Analyzing the Role of the 1996 Pfizer Meningitis Clinical Trial as a Vaccine Hesitancy Enhancer in Nigeria

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

In sub-Saharan Africa (SSA), child mortality is alarmingly high, in part due to vaccine-preventable diseases. One of the countries in SSA, Nigeria, with 14% of the world's unvaccinated children under five (Mahachi et al., 2022), consistently ranks as one of the top five countries with the highest child mortality for preventable diseases, including tuberculosis and meningitis (Vanderslott et al., 2013). This high mortality rate corresponds to high rates of vaccine hesitancy in Nigeria, where COVID-19 vaccine acceptance only ranges from 20% to 58.2% across the country (Olu-Abiodun et al., 2022). The high rate of vaccine non-acceptance and hesitancy is primarily the result of distrust in government and Western medical institutions (Ackah et al., 2022; Ghinai et al., 2013; Jegede, 2007). While the historical sociopolitical landscape of Nigeria heavily influences the sentiment of distrust among the Nigerian people, the 1996 Pfizer clinical trial in Kano, Nigeria, which was associated with the deaths of 11 children and disabilities forming in at least six others, plays an important role in amplifying preexisting vaccine hesitancy (Leonhardt, 2021; Pertwee et al., 2022; Stephens, 2000).

The legacy of the clinical trial has played a role in hindering more recent vaccination campaigns, including polio in 2003-2004 and COVID-19 in 2020-2021 (Garba & Paquette, 2021; Ghinai et al., 2013). With the potential for new viruses and diseases to emerge in nature, it is important to establish vaccine and medical trust in Nigeria. The first step towards this goal is understanding the role the clinical trial has played in Nigerian vaccine hesitancy and the larger system of distrust. As a result, this paper analyzes Nigerian vaccine hesitancy network changes, due to the introduction of the clinical trial, using Actor-Network Theory (ANT). Ultimately, the

paper provides and assesses recommendations to improve vaccination campaigns and destabilize the proposed network.

Research Question and Methods

How did the 1996 Pfizer Trovan Clinical Trial strengthen the Nigerian vaccine hesitancy network? How can the network be destabilized to improve vaccination rates?

This work employs ANT, along with network analysis, to understand how the Trovan clinical trial strengthened the Nigerian vaccine hesitancy network. The network analysis specifically serves to identify and investigate the connections between each of the key network actors: Western institutions, the central Nigerian government, religious leaders, the 1996 Trovan clinical trial, vaccines, and patients. Here, Western institutions, represent any group that arose from a Western country, including Great Britain, which colonized Nigeria until 1960 (Heaton & Falola, 2008b), Pfizer, other Western-based pharmaceutical companies that supply medicines and vaccines, and medical-aid workers. In addition, the term 'patients' broadly refers to all Nigerians who may be impacted by vaccines.

To inform the construction of the links between the actors, this paper analyzes information from a variety of scholarly articles that analyze Nigeria's sociopolitical landscape and study Nigeria's experience with vaccine hesitancy. To supplement the scholarly studies, anecdotes from review papers and newspaper articles, including those from the Nigerian media agency *Premium Times*, are used. The specific papers and articles used in this work are identified using combinations of the following keywords: 'vaccine,' 'mistrust,' 'Nigeria,' 'Pfizer,' 'religion,' and 'politics.' The presented analysis synthesizes information from these sources to lay out how the clinical trial strengthened Nigerian vaccine hesitancy. This paper provides

background information regarding the clinical trial, as well as a review of the literature using ANT in the context of vaccine hesitancy, prior to presenting a discussion of the evolution of the hesitancy network in Nigeria. Specifically, the discussion begins with an analysis of the network in post-colonial, pre-1996 Nigeria, with all actors except the clinical trial. Subsequently, the additional and modified connections in the post-1996 hesitancy network, which includes the clinical trial as an actor, are studied to determine how the network became stronger. Conclusions from the analysis are then used to propose methods for destabilizing the hesitancy network and increasing vaccination rates. Lastly, limitations and future directions of the analysis are considered.

Background on Pfizer's Trovan Clinical Trial

In 1996, Pfizer attempted to seek approval for the use of its antibiotic drug Trovafloxacin (Trovan) during meningitis epidemics. At the time, a meningococcal meningitis epidemic was occurring in Nigeria, so to test the efficacy of the drug against a natural strain, Pfizer set up a Phase II clinical trial in Kano, a northern Nigerian state. The clinical trial was designed to compare the performance of Trovan against the gold standard meningitis treatment at the time, Ceftriaxone, in moderately sick children. However, the researchers did not follow clinical trial protocols and did not adhere to proper standards that would ensure patient safety (Stephens, 2000).

The clinical trial included a wide array of unethical decisions. It is still unclear whether or not there was informed consent that Nigerian patients were taking part in a clinical trial, although Pfizer adamantly states that they obtained verbal consent. Moreover, the trial protocol stated that subjects would only include moderately sick children, but the majority of admitted patients were severely sick. Ethically, if a severely sick patient is not responding to an experimental treatment,

doctors should transition to an approved treatment. To assess whether or not patients are responding favorably to experimental meningitis medications, industry guidelines suggest the use of spinal taps. However, Pfizer made these spinal taps optional. In the absence of a spinal tap to assess the drug performance beyond visual indicators (life, death, and disabilities), some critically-ill patients died while on Trovan. During the trial, 11 children died on either Trovan or Ceftriaxone. At least six children developed arthritis after treatments (Garba & Paquette, 2021). Pfizer states that these deaths and disabilities were solely due to the advanced stage of illness at which the patients were admitted (Pfizer, n.d.). