case investigations Testing results Development of new strategies and analyses for increasing surveillance reach in inaccessible areas	Mapping of settlements reached for surveillance compared to identified inhabited settlements from satellite imagery analyses Number of AFP cases reported Number of community informants Laboratory results	Timely detection of AFP cases and circulation of polioviruses

<sup>i</sup> CIA stands for community informants in inaccessible areas, a group that conducts community surveillance in inaccessible areas.

## Reflections on the conceptual framework

The original conceptual framework for this study placed equal importance on 6 inhibitors of public health surveillance in areas of armed conflict: access, communication, health infrastructure, overall infrastructure, trauma, and health impacts of conflict (malnutrition and disease outbreaks). What came out of the study was that the primary inhibitors in the conflict in Borno were the issue of inaccessibility, lack of communication, and a destroyed health infrastructure. While the other challenges were seen as important, they were not seen as the overriding adaptive challenge.

The conceptual framework included 7 novel approaches: community informants, GIS technology, security support, sampling beyond AFP cases, tailored monitoring indicators, and profiling of displaced people. All of these were viewed as important but the primary strategies that the respondents felt were most impactful were the use of community informants and use of GIS technology, both at the macro level to estimate inhabitation and at the micro level to track surveillance visits. The use of security support was also seen as important although it was considered limited in its impact. Profiling of displaced people was seen as very helpful although it was recognized that it could not replace actual surveillance in the inaccessible areas. Collection of samples beyond AFP cases was also seen as helpful although it was not clear what could be deduced for the lack of positive polio virus in a small convenience sample of healthy children.

The use of tailored surveillance performance indicators was also a major aspect of the strategy for the conflict areas of Borno. Use of process indicators to track surveillance activities and a focus on the number and location of detected AFP cases rather than the rate of detection were the key monitoring strategies. In non-conflict areas the rate of detection (rate of AFP cases per 100,000 children under 15 years of age) is considered a good indication of the quality of surveillance in a given area. For areas with accessibility limitations however the rate can lead to an overconfidence in the sensitivity of the surveillance system by masking areas where surveillance activities are not conducted. Negotiated access was not discussed in the same

way as in other conflicts in that there were no meetings with Boko Haram to discuss access to the trapped population. The conflict in Borno is unique in that Boko Haram is a shadowy organization and not open to negotiation. It does seem however that, at the ground level, important negotiations between community informants and Boko Haram members were taking place which enabled the community informants to evacuate AFP cases for investigation.

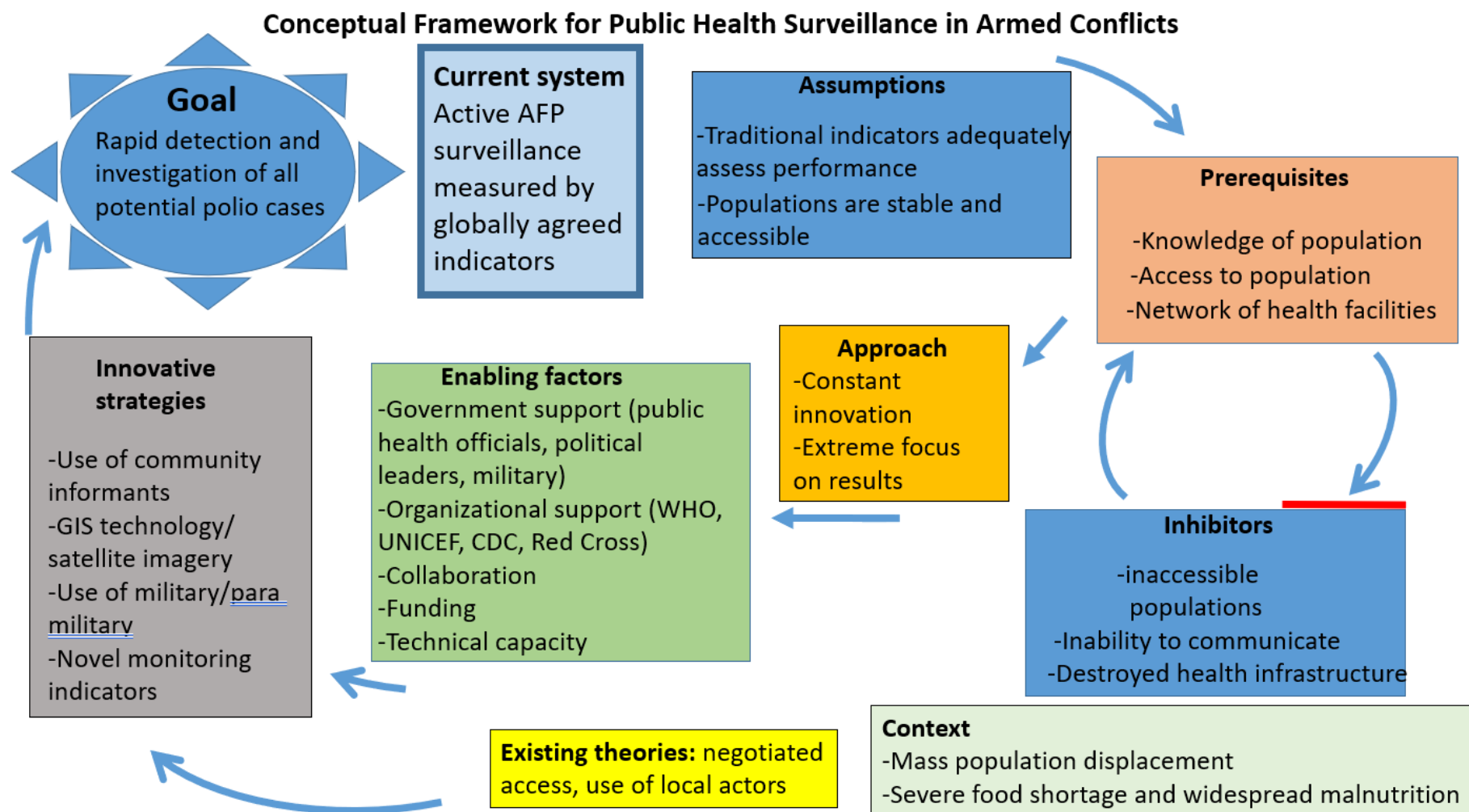
Many respondents spoke of the importance of the enabling factors for the surveillance work in the conflict areas. These included substantial funding from donor agencies, particularly the Bill and Melinda Gates Foundation. They also included the polio Emergency Operations Center in Borno, which served as the hub for the work of planning and monitoring the surveillance in conflict areas of Borno. The availability of partner staff was also seen as a major enabling factor. The work of conducting surveillance among the inaccessible population is much more intensive than traditional surveillance and required a large workforce to manage this including a team of GIS and data specialists. The importance of collaboration and effective communication among a team comprised of many different organizations was a major factor in the effectiveness of the surveillance work in Borno. There were concerns raised about the sustainability of this approach given the heavy investments needed.

One area that came out from this study that was not included in the original conceptual framework is the need for constant innovation and perseverance in the face of seemingly insurmountable adaptive challenges. The polio program in Borno was constantly reviewing the progress and looking for new and better ways of increasing the reach of the program. This culture of intense innovation may, in part, be the result of the failure to detect the ongoing wild polio virus transmission in Borno prior to 2016. This was a big shock to the program and, until then, the program was confident that their system was good enough to detect any polio. Indeed, Nigeria was removed from the list of polio endemic countries because the Nigeria polio program felt confident that their surveillance system was working even in the conflict areas. The entire Global Polio Eradication Initiative, from the heads of major donor organizations to the leads of agencies and down were focused on finding out what went wrong and correcting it. This put

tremendous pressure on the program in Borno to do things differently, show accountability and transparency, and make progress. **It was this culture of constant innovation and piloting new approaches, even in the face of danger, that led to the improvements in surveillance that occurred over time from 2016-2020.**

Based on these findings the revised conceptual framework for this topic is visualized in Figure 21. In the revised conceptual framework the main inhibitors are inaccessibility, inability to communicate, and a destroyed health infrastructure. A new box is added to present the approach of constant innovation with an extreme focus on achieving results. This approach, coupled with the enabling factors, leads to the development of the innovative strategies of community informants, GIS technology, and use of military support. It also leads to the development of new tailored monitoring indicators. The context is the situation of mass population displacement as well as severe and widespread malnutrition. The existing theories are important in formulating the new strategies but the innovations expand beyond the existing theories and are tailored to the local situation.

