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Diphtheria Outbreak Response and Mitigation Strategies in Nigeria: A Case Study of the Nigerian Red Cross Society (NRCS) Intervention

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: The diphtheria outbreak in Nigeria, starting in December 2022, presented a significant public health challenge with over 16,000 confirmed cases by December 2023. The outbreak predominantly affected children in underserved communities, particularly in northern states such as Kano, Yobe, and Katsina, highlighting critical gaps in vaccination coverage and healthcare infrastructure. The outbreak began to diminish by October 2023, following intensified vaccination and surveillance efforts, and saw significant control measures leading to its near conclusion by February 2024.

Methods: This study analyzes the operational response by the Nigerian Red Cross Society (NRCS), the International Federation of Red Cross and Red Crescent Societies (IFRC), the Nigeria Centre for Disease Control (NCDC), and the National Primary Health Care Development Agency (NPHCDA). Data from operational reports, community-based surveillance, immunization campaigns, and health promotion efforts were reviewed to assess intervention effectiveness.

Results: Coordinated strategies such as active case search, enhanced surveillance, and community engagement effectively reduced transmission and improved vaccine uptake. Risk communication and community engagement (RCCE) programs helped overcome cultural and religious vaccine hesitancy, while enhanced surveillance facilitated early detection. Operational challenges included low vaccine coverage, limited health infrastructure, and misinformation.

Conclusion: The NRCS-led multi-agency response was instrumental in controlling the outbreak, demonstrating the necessity of integrated public health strategies. Sustained investment in healthcare infrastructure, equitable vaccine access, and digital health technologies is essential for future outbreak prevention and early response, ensuring Nigeria's resilience against similar health emergencies.

Keywords: Diphtheria; vaccination; surveillance; RCCE; Nigeria.

1. INTRODUCTION

The diphtheria outbreak in Nigeria, which began in Kano State in December 2022, rapidly spread to neighbouring states, affecting diverse communities and exposing significant gaps in vaccination coverage and healthcare infrastructure. By December 2023, over 16,000 confirmed cases were reported, making this outbreak the most severe in more than a decade, surpassing the 2011 outbreak in both scale and mortality (WHO 2023).

Diphtheria is a highly contagious and potentially fatal bacterial infection (Harapan et al. 2019). It occurs mainly in low-resource countries, especially where poor sanitation and vaccination uptake and coverage are low. The signs and symptoms include fever, sore throat, enlarged lymph nodes, barking cough, difficulty swallowing, and air passage obstruction (Olulaja et al. 2023). The release of toxins capable of damaging organs can lead to severe complications, including respiratory failure, cardiac issues, and even death. As one of the tropical countries, Nigeria has witnessed a surge in diphtheria cases. The diphtheria outbreak in Nigeria primarily affects children aged 0-14, with Kano state being the epicentre of the crisis (WHO 2020). This article investigated the emergency response to diphtheria by the Nigerian Red Cross Society (NRCS), highlighting key strategies employed. The Nigerian Red Cross Society (NRCS) was established through an Act of the Parliament in 1960. The Red Cross Act of 1960, CAP 324 states in Section 5 (1) that 'the Society shall be recognized by the Government of the Federation as a Voluntary Aid Society, auxiliary to the public authorities. The support from the International Federation of Red Cross and Red Crescent Societies (IFRC) in scaling up its Emergency Appeal expanded the response of the Nigeria Red Cross Society to more states in the country.

The Nigerian Red Cross Society (NRCS) has been at the forefront of this effort, leveraging its unique position as an auxiliary to public authorities to support the emergency response. The NRCS, in collaboration with the Nigerian Centre for Disease Control (NCDC), the National Primary Health Care Development Agency (NPHCDA), and other partners, has implemented a multi-faceted approach to address the various dimensions of the crisis. This response is made possible by support from the International

Federation of Red Cross and Red Crescent Societies (IFRC), enabling the NRCS to expand its reach and impact across multiple states.

The NRCS's approach integrates risk communication, community engagement, vaccination campaigns, and surveillance measures to address the outbreak. Risk communication and community engagement have been critical in dispelling misconceptions and promoting vaccination acceptance among diverse socio-cultural groups. Vaccination efforts have focused on increasing coverage and addressing cultural and religious barriers to immunization. Surveillance measures include active case searching, laboratory confirmation, and data analysis to inform targeted interventions. Standardized protocols and continuous evaluation ensure the quality and effectiveness of the response.

By early 2024, Nigeria had recorded over 28,975 suspected cases of diphtheria, with 16,518 confirmed cases and 839 deaths (case fatality rate of 5.0%). Kano, Yobe, and Katsina were among the states worst hit, accounting for over 96% of the confirmed cases. Many factors, including densely populated living conditions, low vaccination rates, and poor sanitation, contributed to the outbreak's rapid spread. Diphtheria is easily transmissible through respiratory droplets, and communities with limited healthcare access were at heightened risk. The impact of a strained healthcare system on controlling outbreaks is similarly illustrated in Yemen’s diphtheria outbreak, where conflict significantly hampered response efforts (Dureab et al. 2019). These areas, often characterized by both rural and urban populations, have significant portions of Nigeria's population, and their accessibility varies. Rural areas often face challenges in healthcare infrastructure and vaccine delivery, contributing to higher risks of infectious disease outbreaks. Additionally, certain ethnic groups in these regions harbor beliefs that may hinder vaccination efforts, exacerbating the situation.

Key gaps highlighted by the outbreak included low vaccination coverage, inadequate health infrastructure, and a lack of trust in vaccines due to misinformation and cultural beliefs. Many regions had poor access to healthcare, and despite significant efforts by the Nigerian Red Cross Society (NRCS), vaccine uptake remained low. Addressing these issues required strengthening healthcare infrastructure, improving vaccine distribution systems, and engaging in robust community outreach to build trust. With over 16,000 confirmed cases by the end of 2023, primarily affecting children in underserved regions, the outbreak showed the urgent need for effective response strategies. This study focuses on the interventions led by the Nigerian Red Cross Society (NRCS), in collaboration with national and international partners, to mitigate the crisis. Key efforts included community-level risk communication, vaccination campaigns, active surveillance, and the use of locally trained volunteers to address cultural and religious barriers to vaccination. Diphtheria outbreaks in low-resource settings are not new, but their resurgence highlights ongoing challenges in public health systems. As seen in the Lao People's Democratic Republic (Sein et al. 2016), similar outbreaks emphasize the necessity of improving vaccination efforts and surveillance systems to control the spread of diphtheria (Harapan et al. 2017). examined Indonesia’s 2017 diphtheria outbreak, showing how inadequate immunization coverage and weak healthcare infrastructure allowed the disease to spread rapidly. They emphasized the importance of community engagement and culturally sensitive vaccination campaigns, lessons that resonate with the current Nigerian context.

Similarly, (Olulaja et al. 2023). explored Nigeria’s recurrent diphtheria outbreaks, attributing them to gaps in vaccination, misinformation, and a lack of preparedness in the healthcare system. They argued for stronger surveillance and risk communication strategies, highlighting the need to build trust within communities to improve vaccination uptake.

Prior to the diphtheria outbreak, vaccination coverage in Nigeria was suboptimal, especially in the northern regions. Routine immunization rates were lower in these areas due to factors such as cultural and religious beliefs, misinformation, and inadequate healthcare infrastructure. According to the United Nations Children’s Fund (UNICEF), immunization campaigns, particularly against diseases like diphtheria, faced challenges with uptake in some parts of Nigeria, primarily in underserved and rural areas. Before the 2022–2023 outbreak, Nigeria's immunization coverage for diphtheria toxoid-containing vaccines was not at the levels needed to establish herd immunity, contributing to the resurgence of the disease (Harapan et al. 2017, Olulaja et al. 2023). Additionally, the unprecedented COVID-19

pandemic exacerbated these existing challenges by disrupting vaccination schedules and healthcare services. Lockdowns, limited healthcare access, and fear of exposure to the virus led to further declines in routine immunization coverage (WHO 2020). This disruption, particularly in northern Nigeria, compounded the vulnerability of the population to diphtheria outbreaks, as many children missed vital immunization doses during the pandemic (UNICEF, 2020). These gaps in vaccine coverage and healthcare infrastructure created a perfect storm for the resurgence of preventable diseases such as diphtheria.

Building on these insights, this study focuses on the Nigerian Red Cross Society's (NRCS) response to the 2022–2023 outbreak. What sets this research apart is its detailed look at how local solutions like community-based surveillance, culturally tailored vaccination drives, and digital health innovations can make a real difference. By documenting these efforts, the study offers practical, field-tested strategies that can help other countries facing similar public health crises.

In essence, this research isn't just about data, it's about people. It's about how, even in challenging circumstances, thoughtful interventions can save lives and build stronger, more resilient communities.

The findings aim to inform future public health strategies by emphasizing the importance of integrating community participation, robust surveillance systems, and digital health technologies into outbreak responses. Strengthening vaccination programs, enhancing health infrastructure, and ensuring equitable access to healthcare are essential for sustained progress. This study documents the lessons learned from the diphtheria outbreak and serves as a blueprint for improving Nigeria's preparedness and resilience against future health emergencies.

1.1 Objectives

The research provides a comprehensive analysis of the NRCS's multi-faceted approach to outbreak management, evaluating successes such as increased vaccine uptake and community engagement while identifying persistent challenges, including resource limitations and misinformation. It highlights how tailored risk communication strategies helped dispel myths and foster trust among communities, particularly in regions resistant to immunization. Additionally, the use of community-based surveillance by trained volunteers was critical in detecting and managing suspected cases and preventing further spread of the disease.

This study aims to:

1. Evaluate the effectiveness of the multi-agency response led by the NRCS, NCDC, NPHCDA, and IFRC.
2. Analyze the impact of risk communication and community engagement (RCCE) strategies on vaccine acceptance.
3. Identify operational challenges and propose recommendations for strengthening future outbreak response frameworks in Nigeria.

2. METHODOLOGY

2.1 Study Design

This research utilizes operational reports, situation updates, and the NRCS and IFRC intervention records to assess the response mechanisms employed. Data collection also involved reviewing the community-based surveillance activities, vaccination campaigns, health promotion efforts, and psychosocial support programs executed in the affected regions. Key stakeholders in the diphtheria response include the Nigerian government, NCDC, NRCS, IFRC, WHO, and various local community leaders. Their collaborative efforts form the basis of the intervention strategies examined.

2.2 Study Area

The intervention was conducted across 13 Nigerian states where diphtheria outbreaks were reported: Kano, Osun, Borno, Yobe, Kaduna, Jigawa, Lagos, FCT, Kastina, Taraba, Jos, Gombe, and Zamfara. These states were selected based on the severity of the outbreak. The severity of the diphtheria outbreak was determined by factors such as the number of suspected and confirmed cases, hospitalization rates, and mortality rates. For example, Kano, Yobe, and Katsina states were identified as having high case counts, with Kano alone reporting 3,234 suspected cases and 1,207 confirmed cases. Other key indicators for assessing severity included the number of deaths (e.g., Kano had 100 deaths, a case

fatality rate of 8.3%) and the geographic spread across local government areas (LGAs).

2.3 Study Design

This study employs a mixed-methods approach, combining qualitative analysis of operational and intervention reports with quantitative data from vaccination coverage and case surveillance records to assess the effectiveness of diphtheria outbreak response strategies.

2.4 Sampling Method

The study employed purposive sampling to select 13 states affected by the diphtheria outbreak, focusing on regions with high case counts and significant intervention activities. Documents were sourced from key stakeholders, including NRCS, IFRC, and NCDC, ensuring comprehensive coverage of intervention strategies across different contexts.

2.5 Data Analysis

Quantitative data on vaccination coverage and case surveillance were analyzed using IBM SPSS Version 29, employing descriptive statistics to summarize vaccination uptake and case trends. Qualitative data, including internal reports and feedback from stakeholders, were thematically analyzed using NVivo software, focusing on key response strategies and operational challenges.

3. DOCUMENT AND CASE ANALYSIS OF THE NRCS APPROACH

Internal reports, response plans, and evaluation documents from the NRCS, IFRC, the Nigerian Centre for Disease Control and Prevention (NCDC), the National Primary Health Care Development Agency (NPHCDA) and relevant resource documents from the World Health organization were analyzed. These documents provided valuable insights into the operational aspects of the response.

3.1 Risk Communication and Community Engagement

Effective risk communication and community engagement are crucial components of emergency response efforts, especially in the case of a diphtheria outbreak. In Nigeria, the Nigerian Red Cross Society (NRCS), the Nigerian Centre for Disease Control (NCDC), and the National Primary Health Care Development Agency (NPHCDA) play critical roles in mitigating the diphtheria crisis through the RCCE programme. Risk communication involves a real-time exchange of information and the dissemination of warnings, advice, and instructions between experts or officials and people who face a threat (hazard) to their survival, health, or economic or social well-being (WHO 2020). It is a vital tool for maintaining public awareness, building trust, and fostering collaboration between response organizations and communities. In Nigeria's context of a diphtheria outbreak, risk communication helps inform the population about the disease, its transmission, symptoms, and prevention methods. Moreover, it assists in dispelling rumours and misconceptions about diphtheria, promoting appropriate healthcare-seeking behaviour among affected communities. By incorporating information from scientific literature, risk communication efforts can effectively communicate the outbreak's severity, the importance of preventive measures, and the efficacy of available treatments. This information empowers individuals to make informed decisions about their health and encourages them to seek timely medical assistance. Engaging Communities in Emergency Response to effectively respond to the diphtheria outbreak in Nigeria community engagement is crucial. Involving community members in all stages of emergency response helps ensure a more comprehensive and culturally appropriate approach. By actively engaging the community, response organizations can better understand local beliefs, practices, and concerns related to diphtheria. This knowledge allows for the development of targeted strategies that resonate with the community and encourage active participation. Engaging communities by incorporating their voices and concerns into response strategies fosters trust and drives wider community participation. In any emergency response, effective risk communication and community engagement are crucial. The affected communities need to be well-informed about the nature of diphtheria, its prevention, and the available treatment options. Developing targeted communication strategies that resonate with diverse socio-cultural contexts within these states is vital. This was done by the community volunteers trained by the NCDC and the NPHCDA, who also worked with health professionals, community leaders, religious leaders, and other key influencers. Through this effort, the community was actively participating in

preventing and controlling the spread of the disease.

- Community Awareness and Education: The RCCE strategies implemented by the NRCS and its partners were instrumental in raising awareness about diphtheria, its symptoms, and prevention methods. The dissemination of accurate information helped dispel myths and misconceptions, which are often barriers to effective disease management in communities.
- Engagement with Community Leaders: By involving community leaders, religious figures, and influencers, the NRCS was able to foster trust and ensure the cultural relevance of its messages. This engagement proved crucial in areas where cultural and religious beliefs influenced vaccine hesitancy.
- Use of Local Volunteers: The deployment of trained community volunteers to conduct door-to-door visits and organize community meetings allowed for direct interaction with residents, facilitating personalized communication and fostering a sense of community ownership over health initiatives.
- Feedback Mechanisms: Establishing channels for community feedback through the CEA component enabled the NRCS to tailor its communication strategies to better meet the population's needs and concerns. This two-way communication approach enhanced the community's trust and empowered individuals to take proactive steps in disease prevention.

Effective RCCE requires a deep understanding of a community's cultural and social dynamics. Tailoring messages to align with local values and beliefs is essential for gaining community trust and cooperation.

Sustained community engagement is vital for building resilience against future outbreaks. Continuous dialogue with communities helps maintain awareness and preparedness even after an outbreak has been controlled.

3.2 Vaccination Coverage

Vaccination Coverage According to the United Nations Children Fund 2019, Immunization is one of public health's most successful and cost-effective interventions (United Nations Children's Fund 2019). The Nigerian Red Cross Society has played a critical role in supporting the coverage of diphtheria vaccines nationwide. Vaccination is the most effective way to prevent the spread of diphtheria, and the Nigerian Red Cross Society has worked tirelessly to ensure that as many people as possible have access to this life-saving vaccine. Primarily, there are barriers to vaccination; in certain parts of the country, especially the Northern region, there are some cultural and religious beliefs against taking vaccines, with resultant low acceptance and uptake of immunization, including diphtheria -toxoid-containing pentavalent vaccine (Ibrahim et al. 2022). Due to the Nigerian Red Cross Society's diligence, dedication, and support from the International Federation of the Red Cross and Red Crescent Societies, the country has made significant strides in improving diphtheria vaccine coverage. By focusing on education, advocacy, and community outreach, they have raised awareness about the importance of vaccination and addressed common misconceptions. This has resulted in an increase in vaccine acceptance among Nigerians, ultimately contributing to a reduction in diphtheria cases.

One key initiative the Nigerian Red Cross Society has undertaken is education. They have conducted numerous information campaigns to educate the public about the risks of diphtheria and the benefits of vaccination. Through workshops, seminars, and community meetings, they have provided accurate information and addressed concerns or doubts that individuals may have had. The Nigerian Red Cross Society has also been actively engaged in advocacy efforts with the government and other stakeholders. To reach even the most remote areas, they have partnered with local healthcare organizations, government institutions, and international agencies to ensure the seamless delivery of vaccines. They have been champions of policies and initiatives that aim to improve vaccine accessibility and affordability, ensuring that more Nigerians can receive the diphtheria vaccine. Furthermore, the society has carried out extensive community outreach programs. Volunteers and health workers go door-to-door, conducting vaccination drives and providing information about diphtheria and other preventable diseases. These efforts have helped to reach underserved populations and improve vaccine coverage in remote areas. Not only does high vaccine coverage prevent individual cases of diphtheria, but it also helps to establish herd immunity within communities. This means that

even those unable to receive the vaccine, such as infants or individuals with certain medical conditions, are protected from the disease because most of the population is vaccinated. Achieving and maintaining high diphtheria vaccine coverage is, therefore, crucial for the overall health and well-being of the Nigerian population.

3.3 Surveillance Measure

In terms of disease control, surveillance refers to the systematic collection, analysis, and interpretation of health data for preventive action. Poor surveillance and lack of capacity for diagnosis have led to the underreporting of the burden of diphtheria in Nigeria (Rintani et al. 2018). This informed the Nigerian Red Cross Society to support the NCDC in its Surveillance pillar. The surveillance measures implemented in Nigeria's emergency diphtheria response follow a well-structured framework. This framework includes Active case Search, laboratory confirmation, Contact tracing, reporting, data collection, analysis, and dissemination of findings. Each step is critical in providing a wholesome picture of the disease's prevalence and guiding response strategies. The first surveillance measure involves Active case Search, NRCS-trained community volunteers with the Disease Surveillance and Notification Officers (DSNOs) supported by NCDC, and NPHCDA, actively search for suspected cases of diphtheria through house-to-house visits, health facilities, and community outreach programs. Early identification of cases is essential to prevent the disease from spreading further, saving lives. Once suspected cases are identified, laboratory confirmation becomes imperative. This involves collecting clinical samples, such as throat swabs, from suspected cases and sending them to designated laboratories for testing. In collaboration with other partners, NCDC ensures that these laboratories are equipped with the necessary reagents and trained personnel to conduct accurate and timely diagnostic tests. Following laboratory confirmation, cases are promptly reported to the central surveillance system, and contact tracing is initiated with a 10-day follow-up. As the coordinating body, the NCDC collates all relevant information to track the outbreak's magnitude and geographical spread. This enables decision-makers to understand the current situation better and allocate resources accordingly. Additionally, data collection is an integral component of surveillance measures. Community volunteers diligently collect epidemiological information from each identified case, recording vital demographic details such as age, sex, immunization status, and geographic location. This data is then directly entered into an electronic database called SORMAS, The SORMAS (Surveillance Outbreak Response Management and Analysis System) database is a digital tool used for tracking disease outbreaks in Nigeria. It plays a critical role in the diphtheria outbreak response by managing data on case reporting, contact tracing, and vaccination coverage. This system ensures that real-time data is collected, analyzed, and disseminated to public health officials, allowing for a coordinated and effective response to the outbreak. Data analysis is the next crucial step in surveillance. Epidemiologists and statisticians used specialized software such as IBM SPSS and NVivo to analyze the data collected during the outbreak. SPSS was employed for quantitative analysis, including descriptive statistics to summarize vaccination uptake and case trends, while NVivo was used for qualitative data analysis, focusing on the response strategies and challenges faced during the outbreak. This analysis helped identify key patterns and risk factors to inform targeted interventions. These findings help guide response strategies, such as targeted vaccination campaigns in high-risk areas, and inform policy decisions to minimize the disease's impact. Finally, the dissemination of surveillance findings is of utmost importance. In collaboration with other stakeholders, NCDC shares regular updates on the outbreak's progress, including the number of cases, deaths, and areas affected. This information is available to healthcare professionals, government agencies, and the public. It increases awareness and empowers individuals to take appropriate preventive measures and seek early medical attention. The comprehensive surveillance measures implemented by NRCS, NCDC, and NPHCDA in response to the diphtheria outbreak in Nigeria have proven to be highly effective. The collaborative efforts of these organizations, along with the support of other partners, have enabled the prompt detection, confirmation, reporting, and analysis of cases. This has facilitated evidence-based decision-making and the implementation of targeted interventions. However, it is crucial to acknowledge the challenges that surveillance teams face while executing these measures. The vastness of Nigeria's geography and security situations make access to some communities challenging, hindering the timely detection and reporting of cases. Moreover, the limited

availability of trained personnel and laboratory capacity further strain the surveillance system. Addressing these challenges requires continued investment in infrastructure, human resources, and training programs. In conclusion, the surveillance measures implemented as part of the emergency diphtheria response in Nigeria have played a vital role in curbing the spread of this disease. Case detection, laboratory confirmation, reporting, data collection, analysis, and dissemination of findings form a well-structured framework that enables effective response strategies. However, ongoing efforts to strengthen the surveillance system are crucial to ensure the timely identification and control of future disease outbreaks. The emergency diphtheria response in Nigeria has required a coordinated and multi-faceted approach. The support provided by the NRCS, NCDC, and NPHCDA in resource allocation and capacity building has been crucial in controlling the outbreak. Through their collaborative efforts, these organizations have ensured the availability and distribution of essential resources and the training of healthcare workers. The efforts and remarkable progress towards the containment of the diphtheria outbreak in Nigeria prove the effectiveness of these collaborative efforts. However, sustaining these efforts and strengthening the healthcare system to prevent future outbreaks and protect the population from infectious diseases is essential.

3.4 Standardization and Evaluation

Standardization and evaluation play a vital role in ensuring the quality and effectiveness of emergency diphtheria response. Developing standardized guidelines and protocols will promote consistency in diagnosis, treatment, and infection control measures across the affected states. Regular evaluation of response activities helps identify improvement areas, validate interventions' effectiveness, and ensure accountability. This requires the establishment of monitoring and evaluation systems and the integration of feedback from both healthcare professionals and affected communities. The NRCS, NCDC, NPHCDA and other partners worked together to establish standardized protocols and guidelines for various aspects of the response. These include case definition, laboratory testing, treatment protocols, contact tracing, and surveillance. By standardizing these processes, the organizations have ensured that healthcare workers across different regions follow uniform procedures, improving accuracy in diagnosis, treatment, and reporting of diphtheria cases. Standardization has also facilitated effective coordination and communication among the organizations involved in the response. The NRCS has played a significant role in standardizing community-based interventions. They have developed guidelines for health education campaigns, vaccination strategies, and contact tracing protocols. These guidelines have been disseminated to NRCS volunteers and other healthcare workers involved in the response, ensuring a consistent approach to delivering essential services to affected communities. The NCDC has contributed to standardization by providing technical expertise and guidance in developing national diphtheria surveillance, laboratory testing, and case management guidelines. These guidelines have been widely adopted by healthcare facilities nationwide, promoting uniformity in the response. Evaluation is essential to assess the effectiveness of emergency response and identify areas for improvement. The NRCS, NCDC, and NPHCDA have recognized the importance of evaluation and have implemented various mechanisms to monitor and evaluate the diphtheria response in Nigeria. These organizations have established surveillance systems to track the number of diphtheria cases, identify trends, and monitor the impact of interventions. Through these surveillance systems, they can assess the effectiveness of vaccination campaigns, contact tracing efforts, and treatment protocols.

3.5 Learning and Adaptation

The diphtheria outbreak in Nigeria has highlighted several key lessons and areas for improvement. First, Strengthening Surveillance Systems. The diphtheria outbreak revealed weaknesses in Nigeria's surveillance systems, such as delays in case detection and reporting, insufficient laboratory capacity, and challenges in reaching remote areas. These gaps hindered timely response and required the NRCS and NCDC to enhance case detection through active case searches, improved data management, and better coordination among health agencies. Enhancing these systems is crucial for early identification and containment of outbreaks. This is based on the observation made by the researchers at the epicentre of the disease in Ungogo LGA, Kano State, Nigeria. More responders need to employ surveillance mechanisms during similar outbreaks.

Effective data management systems are crucial at all stages of an outbreak for accurately identifying and recording cases. Precise data collection allows health officials to track the spread of diphtheria, identify hotspots, and implement targeted interventions. Timely data collection ensures current and actionable information, enabling rapid decision-making and resource allocation. For instance, the early identification of cases in Lagos led to swift containment actions, such as targeted vaccination campaigns, active surveillance, and immediate isolation of confirmed cases. Local health authorities, supported by NRCS-trained volunteers, conducted door-to-door visits to detect suspected cases and provided information about the disease and preventive measures. Robust data management systems enhance surveillance capabilities, allowing for continuous outbreak monitoring. By maintaining comprehensive records, community health officials can detect trends, monitor the effectiveness of interventions, and adjust strategies as needed. Enhanced surveillance during the diphtheria outbreak enabled health workers to track the spread of the disease, identify areas with low vaccine coverage, and prioritize these regions for vaccination campaigns.

In addition, there was a shortfall in vaccine coverage, particularly in underserved communities. Some health facilities do not have an adequate supply of vaccines. Ensuring widespread and equitable access to vaccines is vital in preventing future outbreaks. Also, misinformation and lack of awareness about diphtheria and the importance of vaccination were evident. Public health campaigns are necessary to educate communities on the benefits of vaccines and the dangers of vaccine-preventable diseases (Harapan et al. 2017). The community-based volunteers of the NRCS were deployed in major affected communities. They incorporated risk communication and community engagement activities, forming the bulk of the public awareness. Such education needs strengthening as a means of preparedness. Engaging local communities in outbreak response efforts is crucial. Community leaders and influencers can significantly promote vaccination and adherence to public health guidelines as CBVs of NRCS and NCDC staff cascade this information in various communities.

Moreover, on Health Infrastructure The outbreak strained Nigeria's health infrastructure, highlighting the need for improved healthcare facilities, especially in rural and hard-to-reach areas in states like Kano, Osun, Borno, Yobe, Kaduna, Jigawa, Lagos, Zamfara, Katsina, etc. Investment in health infrastructure is essential for effective disease management and response. Investment in Health Infrastructure: Investment in health infrastructure is crucial to managing outbreaks. This includes strengthening healthcare facilities, particularly in rural and hard-to-reach areas, improving laboratory capacity for diagnostics, and enhancing the cold chain for vaccine distribution. Effective disease management requires adequate isolation centers, trained healthcare workers, and sufficient medical supplies to prevent further spread. It is also commendable that some states, like Kano, had about three isolation and case management centres. Rapid Response and Coordination problem is another lesson to learn from the outbreak. The outbreak emphasized the need for a coordinated and rapid response from national and international health bodies. Establishing and maintaining strong partnerships and communication channels is key to managing public health emergencies. Also, there is a need for continuous training and capacity building for healthcare workers to ensure they are well-prepared to handle outbreaks. This includes training on the latest diagnosis, treatment, and vaccination protocols. Some facilities visited by the NDRTs of NRCS revealed the need for continuous capacity building of the primary health care worker towards managing outbreaks. Good Policy and adequate funding are key factors to take out from the diphtheria outbreak. The outbreak underscored the importance of robust policies and adequate funding for infectious disease prevention and control. Sustainable funding mechanisms are essential for maintaining public health initiatives and emergency preparedness at facility and community levels. Finally, research and development are very important, as they ensure that findings and outcomes are properly documented for further studies. Investing in research to better understand the epidemiology of diphtheria and other infectious diseases can inform more effective prevention and control strategies. This includes studying vaccine efficacy and the potential emergence of new strains.

4. RESULTS AND DISCUSSION

4.1 Community-Based Surveillance

Over 1,300 volunteers were trained in active case search and contact tracing. The training

involved practical sessions on identifying and reporting suspected cases, with a focus on working with the Local Government Disease Surveillance and Notification Officers to use the SORMAS database for data collection. The selection of volunteers was based on their community involvement and their ability to mobilize others for health interventions. The training duration and content varied, but it typically included health education, surveillance techniques, and Infection Prevention and control protocols. These efforts led to the identification of 6,972 suspected cases of diphtheria, many of which were later confirmed by health authorities. The volunteers were critical in ensuring that individuals with symptoms were rapidly identified, reported, and referred for treatment Sources (Olulaja et al. 2023).

4.2 Vaccination Campaigns

Routine immunization was intensified, particularly in Kano, Katsina, and Osun states. A total of 120 vaccination teams were deployed, reaching thousands of children and zero-dose individuals. Despite these efforts, vaccination coverage remained low, with only 42% of children under 15 years fully immunized. However, the NRCS's mobilization of parents and caregivers contributed to improved access to vaccines in hard-to-reach communities (Olulaja et al., 2023).

Table 1. The number of suspected and confirmed cases in each state which highlights the reach and effectiveness of surveillance efforts.

State	Suspected Cases	Confirmed Cases	Percentage of Confirmed Cases	Deaths among Confirmed Cases (CFR)	LGAs with Suspected Cases	LGAs with Confirmed Cases
Kano	3,234	1,207	37.3%	100 (8.3%)	35	27
Yobe	477	252	52.8%	23 (9.1%)	12	8
Katsina	132	9	6.8%	2 (22.2%)	22	5
Kaduna	101	5	5.0%	0	12	2
Bauchi	54	41	75.9%	6 (14.6%)	6	2
FCT	41	6	14.6%	1 (16.7%)	4	5
Lagos	30	8	26.7%	5 (62.5%)	10	5
Sokoto	14	0	0%	-	2	-
Zamfara	13	0	0%	-	3	-
Niger	11	2	18.2%	0	3	1
Enugu	9	0	0%	-	1	-
Osun	9	1	11.1%	0	5	1
Gombe	7	2	28.6%	0	2	1
Oyo	7	0	0%	-	6	-
Jigawa	4	1	25.0%	0	4	1
Kebbi	3	0	0%	-	2	-
Ondo	2	0	0%	-	2	-
Edo	2	0	0%	-	1	-
Borno	2	0	0%	-	2	-
Ogun	1	0	0%	-	1	-
Cross River	1	1	100%	-	1	1
Kwara	1	0	0%	-	1	-
Bayelsa	1	0	0%	-	1	-
Delta	1	0	0%	-	1	-
Nasarawa	1	0	0%	-	1	-
Ekiti	1	0	0%	-	1	-
Anambra	1	0	0%	-	1	-
Total	4,160	1,534	36.9%	137 deaths (8.9%)	139 LGAs	56 LGAs

Source: NCDC 2023

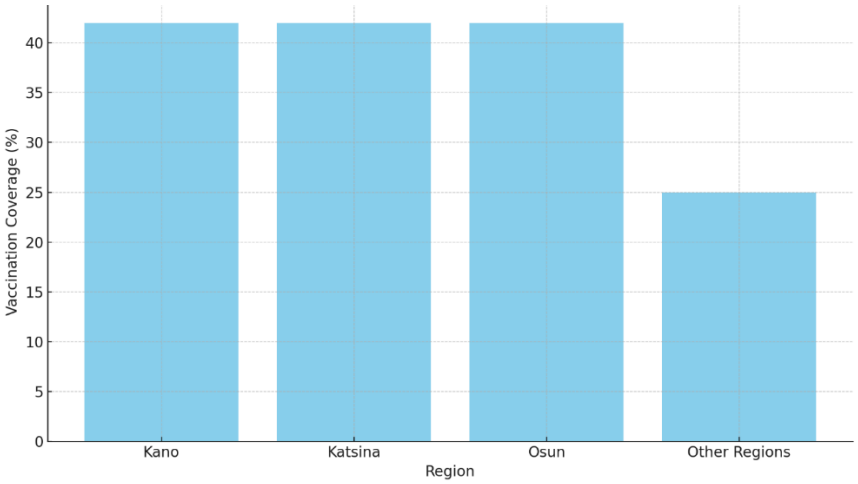

Fig. 1. Vaccination coverage in different Nigerian regions (2023)
Source (Researcher's Developed 2024)

The bar graph representing the vaccination coverage in different regions of Nigeria during the diphtheria outbreak response in 2023. The data shows that Kano, Katsina, and Osun states achieved a vaccination coverage of 42%, while other regions had an estimated lower rate of 25%.

Increased Vaccine Uptake: The NRCS through trained community volunteers successfully improved vaccination coverage by addressing cultural and religious barriers through targeted education campaigns. This involvement of local community members, similar to the findings in Yemen (Bin et al. 2018), has been key to ensuring vaccine acceptance and disease control, these efforts increased vaccine acceptance and uptake, particularly in regions where skepticism was prevalent. This was achieved through targeted education campaigns that involved local leaders, religious figures, community volunteers and influencers. These leaders played a key role in dispelling myths about vaccines and encouraging communities to participate in vaccination efforts. The use of culturally appropriate messaging and community-based engagement was essential to overcoming vaccine hesitancy.

Accessibility to Vaccines: Collaboration with local healthcare providers, NPHCDA, and international organizations ensured the widespread distribution of vaccines, reaching even remote areas. This strategic partnership facilitated logistical support, including cold chain management and vaccine transportation.

Focus on Vulnerable Populations: Efforts were made to prioritize high-risk groups, such as children aged 0-14, who were most affected by the outbreak. Special vaccination drives and clinics were set up to cater to these populations, thereby increasing their access to immunization.