Figure 21: Revised conceptual framework



## Level of success in implementing AFP surveillance in Borno

Through all the work of the polio program in Borno state, great strides were made in improving AFP surveillance in the conflict areas of Borno. The number of settlements not being reached for surveillance decreased from above 50% to around 10%. The number of AFP cases detected and tested from inaccessible areas also increased dramatically, from almost none in 2016 to 164 in 2019. Equally important, the program was able to demonstrate these successes through innovative use of GIS technology to assess inhabitation status in the inaccessible areas and track the surveillance visits of the community informants and security teams (RES and RIC). All of this resulted in the African Regional Certification Committee deciding to certify Nigeria as free from wild polio virus in June of 2020. This was the main hurdle for the certification of the entire African region as wild polio free, which occurred in August of 2020. This was a tremendous achievement for Nigeria, the African region, and GPEI in its mission to eradicate polio globally.

The surveillance however is still imperfect with gaps in the reach of surveillance in Bama, Dikwa, and Abadam districts in particular, delays in collection of specimens from AFP cases, challenges in collecting contact specimens from AFP cases, and questions about potential undetected cases. The Borno polio program is continuing to chip away at these remaining challenges and is making continued progress. The strategies currently being used are appropriate for the current situation but, given the dynamic nature of the conflict, new strategies may be needed as the situation changes. It seems that the program is currently robust enough to continue adapting as needed. However, the ability of the program to meet the challenges is dependent on the continued availability of sufficient resources to keep the program going. It is unclear how long the investments from donors will continue to be sufficient for this work.

## Ethical issues with working in conflict areas

The inherent tension between ensuring the highest possible surveillance quality and protecting the safety of the people conducting surveillance came out in the discussions. Several respondents mentioned that polio surveillance workers had been injured or killed in the line of work and many mentioned the risks they are taking and the palpable fear that envelopes those areas. Specifically, many mentioned the concern that many informants have of using phones to track their movements in the inaccessible areas. The fact that the informants and families of AFP cases are provided incentives to report and evacuate cases seems effective but raises the question of whether they are risking their safety for the sake of those incentives (given the extreme poverty and scarcity of food in the inaccessible areas). While the work of the polio program is working to improve the health of the local population and prevent paralysis and death caused by polio, it is unclear where the line should be drawn between achieving the program's goals and putting people's lives in danger. The polio program is trying to protect their workers as much as possible, and many respondents reported that the community informants choose for themselves the areas that they think they can safely reach. Nevertheless, the polio program has been more daring than other programs in the humanitarian response, including the food distribution agencies and has been willing to take greater chances than the rest of the humanitarian response in reaching the trapped population. If the numbers of people killed in the line of this work continue to go up, it is likely that the program will have to rethink the strategy or focus only on areas where there is less risk involved.

## C. Reflections on the data collection and analysis process

The interviews that I conducted, the review of documents, and the analysis of the transcripts were very enlightening for me. The reach details and insights into the surveillance system, including the nature of the local level negotiation with Boko Haram, the factors that led to the complex and

effective collaborations, the importance of the enabling factors, and the culture of continuous innovation to overcome challenges. The process of conducting the interviews answered many of my questions, helped me understand the strengths and limitations of the current approaches, and also led to some new questions. I was pleasantly surprised at the consistency of information across agencies and levels. This gave me more assurance in the data and the conclusions. One limitation that surprised me was that most respondents did not have a good grasp of the data on the number of settlements being reached and the size of the unreached population. It was encouraging however to consistently hear that cases were being identified and evacuated for investigation. Based on the initial interviews, I probed more to understand how the program is tracking cases that could not be evacuated or could not be re-evacuated for the 60-day follow up as needed. I also delved further into the tools being used by the community informants including tally sheets, ODK forms, and monthly meetings. I tried to tease out the percentage of community informants that are using phones for tracking their movements but was unable to get a quantitative response other than that most CIAs were using the phones. I came to the realization however that since not all the CIAs are using the phones, the true extent of the surveillance is somewhat greater than what the data and the maps show. It was also interesting to note the evolution of the program and the comments that the strategies being used now probably would not have worked at the height of the conflict in 2014-2016 before the military had made inroads in recapturing territory from Boko Haram. It was interesting to note that several respondents reported that inaccessible populations often flee when the military arrive. This means that the military will not be able to conduct surveillance and may inaccurately report settlements as being abandoned when in fact the population has merely gone into hiding. It also became clear that there were important differences between districts that can affect the quality and completeness of surveillance. Some districts have large nomadic populations, some districts are completely inaccessible, some districts still have a sizeable number of settlements that have not been reached by any strategy, and some districts are particularly hard to reach in the rainy season.

Some new areas came to light that I had not thought of while planning this study. These include the role of the nomadic population in potentially spreading polio between accessible and inaccessible areas and the need to better track the nomadic groups for surveillance. The use of health facilities at the borders of the inaccessible areas is another potential strategy that came up in some of the interviews. Another area that was uncovered but could be pursued in greater depth is the impact of the rainy season in the ability to conduct surveillance in the inaccessible areas. For some inaccessible areas the surveillance slows down considerably during the rainy season.

## D. Reflections on the standards for reporting qualitative studies

O'Brien et al<sup>89</sup> present a list of 21 standards for reporting qualitative research by conducting a review of existing standards and consolidating and refining that list through a process of expert review. These standards can help improve the development and review of qualitative research publications similar to standards developed for quantitative research reporting. I reviewed and revised this report in an attempt to fulfill the O'Brien et al standards. Table 11 below gives a summary of each standard and whether the report meets the standard. By undergoing this exercise I was able to strengthen this report. The process of reviewing the O'Brien et al standards helped me to strengthen the report and ensure that all the relevant aspects of the study were addressed. Prior to reviewing the O'Brien et al standards I had not reported on the researcher characteristics, funding, or conflicts of interest. In addition, I had not included the type of study in the title. This highlights the value of having standards for qualitative research and reporting and the likelihood of omitting relevant information without referring to a set of standards for reporting.

*Table 11: Summary of the study's achievement of the O'Brien et al standards for qualitative research reporting<sup>89</sup>*

Standard	Met?	Comments
S1 Title	yes	

S2 Abstract	yes	
S3 Problem formulation	yes	
S4 Purpose	yes	
S5 Qualitative approach	yes	I did not specify a research paradigm for this study
S6 Researcher characteristics	yes	
S7 Context	yes	
S8 Sampling strategy	yes	
S9 Ethical issues	yes	
S10 Data collection methods	yes	
S11 Data collection instruments and technologies	yes	
S12 Units of study	yes	
S13 Data processing	yes	
S14 Data analysis	yes	
S15 Techniques to enhance trustworthiness	yes	
S16 Synthesis and interpretation	yes	
S17 Links to empirical data	yes	
S18 Contributions to the field	yes	
S19 Limitations	yes	
S20 Conflicts of interest	yes	
S21 Funding	yes	

## E. Recommendations

### Recommendations for the polio program in Borno:

1. The program is currently focused on tracking surveillance reach and increases in the number of AFP cases reported. It is important however for the program to track potentially missed AFP cases. This includes cases detected by CIAs but not evacuated and cases lost to follow up. A focus should be placed on ensuring that CIAs report the cases that they detect even if they cannot evacuate them. This could be operationalized by

training CIAs on the importance of notifying all AFP cases detected and then tracking the percentage of notified cases that are investigated and percentage of cases requiring a 60-day follow-up visit that receive it.