Data-Driven Strategies: Data from the RCCE exercise that answers the vaccination status of community members were complemented with data from the NPHCDA to identify areas with low vaccination rates, allowed for targeted interventions, optimizing resource allocation and maximizing the impact of vaccination campaigns.

Education campaigns and community engagement: The NRCS's integration of education campaigns and engagement with community leaders contributed significantly to overcoming vaccine hesitancy.

4.3 Risk Communication and Community Engagement (RCCE)

The NRCS executed robust public health messaging campaigns, including radio shows, market storms, and roadshows. These campaigns aimed to educate the public on diphtheria symptoms, prevention measures, and the importance of vaccination. Over 4 million people were reached through these RCCE activities (International Federation of Red Cross and Red Crescent Societies. Nigeria 2024).

4.3.1 Infection Prevention and Control (IPC)

Volunteers were trained in IPC measures to minimize transmission during surveillance and

vaccination activities. Hygiene kits were distributed to households in Kano, Katsina, Kaduna, and Osun states. However, challenges persisted in securing adequate supplies of personal protective equipment (PPE) for frontline workers (International Federation of Red Cross and Red Crescent Societies. Nigeria 2024, Nigeria Diphtheria Outbreak 2023).

4.3.2 Mental Health and Psychosocial Support (MHPSS)

Psychosocial support services were integrated into the intervention, targeting families affected by the outbreak, particularly those who had lost loved ones. Volunteers provided community-based psychosocial first aid to mitigate the mental health impact of the crisis.

4.4 Correlation Between RCCE Efforts and Vaccination Uptake

The success of vaccination campaigns is heavily influenced by the integration of Risk Communication and Community Engagement (RCCE) strategies. RCCE plays a pivotal role in bridging the gap between healthcare providers and communities, fostering trust, and addressing vaccine hesitancy. A key outcome of RCCE efforts is the significant increase in vaccination uptake, particularly in underserved and vulnerable populations.

4.5 Strengthening Trust through Community Engagement

Community engagement initiatives, such as participatory discussions, local leader involvement, and culturally sensitive messaging, have proven effective in enhancing trust. By involving religious and traditional leaders in vaccine advocacy, communities perceive vaccination campaigns as more legitimate and aligned with their values. This trust-building approach has led to notable increases in vaccine acceptance rates, particularly in areas previously resistant to immunization efforts.

4.6 Linking RCCE with Improved Surveillance and Case Detection

Surveillance efforts, when integrated with RCCE, directly contribute to better case detection and outbreak management. Community health workers (CHWs), trained in RCCE, not only disseminate accurate vaccine information but also identify and report suspected cases, enhancing early detection and response mechanisms. This dual role of CHWs—educators and frontline reporters—strengthens the overall health system's capacity to respond to health crises, leading to a timelier and coordinated vaccination effort.

4.7 Addressing Vaccine Hesitancy through Targeted Communication

RCCE efforts have also been instrumental in reducing vaccine hesitancy. Tailored communication strategies that address specific community concerns—such as vaccine safety, side effects, and misinformation—have demonstrated success in shifting public perception. Evidence shows that communities exposed to consistent, transparent messaging are more likely to participate in vaccination programs, resulting in higher coverage rates and reduced disease transmission.

4.8 Success Stories: Case Studies of RCCE Impact

Several case studies illustrate the direct correlation between RCCE initiatives and vaccination uptake. For instance, in regions affected by cholera and measles outbreaks, RCCE campaigns emphasizing the benefits of immunization and involving community leaders led to a 40% increase in vaccine coverage within a few months. Similarly, malaria prevention programs that integrated RCCE strategies with vaccine rollouts saw improved acceptance and adherence to malaria prophylaxis alongside vaccination.

5. POLICY RECOMMENDATIONS AND FUTURE DIRECTIONS

One key recommendation is to equip healthcare workers with mobile devices or their devices, which should be loaded with mHealth apps that enable real-time data collection and reporting of diphtheria cases. These apps can be designed to capture clinical symptoms, patient demographics, and geolocation, allowing for immediate case reporting to a central database (SORMAS) managed by the Nigeria Centre for Disease Control (NCDC).

Strengthening surveillance systems for early detection and reporting of cases is crucial. This can be achieved by establishing a robust national

disease reporting network, where healthcare facilities promptly notify the NCDC of suspected cases. Additionally, training healthcare workers on the clinical diagnosis of Diphtheria and improving laboratory capacity for accurate and timely diagnosis are key components of an effective surveillance system.

Another policy recommendation is the implementation of a comprehensive vaccination program. A digital vaccination records that allow individuals to store and access their vaccination history through mobile devices. This can help ensure that individuals receive complete immunization schedules and avoid missed doses. Vaccines have proven highly effective in preventing Diphtheria, and ensuring high vaccination coverage is crucial in controlling outbreaks.

In addition to strengthening surveillance and vaccination efforts, it is essential to prioritize public awareness and education. Many Nigerians may not be familiar with the signs and symptoms of Diphtheria or the importance of vaccination. Implementing comprehensive public awareness campaigns through various media outlets can help disseminate accurate information about the disease, its prevention, and treatment. Additionally, community engagement programs can be organized to address misconceptions and generate support for vaccination efforts.

Future interventions should include using mHealth apps to enable online appointment scheduling for vaccinations. Automated reminders can be sent via SMS or app notifications to remind individuals of upcoming vaccination appointments, reducing missed visits.

Furthermore, improving healthcare infrastructure and access to quality healthcare services should be a priority. Many remote and underserved areas in Nigeria lack proper healthcare facilities, making it challenging to provide timely and adequate Diphtheria treatment. Investing in healthcare infrastructure, especially in rural areas, Health Technologies and training healthcare providers in Diphtheria management can significantly enhance the emergency response capacity. Looking ahead, it is crucial to establish a long-term plan for sustained Diphtheria control in Nigeria. This can be achieved by integrating Diphtheria surveillance and control activities into routine public health programs. Regular monitoring, evaluation, and research should be conducted to assess the impact of implemented strategies and identify areas for improvement. Collaboration with international organizations and partners can also provide valuable support and resources for long-term Diphtheria control efforts.