2. The program is focused on tracking progress towards improving the reach of surveillance, but equally important is tracking the regularity of surveillance. Currently the program considers the surveillance by CIAs as sustained but data analysis and visualization of the regularity of settlement visits by CIAs is needed to confirm this. A system for tracking and mapping the regularity of surveillance is needed to ensure that the visits by CIAs are frequent enough to detect AFP cases within 14 days of paralysis onset. This could be done for example by regularly displaying a table of the percentage of inaccessible settlements that have been reached for surveillance monthly, every 3 months, every 6 months, or less than every 6 months.
3. The program is currently focused on tracking the number of settlements that are still unreached for surveillance. This is very helpful but it would also be useful to track the number of children under 15 years of age that are unreached and also the number that are not reached regularly. This could be done by geographic blocks to better understand the likely level of contact between the populations.
4. The program is struggling to collect specimens from contacts of AFP cases in inaccessible areas. A simple system should be implemented to track and regularly report the percentage of AFP cases from inaccessible areas for which specimens were collected from contacts of the AFP case to allow the program to monitor the quality of the collection of contact specimens, which increase the likelihood of detecting poliovirus. This system could track cases with 3 contacts as recommended and also cases with 1-2 contacts and cases with 0 contacts. This is especially important to track for AFP cases that are detected late.
5. The system developed for polio surveillance by CIAs demonstrated the ability of the public health system to reach the most vulnerable children. It is now being expanded to also provide polio vaccination in some cases. This demonstrates the value of the system and the potential of the

system to do more. It would be worth exploring how to expand the system to include surveillance of other priority diseases, and also provision of other priority health services.

## **Leadership Implications: Recommendations for surveillance in areas of armed conflict outside of Borno**

1. The approach used in Borno was characterized by intense sustained efforts with large financial backing, constant innovation, strong collaboration, attention to data, and a focus on accountability and transparency. While the specific strategies needed to conduct public health surveillance will likely vary based on the local context, these overriding approaches are likely to be useful in other conflict areas. These approaches could be considered as a framework for public health interventions in other areas of armed conflict.
2. In Borno the CIAs were engaged in negotiation with Boko Haram at the local level. This type of “micro negotiation” may be useful in other areas either in conjunction with negotiation at higher levels or as a replacement for higher level negotiation. The approach in Borno involved using local community members who were known to the insurgents and could establish trust with them. The community members were carefully shielded from the official polio program to protect them from any aggression against the polio program. This approach could be promising for other conflict areas.
3. Collaboration with security forces can be a very useful approach in other conflict areas. The lessons learned from Borno may be helpful in considering this approach in other conflict areas. These include opportunistic engagement with the military in which the military looks for AFP cases while conducting their operations. This required high level advocacy and careful GIS data analysis to convince the military to participate in the polio effort. The program also reached out to local civilian security groups which proved to be very effective in Borno.
4. Finally, the use of GIS technology, both as a tool for monitoring and tracking the performance of the surveillance system and also as a tool for estimating the inhabitation status of settlements in the conflict areas, was an extremely powerful tool in Borno. Satellite imagery now covers the entire world and this approach can be useful in any conflict setting when direct visits to the conflict areas is impossible. Without the satellite imagery data, it would have been impossible for the program in Borno to know how many people were still living in the

inaccessible areas and which settlements were still inhabited. It is likely that this type of analysis would be useful in other conflict areas where there is insufficient information about the population living in the conflict areas. Machine learning technology is rapidly improving which would make this type of analysis much faster, easier, and cheaper than in the past. The use of GSP tracking devices to monitor where interventions are taking place in conflict areas is also likely to be useful in other conflict settings.

## F. Peer debriefing and member checking

To enhance the validity of this study I conducted a peer debriefing with a group of six colleagues who work on polio eradication in areas of armed conflict in Nigeria, Somalia, Pakistan, and Afghanistan. The purpose of the peer debriefing was to help reveal any hidden biases, to assess if the findings resonated with experienced colleagues not involved in the research, and to provide an opportunity to more deeply reflect on the findings with others who know the subject matter. The peers confirmed that the findings resonated with them and it was a very rich discussion. One colleague asked about the local level negotiation and whether there were differences in how the negotiations occurred between the two factions of the insurgency. Unfortunately I was not able to glean this from the interviews. A colleague also asked about whether the satellite imagery analysis could be conducted by local staff rather than by CDC staff in Atlanta. It was interesting to compare and contrast the challenges in Borno with the challenges in Somalia. For example, in Somalia there is a health system in the inaccessible areas but the polio program cannot reach it. Also, in Somalia the AFP cases are not brought out of the inaccessible areas and the investigations are done by local polio volunteers. The program in Somalia is therefore struggling with how to validate the findings of those investigations. The strategy of evacuation AFP cases for investigation may prove useful in Somalia. A question was also raised about the collaboration with the military and whether that would cause friction with the local community and the insurgency groups. The Borno polio program was very careful to keep the community informant program totally separate from the rest of the polio program for exactly that reason

and the study respondents reported that this was successful. Another colleague commented that the use of tailored surveillance indicators was a major gap in the Borno polio program in 2015-2016 and so it was gratifying to see how the program progressed in developing these new indicators. The colleague also felt that additional quantification of the cost of the program in Borno would be useful. A colleague also discussed collaborations in other countries with similar organizations to the ones the Borno program is working with, including the International Organization on Migration.

In addition to the peer debriefing I also conducted member checking exercises with study respondents. During the course of the analysis I periodically contacted various respondents to ask clarifying questions and ensure that my interpretations of the interviews were in line with their perspectives. After drafting the findings and recommendations I conducted a more formal process of convening six respondents to review the findings and recommendations. The purpose of this member checking was to allow a subset of the respondents to suggest changes or additions to ensure that the findings were not perceived as misinterpretations of the respondent data. The respondents all felt that the findings and recommendations resonated with them. They made many suggestions and observations which I attempted to incorporate into the presentation and dissertation report. Many of the questions concerned issues that I did not have time to present to them but that were included in the dissertation report. I shared a section of the dissertation with one of them after the call to confirm that my observations were accurate. The respondents also provided additional context on the different types of conflicts in Nigeria including conflicts between pastoralists and farmers in many parts of the country and emphasized that the conflict in Borno is an insurgency and is unique in Nigeria. One peer mentioned that they had collaborated with veterinarians and the Food and Agriculture Organization and I added this to the dissertation report. Another peer commented that the study did not include vaccination efforts in the areas of armed conflict. This was outside of the scope of this study but is worthy of study as discussed below in the future research section of this dissertation. Another peer emphasized that the community informants are known and trusted in the local communities and I verified with him that the way I had written this was accurate. One peer felt that the challenge of following-up with the AFP cases from the inaccessible areas should be

highlighted. I added a sentence to this section of the dissertation to ensure that this point was adequately captured. One peer felt that the issue of the regularity of the surveillance activities needed to be emphasized and I reviewed the report to make sure this came out clearly. Another peer explained that the figures in the dissertation such as number of unreached children should all be given a date because things changed so rapidly with the program in Borno and I reviewed the dissertation to ensure that the dates were included.

## G. Generalizability and lessons learned

The end result of the surveillance work in Borno state was the certification of Nigeria and the African Region as being free from wild polio virus in August 2020. This is a remarkable achievement that could not have been realized without the intense efforts to improve AFP surveillance in the conflict zones of Borno State. The African Regional Certification Commission (ARCC) requires documented proof of highly sensitive polio surveillance in all areas in order to certify a country as free from wild polio virus. Given that the last known case of wild polio in the African Region was in Borno state, there was an extreme focus on this area by the ARCC and a very high bar for demonstrating the quality of the surveillance. This was especially true after the previous claims to be wild polio virus free in Borno State turned out to be false (when the 2016 cases were detected). For this reason, Nigeria was the last country in the African Region to be certified as wild polio virus free. Wild polio virus is the naturally occurring virus that has existed for thousands of years. The use of the live attenuated polio vaccine however can result in mutations and a reversion back to a virulent form that can cause paralysis, called vaccine-derived poliovirus. It should be noted that there are still cases of vaccine derived polio in Africa and this is a major challenge to the polio eradication program. This study highlights the importance of intense efforts with large financial investments, constant innovation, strong collaboration, and a strong focus on accountability and transparency as key to the success of the surveillance improvements in the conflict areas of Borno.

The conflict in Borno State Nigeria is unique in many ways. The complete destruction of the health and communication infrastructure is unusual even for conflict settings. The complete inaccessibility of the conflict zones is also extreme and unusual. The lack of a negotiating partner is also atypical for conflicts. All of these characteristics of the Borno conflict point to the fact that the challenges to conducting surveillance in Borno were probably greater than in most conflict zones. Therefore, the strategies employed in Borno may not all be necessary for other conflicts. It is useful to know that they exist however and could be tried in other areas that present with similar challenges.

Conflict is a constant challenge in today's world. According to the UN 70.8 million people were either IDPs or refugees in 2018 as a result of conflict and persecution<sup>90</sup>. There are over 40 active conflicts in the world today<sup>91</sup>. The public health community needs to find better ways of reaching the populations living in these areas. This is true for polio eradication in Afghanistan and Yemen, and for other public health programs in many parts of the world. Many saw the conflict in Borno as too severe for sensitive polio surveillance to be possible. Indeed, the situation in 2016 seemed quite bleak. Nevertheless, this study demonstrates how effective public health surveillance can take place even in the most intractable of conflicts. It is worth mentioning however that the solutions did not take place all at once. It took years of efforts to improve the surveillance and during the height of the conflict in 2014-2016 it would not have been possible to implement the current strategies in the conflict areas.

The methods used in Borno are likely to cross over to other conflict areas around the world. These include focusing on transparency and accountability, partnering across agencies, ensuring robust financial investments, and constantly seeking new innovations. The specific strategies used in Borno may also be useful in other conflict areas. The main strategies using technology with a focus on GIS, working with the local communities, and negotiating at the ground level if not possible at higher levels proved to be very powerful tools in Borno and are likely to be valuable in other conflicts as well. Each conflict situation however has its own characteristics and particularities. For example, in some conflicts the use of smart phones would be

not be possible. Therefore, the development of effective strategies for conducting public health surveillance in areas of armed conflict must be developed from the bottom up to address the specific issues of each conflict.

## H. Future research

Literature on conducting public health interventions in areas of armed conflict remains quite limited. This study adds to the body of literature on this subject but more is needed. This study focused specifically on the Boko Haram conflict in Borno State. Additional research would be useful to better understand how the system of incentives for the community informants was developed and what impact the system had on the surveillance. Further research on the cost of the polio surveillance system in Borno, and potential ways to conduct similar efforts with fewer resources would also be helpful given the likely reduction in funding for polio in Nigeria in the coming years. Additional research would also be valuable to study the local leadership structure in the conflict affected areas and how the community informants fit into the local political and leadership structure. While Borno State is the center of the Boko Haram conflict, the conflict has spilled over into other states in northeastern Nigeria as well as parts of Cameroon, Chad, and Niger. It would be useful to conduct a larger case study of how polio surveillance is taking place in these other settings. It would also be useful to conduct similar case studies of polio surveillance in other conflict zones such as parts of Yemen, Somalia, Afghanistan, and South Sudan. Moving beyond polio, it would be useful to expand the focus of the research to learn how conflicts are impacting other public health surveillance programs and what strategies have been used to overcome the challenges. In addition, while this study focused on polio surveillance specifically, it would be useful to study how to conduct more integrated public health surveillance in conflict areas including key diseases and syndromes rather than focusing on one disease. Furthermore, this study focused on surveillance alone. However, the greater need for conflict-affected populations is the provision of public health services including vaccination, primary health care, and supplemental feeding. More research is needed to better understand the effective strategies for providing these

services in conflict zones. One potential strategy that is starting to be used for public health interventions is the use of drones for provision of health supplies in conflict-affected areas and hard to reach zones. This and other potential new technologies and strategies deserve greater attention. It was very striking in this study that no public health services were reaching the population in the inaccessible areas of Borno beyond those provided by the polio program (polio vaccination and polio surveillance). Clearly more research and programmatic work is needed to better serve these populations, the most vulnerable groups in the world.

## Annex 1: Codebook

### 1 Inhibitors

#### 1.1 Inhibitors\Nomadic population

Discussion of the nomadic population in inaccessible areas, how this population may impact polio transmission, and challenges of conducting AFP surveillance among this population.

#### 1.2 Inhibitors\Accessibility of populations

Comments related to accessibility of populations in areas of armed conflict.

#### 1.3 Inhibitors\Communication

Comments related to the ability to communicate with people in areas of armed conflict

#### 1.4 Inhibitors\Health infrastructure

Comments related to the status of health facilities in areas of armed conflict

#### 1.5 Inhibitors\Overall infrastructure

Comments related to the condition of infrastructure including roads and electricity in areas of armed conflict

#### 1.6 Inhibitors\Population movement

Comments about population movement and how it is measured in areas of armed conflict

### **1.7 Inhibitors\Traumatizing violence**

Comments about violence in areas of armed conflict and how it impacts people's ability to work effectively

### **1.8 Inhibitors\Malnutrition and disease outbreaks**

Comments about malnutrition and disease outbreaks in areas of armed conflict and how it impacts people's ability to work effectively

### **1.9 Inhibitors\Rainy season**

Information on the impact of the rainy season on conducting surveillance in inaccessible areas

## **2 Strategies**

### **2.1 Strategies\Nomadic population**

Discussion of strategies to improve AFP surveillance among nomadic populations who travel through inaccessible areas.

### **2.2 Strategies\Community informants**

Comments about the use and effectiveness of community informants for AFP surveillance in areas of armed conflict

### **2.3 Strategies\GIS technology**

Comments about the use and effectiveness of GIS technology for assessing populations and AFP surveillance reach in areas of armed conflict

### **2.4 Strategies\Collection and testing of specimens beyond AFP cases**

Comments about the use and effectiveness of collecting and testing of specimens beyond AFP cases for improving AFP surveillance sensitivity in areas of armed conflict

## **2.5 Strategies\Collaboration with security forces**

Comments about the use and effectiveness of collaboration with security forces for improving AFP surveillance reach in areas of armed conflict

## **2.6 Strategies\Profiling of displaced people**

Comments about the use and effectiveness of profiling of displaced people for improving AFP surveillance sensitivity in areas of armed conflict

## **2.7 Strategies\Evacuation**

Information about the process of evacuating AFP cases from inaccessible areas for investigation

## **3 Monitoring systems**

### **3.1 Monitoring systems\Tailored surveillance performance indicators for inaccessible a**

Comments about the use and effectiveness of tailored/modified surveillance performance indicators for improving AFP surveillance sensitivity in areas of armed conflict

### **3.2 Monitoring systems\Tailored surveillance quality assessment tools for areas that s**

Comments about the use and effectiveness of tailored/modified surveillance quality assessment tools for improving AFP surveillance sensitivity in areas of armed conflict

## **4 Collaboration and information sharing systems**

Comments about collaborating and sharing information in support of polio surveillance between humanitarian response agencies.

## Annex 2. List of key documents reviewed

#	Document	Question	Construct	Source
1	UN International Organization of Migration (IOM) Displacement Tracking Matrix (DTM) Emergency Tracking Tool (ETT) reports for Borno 20016-2019	inhibitors of effective surveillance	population movement	<a href="http://www.globaldtm.info/global/">http://www.globaldtm.info/global/</a>
2	UN Office for Coordination of Humanitarian Affairs (OCHA) reports on Borno 20016-2019	inhibitors of effective surveillance	traumatizing violence and malnutrition and disease outbreaks	<a href="https://www.humanitarianresponse.info/en/operations/nigeria/borno-state-coordination">https://www.humanitarianresponse.info/en/operations/nigeria/borno-state-coordination</a>
3	UN Office for Coordination of Humanitarian Affairs (OCHA) Lake Chad Basin Crisis Overview	inhibitors of effective surveillance	traumatizing violence, malnutrition and disease 4outbreaks	<a href="https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/lac_chad_snapshot_11_aug_2017.pdf">https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/lac_chad_snapshot_11_aug_2017.pdf</a>
4	National Primary Health Care Development Agency National Polio Eradication Emergency Plan (surveillance strengthening section).	opportunities for effective surveillance	community informants, profiling of displaced people, and use of military for surveillance in inaccessible areas.	<a href="http://polioeradication.org/wp-content/uploads/2018/04/Nigeria-National-Polio-Emergency-Plan-2018.pdf">http://polioeradication.org/wp-content/uploads/2018/04/Nigeria-National-Polio-Emergency-Plan-2018.pdf</a>
5	Global Polio Eradication Initiative (GPEI) polio updates for Borno 20016-2019	Provides information on polio cases	NA	<a href="http://polioeradication.org/">http://polioeradication.org/</a>
6	33rd meeting of the Expert Review Committee on Polio Eradication and Routine Immunization 2017	opportunities for effective surveillance	community informants, profiling of displaced people, and use of military for surveillance in inaccessible areas.	<a href="http://polioeradication.org/wp-content/uploads/2017/03/finalreport-33ERCmeeting-012017.pdf">http://polioeradication.org/wp-content/uploads/2017/03/finalreport-33ERCmeeting-012017.pdf</a>