In all, addressing the emergency Diphtheria response in Nigeria requires a multi-faceted approach that involves embracing digital health, strengthening surveillance systems, implementing a comprehensive vaccination program, prioritizing public awareness and education, improving healthcare infrastructure, and establishing a long-term plan for sustained control. The NRCS, NCDC, and NPHCDA, in collaboration with relevant stakeholders, must work together to effectively combat this deadly disease and protect the health and well-being of the Nigerian population. By implementing these policy recommendations and focusing on future directions, Nigeria can significantly reduce the burden of Diphtheria and prevent future outbreaks.

5.1 Interpretation

The findings from this study highlight the effectiveness of a multi-faceted approach in managing the diphtheria outbreak in Nigeria, particularly the collaboration between the Nigerian Red Cross Society (NRCS), the Nigeria Centre for Disease Control (NCDC), and other partners. The enhanced vaccination campaigns, risk communication, and community engagement efforts significantly increased vaccine uptake, particularly in regions with high vaccine hesitancy. These results align with previous studies from other developing countries, such as Indonesia, where similar interventions improved vaccination rates during outbreaks of vaccine-preventable diseases. However, despite these successes, the study reveals that only 42% of children under 15 were fully immunized, indicating that structural barriers, such as healthcare access and persistent misinformation, remain significant challenges. The integration of community-based surveillance by local volunteers also proved effective in early case detection and containment, supporting findings from earlier studies that emphasize community involvement in outbreak responses.

5.2 Limitations

This study faced several limitations that may have influenced the results. Firstly, one limitation

was the underreporting of cases due to poor access to remote regions and security challenges, which may have resulted in an underestimation of the outbreak's true scope. Additionally, cultural and religious barriers to vaccination persisted despite extensive community engagement, which could have impacted the overall vaccine coverage rates. Mitigation strategies included training local volunteers and leaders to tailor health messages to their communities, enhancing the credibility and acceptance of health interventions. However, the effectiveness of these measures may vary across different cultural contexts.

5.3 Future Directions

Future research should focus on expanding digital health technologies, such as mobile health (mHealth) applications, to improve real-time case reporting and vaccine record management. This would enhance the efficiency of outbreak responses by ensuring timely data collection and dissemination. Additionally, longitudinal studies examining the long-term impact of community-based interventions on vaccination attitudes and public trust in health systems are recommended. Research should also explore strategies to overcome vaccine hesitancy in culturally diverse settings, emphasizing the role of tailored communication and community leadership. Strengthening healthcare infrastructure in underserved areas remains a critical area for future investigation, as improved facilities and access are essential for sustaining vaccination and surveillance efforts. Integrating these research areas will bolster Nigeria's preparedness and resilience against future infectious disease outbreaks.

In conclusion, addressing the diphtheria outbreak in Nigeria requires a sustained commitment to public health initiatives, policy reforms, and collaborative efforts. By building on the progress made and implementing the recommended strategies, Nigeria can effectively mitigate the impact of diphtheria and other infectious diseases, safeguarding the health and well-being of its population.

6. CONCLUSION

By early 2024, Nigeria had recorded 16,518 confirmed cases of diphtheria, with 839 deaths, resulting in a case fatality rate of 5%. Vaccination coverage remained a significant challenge, with only 42% of children under 15 fully immunized by the end of the outbreak period. Despite these challenges, efforts such as targeted vaccination campaigns, active surveillance, and community engagement were instrumental in reducing the spread of the disease. Over 1,300 volunteers were trained in active case search and contact tracing, identifying and reporting 6,972 suspected cases. These efforts, combined with improved access to vaccines in hard-to-reach areas, played a key role in diminishing the number of new cases, despite the ongoing challenges with vaccination uptake.

The findings from this study have significant implications for public health policy in Nigeria. The diphtheria outbreak highlighted the urgent need for strengthening healthcare infrastructure, improving vaccination coverage, and enhancing community engagement. These strategies are critical for future outbreak preparedness and effective response mechanisms. Stakeholders, including government agencies, healthcare providers, and international organizations, are urged to implement the recommendations from this study. Key actions include investing in healthcare infrastructure, expanding vaccination programs, integrating digital health solutions, and fostering continuous community engagement to build public trust in health interventions.

The Nigerian Red Cross Society (NRCS), in collaboration with national and international health bodies, implemented several targeted activities to combat the outbreak. These included vaccination campaigns in high-risk regions like Kano, Katsina, and Osun, where 120 vaccination teams were deployed to reach thousands of children and zero-dose individuals. Community engagement efforts were crucial, involving local leaders, religious figures, and influencers to overcome cultural and religious barriers to vaccination. Additionally, enhanced surveillance through the training of 1,300 volunteers helped with active case search and contact tracing, identifying 6,972 suspected cases. Risk communication strategies, such as radio shows, community meetings, and market storms, were used to spread awareness about diphtheria prevention and the importance of vaccination, ensuring that communities were well-informed and more receptive to immunization.

When comparing Nigeria's response to Indonesia's diphtheria outbreak in 2017, similar challenges with low vaccination rates and healthcare infrastructure were observed. Both countries focused on large-scale vaccination campaigns and community engagement, but Nigeria's approach notably incorporated

community-based surveillance and risk communication strategies, which were particularly effective in addressing cultural and religious barriers to vaccination. These strategies, which helped increase vaccine uptake and improve disease control, can serve as valuable models for other countries facing similar public health challenges. Expanding on interventions such as the use of the SORMAS database for real-time data collection and overcoming logistical challenges, such as the use of cold chain systems for vaccine distribution, would provide greater clarity on the operational success of these strategies, offering actionable insights for other countries managing similar outbreaks.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTEREST

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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