7	News reports on Borno attacks and displacement	Provides context of the conflict. Relates to questions on inhibitors of effective surveillance	traumatizing violence and malnutrition and disease outbreaks	<a href="https://www.washingtonpost.com/world/africa/nigerian-children-who-escaped-boko-haram-say-they-faced-another-prison-military-detention/2019/09/14/e30a0da2-d40c-11e9-8924-1db7dac797fb_story.html">https://www.washingtonpost.com/world/africa/nigerian-children-who-escaped-boko-haram-say-they-faced-another-prison-military-detention/2019/09/14/e30a0da2-d40c-11e9-8924-1db7dac797fb_story.html</a> ; <a href="https://www.nytimes.com/2019/09/13/world/africa/nigeria-boko-haram.html">https://www.nytimes.com/2019/09/13/world/africa/nigeria-boko-haram.html</a> ; <a href="https://www.msn.com/en-us/news/world/action-against-hunger-nigeria-army-accuses-international-aid-agency-of-feeding-boko-haram-terrorists/ar-AAHA9nN">https://www.msn.com/en-us/news/world/action-against-hunger-nigeria-army-accuses-international-aid-agency-of-feeding-boko-haram-terrorists/ar-AAHA9nN</a>
8	Article on finding inhabited settlements and tracking vaccination in Borno (Higgins et al 2019)	inhibitors of effective surveillance	construct use of GIS technology	<a href="https://ij-healthgeographics.biomedcentral.com/articles/10.1186/s12942-019-0175-y">https://ij-healthgeographics.biomedcentral.com/articles/10.1186/s12942-019-0175-y</a>
9	Polio Independent Monitoring Board (IMB) review of polio endemic countries (2018)	Provides context to the surveillance challenges		<a href="http://polioeradication.org/tools-and-library/policy-reports/imb-resources/reports/">http://polioeradication.org/tools-and-library/policy-reports/imb-resources/reports/</a>
10	WHO–recommended standards for surveillance of selected vaccine-preventable diseases*- polio (2018)	monitoring systems and indicators for surveillance	performance indicators for inaccessible areas	<a href="https://www.who.int/immunization/monitoring_surveillance/burden/vpd/WHO_SurveillanceVaccinePreventable_18_Polio_R2.pdf?ua=1">https://www.who.int/immunization/monitoring_surveillance/burden/vpd/WHO_SurveillanceVaccinePreventable_18_Polio_R2.pdf?ua=1</a>
11	Analyzing disrupted health sectors, a modular manual 2009. (Modules 2 and 4)	monitoring systems and indicators for surveillance and on inhibitors of effective surveillance	performance indicators for inaccessible areas and on population movement.	<a href="https://www.who.int/hac/techguidance/tools/disrupted_sectors/en/">https://www.who.int/hac/techguidance/tools/disrupted_sectors/en/</a>
12	Northeast Nigeria Humanitarian Response bulletin. Borno State Government.	inhibitors of effective surveillance	health infrastructure and malnutrition and disease outbreaks	<a href="https://reliefweb.int/sites/reliefweb.int/files/resources/health_sector_bulletin_july_19_ne_nigeria.pdf">https://reliefweb.int/sites/reliefweb.int/files/resources/health_sector_bulletin_july_19_ne_nigeria.pdf</a>

13	USAID Lake Chad Basin Complex Emergency	inhibitors of effective surveillance	population movement and malnutrition. Also provide data on funding for emergency response efforts which is an enabling factor in the conceptual framework	<a href="https://www.usaid.gov/sites/default/files/documents/1866/05.12.17_-_USAID-DCHA_Lake_Chad_Basin_Complex_Emergency_Fact_Sheet_15.pdf">https://www.usaid.gov/sites/default/files/documents/1866/05.12.17 - USAID-DCHA Lake Chad Basin Complex Emergency Fact Sheet 15.pdf</a>
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## Annex 3: Interview guides

### Field surveillance officer interview (those involved in collecting data)

1. Please describe the situation of inaccessibility and conflict in your area.
2. Please describe your involvement in AFP surveillance in inaccessible areas of Borno.
3. Please describe the major challenges to conducting surveillance among this population. (probe – please give examples)

#### Inhibitors

4. How is population accessibility impacting AFP surveillance? (pre-requisite construct: access to population)
5. How is communication infrastructure impacting AFP surveillance? (inhibitor construct: inability to communicate)
6. How is health infrastructure impacting AFP surveillance? (inhibitor construct: destroyed infrastructure)
7. How is overall infrastructure impacting AFP surveillance? (inhibitor construct: destroyed infrastructure)
8. How is population movement impacting AFP surveillance? (inhibitor construct: dynamic population movement)
9. How is the psychological trauma caused by the armed conflict impacting AFP surveillance? (inhibitor construct: atmosphere of traumatizing violence)
10. How are malnutrition and disease outbreaks impacting AFP surveillance? (inhibitor construct: widespread malnutrition and disease outbreaks)
11. Are there other factors that are impacting effective AFP surveillance in conflict-affected areas of Borno? Please describe.
12. Is there a difference between rainy season and dry season in accessibility and ability to conduct AFP surveillance in inaccessible areas?

### Opportunities (strategies and field methods) for effective surveillance in conflict-affected areas

13. Please describe the approaches (combination of strategies) used for AFP surveillance in inaccessible areas. (probe)
14. Please describe any new methods that have been used to improve surveillance in inaccessible areas. What has been successful? What has not been successful? (probe)
  - a. Could community informants be used to supplement traditional surveillance methods? How? (Novel tools construct: community informants)
  - b. Could GIS technology be used to supplement traditional surveillance methods? How? (Novel tools construct: use of GIS)
  - c. Could the collection of specimens beyond AFP cases such as environmental surveillance sweeps and health children stool surveys improve surveillance? How? (Novel tools construct: stools surveillance and environmental surveillance sweeps)
  - d. Could security forces support surveillance? How? (Novel tools construct: use of military/paramilitary)
  - e. Could profiling of displaced people supplement the traditional surveillance? How? (Novel tools construct: profiling displaced people)
15. Can you tell me about your experiences with evacuation?

- a. Under what circumstances can detected AFP cases in inaccessible areas be evacuated for investigation and for 60-day follow up? (inhibitor construct: inaccessible population)
  - b. How long does it take to evacuate an AFP case from an inaccessible area? (inhibitor construct: inaccessible population)
  - c. What means of transportation are available for evacuating AFP cases from inaccessible areas? (inhibitor construct: inaccessible population)
16. Are there other opportunities for effective surveillance that we have not discussed? (probe)

#### **Monitoring systems and indicators for monitoring surveillance performance in inaccessible areas**

17. Please describe the indicators used to monitor the performance of AFP surveillance in inaccessible areas. (probe) (Novel tools construct: use of tailored process performance indicators)
18. What new indicators could be useful for monitoring surveillance performance? Are there indicators of active surveillance activities that could be monitored? (Novel tools construct: use of tailored process performance indicators)
19. Please describe the assessment tools used to monitor the performance of AFP surveillance in inaccessible areas. (probe) (Novel tools construct: use of tailored process performance indicators)
20. What new assessment tools could be useful for assessing surveillance performance? (Novel tools construct: use of tailored process performance indicators)
21. How can the quality of surveillance be assessed in inaccessible areas (likelihood that any AFP case would be detected and reported)? (probe) (Novel tools construct: use of tailored process performance indicators)
22. How can the accuracy of surveillance be assessed in inaccessible areas (accuracy of the information collected from detected AFP cases including date of onset, symptoms, true AFP, vaccination status, date of specimen collection, location of case, 60-day follow up investigation)? (probe) (Novel tools construct: use of tailored process performance indicators)
23. How can the reach of surveillance (which areas are covered by surveillance informants and which areas are not covered) be assessed for inaccessible areas? (probe) (Novel tools construct: use of tailored process performance indicators)

#### **Collaboration Mechanisms**

24. What agencies are involved in the humanitarian response in this LGA (district)?
25. What systems are in place to share information between the various agencies that are involved in the humanitarian response in this LGA?
26. What systems are in place for collaborate between the various agencies that are involved in the humanitarian response in this LGA?
27. How might these systems benefit AFP surveillance in this LGA?

## **State level: Data manager and epidemiologist interview (those involved in using data)**

1. Please describe the situation of conflict and inaccessibility in Borno.
2. Please describe your involvement in AFP surveillance in inaccessible areas of Borno.
3. Please describe the major challenges to conducting surveillance among this population. (probe – please give examples)

### **Inhibitors**

4. How is population accessibility impacting AFP surveillance? (pre-requisite construct: access to population)
5. How is communication infrastructure impacting AFP surveillance? (inhibitor construct: inability to communicate)
6. How is health infrastructure impacting AFP surveillance? (inhibitor construct: destroyed infrastructure)
7. How is overall infrastructure impacting AFP surveillance? (inhibitor construct: destroyed infrastructure)
8. How is population movement impacting AFP surveillance? (inhibitor construct: dynamic population movement)
9. How is the psychological trauma caused by the armed conflict impacting AFP surveillance? (inhibitor construct: atmosphere of traumatizing violence)
10. How are malnutrition and disease outbreaks impacting AFP surveillance? (inhibitor construct: widespread malnutrition and disease outbreaks)
11. Are there other factors that are impacting effective AFP surveillance in conflict-affected areas of Borno? Please describe.
12. Is there a difference between rainy season and dry season in accessibility and ability to conduct AFP surveillance in inaccessible areas?

### **Opportunities (strategies and field methods) for effective surveillance in conflict-affected areas**

13. Please describe the approaches (combination of strategies) used for AFP surveillance in inaccessible areas. (probe)
14. Please describe any new methods that have been used to improve surveillance in inaccessible areas. What has been successful? What has not been successful? (probe)
  - a. Could community informants be used to supplement traditional surveillance methods? How? (Novel tools construct: community informants)
  - b. Could GIS technology be used to supplement traditional surveillance methods? How? (Novel tools construct: use of GIS)
  - c. Could the collection of specimens beyond AFP cases such as environmental surveillance sweeps and health children stool surveys improve surveillance? How? (Novel tools construct: stools surveillance and environmental surveillance sweeps)
  - d. Could security forces support surveillance? How? (Novel tools construct: use of military/paramilitary)
  - e. Could profiling of displaced people supplement the traditional surveillance? How? (Novel tools construct: profiling displaced people)
15. Can you tell me about your experiences with evacuation?
  - a. Under what circumstances can detected AFP cases in inaccessible areas be evacuated for investigation and for 60-day follow up? (inhibitor construct: inaccessible population)
  - b. How long does it take to evacuate an AFP case from an inaccessible area? (inhibitor construct: inaccessible population)
  - c. What means of transportation are available for evacuating AFP cases from inaccessible areas? (inhibitor construct: inaccessible population)

16. Are there other opportunities for effective surveillance that we have not discussed? (probe)

### **Monitoring and assessment**

17. Please describe your involvement in using AFP surveillance data from inaccessible areas of Borno.
18. Please describe the major challenges to monitoring surveillance among this population. (probe)
19. Please describe the indicators and tools used to monitor the performance of AFP surveillance in inaccessible areas. ((give examples)) (Novel tools construct: use of tailored process performance indicators)
20. Please describe how surveillance data from inaccessible areas of Borno are analyzed (probe) (Novel tools construct: use of tailored process performance indicators)
21. Please describe how surveillance data from inaccessible areas of Borno are used (probe) (Novel tools construct: use of tailored process performance indicators)
22. Please describe any new methods that have been used to improve surveillance monitoring in inaccessible areas. What has been successful? What has not been successful? (probe) (Novel tools construct: use of tailored process performance indicators)
23. What new indicators could be useful for monitoring surveillance performance? Are there indicators of active surveillance activities that could be monitored? (Novel tools construct: use of tailored process performance indicators)
  - a. Could data from community informants be used to strengthen surveillance monitoring? How? (Novel tools construct: use of tailored process performance indicators)
  - b. Could GIS technology be used to strengthen surveillance monitoring? How? (Novel tools construct: use of GIS)
  - c. Could data from environmental surveillance sweeps and health children stool surveys improve surveillance monitoring? How? (Novel tools construct: use of environmental surveillance sweeps and healthy children stool surveys)
  - d. Could data from security forces strengthen surveillance monitoring? How? (Novel tools construct: use of military)
  - e. Could data from profiling of displaced people strengthen surveillance monitoring? How? (Novel tools construct: use of profiling of displaced people)
  - f. Other
24. Please describe the assessment tools used to evaluation the performance of AFP surveillance in inaccessible areas. (probe) (Novel tools construct: use of tailored process performance indicators)
25. What new assessment tools could be useful for evaluating surveillance performance? (Novel tools construct: use of tailored process performance indicators)
26. Do you have ideas or recommendations of opportunities to improve surveillance in inaccessible areas?

### **Collaboration Mechanisms**

27. What agencies are involved in the humanitarian response in Borno?
28. What systems are in place to share information between the various agencies that are involved in the humanitarian response in Borno?
29. What systems are in place for collaboration between the various agencies that are involved in the humanitarian response in Borno?
30. How might these systems benefit AFP surveillance in Borno?

## Annex 4: Study Sample

### Borno State level potential interviewees

Number	Name/position	Level	Organization	Focus
1	National polio EOC officer (with a focus on Borno)	National	CDC	surveillance/SIA
2	Borno support officer	Borno State	CDC	Surveillance
3	NSTOP state coordinator	Borno State	NSTOP	Oversight of NSTOP in Borno
4	NSTOP outbreak officer	Borno State	NSTOP	surveillance/SIA
5	NSTOP surveillance officer	Borno State	NSTOP	surveillance/SIA
6	NSTOP data manager	Borno State	NSTOP	data analysis
7	WHO surveillance officer	Borno State	WHO	surveillance/SIA
8	WHO Borno State Coordinator	Borno State	WHO	Oversight of WHO in Borno
9	Core Group state coordinator	Borno State	Core group	Oversight of Core group in Borno
10	Polio EOC Incident Manager	Borno State	SPHCDA	surveillance/SIA
11	State surveillance officer	Borno State	SPHCDA	surveillance/SIA
12	Data support team	Borno State	Ehealth	data analysis
13	WHO data manager	Borno State	Ehealth	data analysis
14	Humanitarian support	Borno State	OCHA	Humanitarian support (coordination of emergencies)
15	Humanitarian support	Borno State	IOM	Humanitarian support (IDPs)
16	Humanitarian support	Borno State	Medecins Sans Frontiers (MSF)	Humanitarian support (medical support)
17	Humanitarian support	Borno State	Nigerian Red Cross Society	Humanitarian support (health outreach)

#### *Table notes*

*CDC: CDC is a founding partner in the Global Polio Eradication Initiative. CDC staff in the sample have been providing field support for strengthening surveillance and supplemental immunization activities in Borno for several years.*

*NSTOP: NSTOP is a CDC-funded polio program that was created in 2012 to support polio eradication activities in northern Nigeria. They have over 245 staff across the country working at both the state and district levels including 27 staff in Borno.*

*WHO: The World Health Organization provides support for all aspects of the immunization program in Nigeria. They have over 2,500 staff across the country including over 30 staff in Borno state.*

*Core Group: The Core Group is a USAID funded program that supports community based AFP surveillance among hard to reach and conflict-affected communities.*

*SPHCDA: Borno State's State Primary Health Care Development Agency (SPHCDA) is charged with overseeing primary health care, including polio eradication activities.*

*Ehealth: Ehealth Africa is an NGO focused on providing technological support for public health initiatives. They have been supporting the polio in Nigeria since 2012.*

*OCHA: OCHA is the UN office responsible for the coordination of humanitarian emergencies.*

*IOM: IOM is responsible for supporting the safety of migrants including internally displaced people and refugees.*

*MSF: Medecins Sans Frontiers (MSF) is a medical humanitarian organization that provides health care to populations affected by emergencies including armed conflict.*

*Nigerian Red Cross Society: Nigerian Red Cross Society is an organization dedicated to supporting vulnerable populations in Nigeria including those affected by armed conflict.*

#### Borno district level potential interviewees

Number	Name/postion	Level	Organization	Focus
1	NSTOP Local Government Officer (NSLO)	Bama LGA (district)	NSTOP	surveillance/SIA
2	NSTOP Local Government Officer (NSLO)	Marte LGA (district)	NSTOP	surveillance/SIA
3	NSTOP Local Government Officer (NSLO)	Guzamala LGA (district)	NSTOP	surveillance/SIA
4	NSTOP Local Government Officer (NSLO)	Abadam LGA (district)	NSTOP	surveillance/SIA
5	NSTOP Local Government Officer (NSLO)	Gwoza LGA (district)	NSTOP	surveillance/SIA
6	NSTOP Local Government Officer (NSLO)	Mungono LGA (district)	NSTOP	surveillance/SIA
7	WHO Local Government Facilitator (LGF)	Bama LGA (district)	WHO	surveillance/SIA
8	WHO Local Government Facilitator (LGF)	Marte LGA (district)	WHO	surveillance/SIA
9	WHO Local Government Facilitator (LGF)	Guzamala LGA (district)	WHO	surveillance/SIA
10	WHO Local Government Facilitator (LGF)	Abadam LGA (district)	WHO	surveillance/SIA
11	WHO Local Government Facilitator (LGF)	Gwoza LGA (district)	WHO	surveillance/SIA
12	WHO Local Government Facilitator (LGF)	Mungono LGA (district)	WHO	surveillance/SIA
13	LGA Disease Surveillance Notification Officer (DSNO)	Bama LGA (district)	SPHCDA	surveillance/SIA

14	LGA Disease Surveillance Notification Officer (DSNO)	Marte LGA (district)	SPHCDA	surveillance/SIA
15	LGA Disease Surveillance Notification Officer (DSNO)	Guzamala LGA (district)	SPHCDA	surveillance/SIA
16	LGA Disease Surveillance Notification Officer (DSNO)	Abadam LGA (district)	SPHCDA	surveillance/SIA
17	LGA Disease Surveillance Notification Officer (DSNO)	Gwoza LGA (district)	SPHCDA	surveillance/SIA
18	LGA Disease Surveillance Notification Officer (DSNO)	Mungono LGA (district)	SPHCDA	surveillance/SIA
19	WHO field volunteer	Bama LGA (district)	WHO	surveillance/SIA
20	WHO field volunteer	Marte LGA (district)	WHO	surveillance/SIA
21	WHO field volunteer	Guzamala LGA (district)	WHO	surveillance/SIA
22	WHO field volunteer	Abadam LGA (district)	WHO	surveillance/SIA
23	WHO field volunteer	Gwoza LGA (district)	WHO	surveillance/SIA
24	WHO field volunteer	Mungono LGA (district)	WHO	surveillance/SIA
25	Unicef Volunteer Community Mobilizer	Bama LGA (district)	Unicef	surveillance/SIA
26	Unicef Volunteer Community Mobilizer	Marte LGA (district)	Unicef	surveillance/SIA
27	Unicef Volunteer Community Mobilizer	Guzamala LGA (district)	Unicef	surveillance/SIA
28	Unicef Volunteer Community Mobilizer	Abadam LGA (district)	Unicef	surveillance/SIA
29	Unicef Volunteer Community Mobilizer	Gwoza LGA (district)	Unicef	surveillance/SIA
30	Unicef Volunteer Community Mobilizer	Mungono LGA (district)	Unicef	surveillance/SIA

*Table Notes:*

*NSTOP Local Government Officers are NSTOP staff at the district level who work to build immunization and surveillance capacity of the district health officers*

*WHO Local Government Facilitators are WHO staff at the district level who work to improve surveillance sensitivity and vaccination quality at the district level*

*WHO field volunteers are WHO staff at the ward level who work to improve surveillance sensitivity and vaccination quality at the ward level*

*Unicef Volunteer Community Mobilizers are Unicef staff at the community level who work to improve immunization coverage and surveillance quality at the community level.*

## Annex 5: Code Book Linked to Study Questions and Constructs

Table 6: Codebook for data analysis

Subquestion	Construct	Subsconstructs	Definition/Memo
1. What are the inhibitors (barriers) of effective surveillance?	Accessibility of populations	Who has access, how do they go in and out, how often do they have access, geographic area of access, opportunities for access, limits and levels of accessibility, restriction in movement of local residents (within BH areas and out of BH areas).	Comments related to accessibility of populations in areas of armed conflict.
1. What are the inhibitors (barriers) of effective surveillance?	Communication	Mail, Phone, Email, Cell Phone call, Cell Phone Text, satellite phones, informal communication channels. Transmission of medical information, radio communication.	Comments related to the ability to communicate with people in areas of armed conflict
1. What are the inhibitors (barriers) of effective surveillance?	Health infrastructure	Status of health facilities (fully operational, partially operational (describe what services are provided), destroyed, partially destroyed, closed), health care access, distribution of clinics	Comments related to the status of health facilities in areas of armed conflict
1. What are the inhibitors (barriers) of effective surveillance?	Overall infrastructure	Roads, electricity, gas stations, computers, refrigeration capacity, vehicles,	Comments related to the condition of infrastructure including roads and electricity in areas of armed conflict

1. What are the inhibitors (barriers) of effective surveillance?	Population movement	Changes in population, displaced population, returning population, timing of movement, place of movement, new settlements, abandoned settlements, destroyed settlements.	Comments about population movement and how it is measured in areas of armed conflict
1. What are the inhibitors (barriers) of effective surveillance?	Traumatizing violence	Attacks, bombs, rapes, slaves, hostages, killings, fleeing, roadside bombs, terrorists, terror attacks, injured people, traumatized people, people with conflict related mental health problems	Comments about violence in areas of armed conflict and how it impacts people's ability to work effectively
1. What are the inhibitors (barriers) of effective surveillance?	Malnutrition and disease outbreaks	Severe malnutrition, famine, diarrhea, measles, cholera, malaria, meningitis, outbreak response, feeding center, competing priorities	Comments about malnutrition and disease outbreaks in areas of armed conflict and how it impacts people's ability to work effectively
2. What opportunities (strategies and field methods) would enable effective surveillance in these settings?	Community informants	Traditional leader, village health volunteer, informant, surveillance focal person, patent medicine vendor, traditional healer, nurse, traditional birth attendant, barber, religious leader, village chief	Comments about the use and effectiveness of community informants for AFP surveillance in areas of armed conflict

2. What opportunities (strategies and field methods) would enable effective surveillance in these settings?	GIS technology	satellite imagery, settlement inhabitation status, vaccination tracking, surveillance tracking, case verification, open data kit (ODK), integrated supportive supervision (ISS), audio visual AFP detection and reporting (AVADAR), electronic surveillance (eSURV), population estimates	Comments about the use and effectiveness of GIS technology for assessing populations and AFP surveillance reach in areas of armed conflict
2. What opportunities (strategies and field methods) would enable effective surveillance in these settings?	Collection and testing of specimens beyond AFP cases	Environmental surveillance, ad-hoc environmental surveillance, healthy children stool surveys, specimen collection from contacts of AFP cases, specimen collection from recent escapees from inaccessible areas.	Comments about the use and effectiveness of collecting and testing of specimens beyond AFP cases for improving AFP surveillance sensitivity in areas of armed conflict
2. What opportunities (strategies and field methods) would enable effective surveillance in these settings?	Collaboration with security forces	Civilian joint task force, military, reaching every settlement strategy (RES), reaching inaccessible children strategy (RIC)	Comments about the use and effectiveness of collaboration with security forces for improving AFP surveillance reach in areas of armed conflict

2. What opportunities (strategies and field methods) would enable effective surveillance in these settings?	Profiling of displaced people	Data collection from displaced persons including location of home, time of displacement, route taken out of inaccessible area, vaccination status of children, existence of AFP cases, information on populations left behind in inaccessible areas.	Comments about the use and effectiveness of profiling of displaced people for improving AFP surveillance sensitivity in areas of armed conflict
3. What monitoring systems and indicators may be useful in monitoring surveillance performance in inaccessible areas?	Tailored surveillance performance indicators for inaccessible areas	Frequency of active surveillance, documentation of active surveillance, areas covered by active surveillance, active surveillance reports, level of accuracy of reported AFP cases (true AFP cases, correct date of onset, correct number of vaccine doses received), number of late cases reported from previously unreachable areas (cases reported >14 days after paralysis onset), methods of active surveillance.	Comments about the use and effectiveness of tailored surveillance performance indicators for improving AFP surveillance sensitivity in areas of armed conflict

3. What monitoring systems and indicators may be useful in monitoring surveillance performance in inaccessible areas?	Tailored surveillance quality assessment tools for areas that supervisors cannot reach	Cross verification of areas reported to be visited with assessments of settlement inhabitation (are surveillance activities reported from uninhabited areas), number of AFP cases reported (are unexpected numbers of cases reported), detailed interviews with surveillance informants (community or military) to understand in more detail the extent and quality of the activities they conducted, mapping of areas reached for surveillance.	Comments about the use and effectiveness of tailored surveillance quality assessment tools for improving AFP surveillance sensitivity in areas of armed conflict
4. What system are in place for collaboration and information sharing for polio surveillance between the various actors (governmental, non-governmental, and multinational) that are supporting the humanitarian response in Borno?	Collaboration and information sharing systems	<ul style="list-style-type: none"> <li>• Agencies involved in the humanitarian response</li> <li>• Information sharing systems in between agencies involved in the Borno humanitarian response</li> <li>• Systems for collaboration between agencies</li> <li>• Benefits of systems for AFP surveillance</li> </ul>	Emergency response, Humanitarian response, NGO, MSF, Red Cross, OCHA, IOM

## Annex 6: Excerpt of Memo List

Overview of Memos

Document group	Document	Document set	Title	Author	Last changed	Preview	Origin	Beginning	End
Interview notes	Notes Forbi Interview ...		Memo 2	ejv2	4/24/2020 11:47 AM	Note - is there an element of time and regularity or just yes/n	In-document	56	56
Interview notes	Notes Forbi Interview ...		Memo 3	ejv2	4/24/2020 11:49 AM	ask others what percentage of CIIA are doing geocoding	In-document	59	59
Interview notes	Notes Forbi Interview ...		Memo 4	ejv2	4/24/2020 2:34 PM	ask if there is mapping of settlements not reached but CIIA.	In-document	59	59
Interview notes	Notes Forbi Interview ...		Memo 5	ejv2	4/24/2020 11:52 AM	Would be good to ask about what is done when unexpectedly high	In-document	89	89
Interviews	Respondent 1: CDC stat...		Memo 28	ejv2	6/22/2020 5:53 PM		In-document	32	35
Interviews	Respondent 1: CDC stat...		Memo 29	ejv2	7/3/2020 9:33 AM	New inhibitor - the high amount of resources (money and people)	In-document	49	49
Interviews	Respondent 1: CDC stat...		Memo 30	ejv2	7/3/2020 9:41 AM	This is a new potential strategy for border areas - conduct sur	In-document	95	106
Interviews	Respondent 1: CDC stat...		Memo 31	ejv2	7/3/2020 9:51 AM	This is a new potential challenge - cultural barriers of not br	In-document	140	140
Interviews	Respondent 1: CDC stat...		Memo 32	ejv2	7/3/2020 9:55 AM	Challenges of monitoring the progress with RIC. Challenge in k	In-document	153	156
Interviews	Respondent 1: CDC stat...		Memo 33	ejv2	7/3/2020 3:10 PM	The community informants could be members of Boko Haram	In-document	170	170
Interviews	Respondent 1: CDC stat...		Memo 34	ejv2	7/3/2020 3:14 PM	some people in inaccessible areas refuse to come out (be evacua	In-document	207	208
Interviews	Respondent 1: CDC stat...		Memo 35	ejv2	7/3/2020 3:15 PM	I couldn't find any mention of this elsewhere and he didn't see	In-document	214	215
Interviews	Respondent 1: CDC stat...		Memo 36	ejv2	7/3/2020 3:20 PM	Danger to CIAs in using phones for geocoding their active surv	In-document	282	283
Interviews	Respondent 1: CDC stat...		Memo 37	ejv2	7/3/2020 3:22 PM	he didn't seem very confident about this	In-document	304	304
Interviews	Respondent 1: CDC stat...		Memo 38	ejv2	7/3/2020 3:31 PM	Nomadic population	In-document	372	376
Interviews	Respondent 1: NSTOP ...		Memo 41	ejv2	7/6/2020 3:06 PM	some areas remain strongholds for Boko Haram and are more dange	In-document	51	53
Interviews	Respondent 3: NSTOP ...		Memo 42	ejv2	7/6/2020 3:07 PM	useful quote for communication	In-document	55	55
Interviews	Respondent 3: NSTOP ...		Memo 43	ejv2	7/6/2020 3:13 PM	Boko Haram does not allow satellite phones	In-document	59	59
Interviews	Respondent 3: NSTOP ...		Memo 44	ejv2	7/6/2020 3:19 PM	surveillance officers are timid about conducting surveillance b	In-document	94	94
Interviews	Respondent 3: NSTOP ...		Memo 45	ejv2	7/6/2020 3:20 PM	cases of weakness due to malnutrition may be incorrectly diagno	In-document	98	98
Interviews	Respondent 3: NSTOP ...		Memo 46	ejv2	7/6/2020 3:23 PM	good quote on the impact of trauma on surveillance	In-document	108	108
Interviews	Respondent 3: NSTOP ...		Memo 47	ejv2	7/6/2020 3:25 PM	Military has challenges to reach inaccessible areas during rain	In-document	116	116
Interviews	Respondent 3: NSTOP ...		Memo 48	ejv2	7/6/2020 3:26 PM	some areas particularly cut off during rains - Kala Balge and N	In-document	120	122
Interviews	Respondent 3: NSTOP ...		Memo 49	ejv2	7/6/2020 3:36 PM	keeping a low profile and working discreetly when evacuating ca	In-document	145	145
Interviews	Respondent 3: NSTOP ...		Memo 50	ejv2	7/6/2020 3:37 PM	34,000 children under 5 years of age still not being reached e	In-document	164	164
Interviews	Respondent 3: NSTOP ...		Memo 51	ejv2	7/6/2020 3:38 PM	evolution of the strategy to target unreachable settlements.	In-document	170	170
Interviews	Respondent 3: NSTOP ...		Memo 52	ejv2	7/6/2020 3:40 PM	CIAs may be Boko Haram or BH sympathizers	In-document	174	174

## Annex 7: Code relation browsers

### Code relation browser for inhibitors

**Code Relations Browser**

The interface displays a matrix of relationships between various code systems and inhibitors. The columns represent different inhibitors, and the rows represent different code systems. The relationships are indicated by colored squares: blue for a weak relationship, red for a strong relationship, and dark blue for a very strong relationship.

Code System	Inhibitors	Nomadic population	Accessibility of populations	Communication	Health infrastructure	Overall infrastructure	Population movement	Traumatizing violence	Malnutrition and disease outbreaks	Rainy season	Other
<b>Inhibitors</b>											
Nomadic population											
Accessibility of populations											
Communication											
Health infrastructure											
Overall infrastructure											
Population movement											
Traumatizing violence											
Malnutrition and disease outbreaks											
Rainy season											
Other											
<b>Strategies</b>											
Nomadic population											
Community informants											
GIS technology											
Collection and testing of specimens bey											
Collaboration with security forces											
Profiling of displaced people											
Evacuation											
Other											
<b>Monitoring systems</b>											
Tailored surveillance performance indic											
Tailored surveillance quality assessment											
Other											
Collaboration and informations sharing syste											

## Code relations browser for strategies

**Code Relations Browser**

Code System	Strategies	Nomadic population	Community informants	GIS technology	Collection and testing of specimens beyond AFP cases	Collaboration with security forces	Profiling of displaced people	Evacuation	Other
▼ Inhibitors									
Nomadic population		■							■
Accessibility of populations		■	■					■	
Communication									
Health infrastructure									
Overall infrastructure			■					■	
Population movement			■	■			■		
Traumatizing violence			■	■		■			
Malnutrition and disease outbreaks									
Rainy season		■				■			
Other									
▼ Strategies									
Nomadic population			■	■		■			■
Community informants	■	■		■	■	■		■	
GIS technology			■	■		■	■		
Collection and testing of specimens bey			■					■	
Collaboration with security forces		■	■	■				■	
Profiling of displaced people				■					
Evacuation			■		■	■			
Other		■							
▼ Monitoring systems									
Tailored surveillance performance indic		■	■	■		■	■	■	■
Tailored surveillance quality assessment									
Other									
Collaboration and informations sharing syste		■							

## Code Relations Browser

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 Code Relations Browser

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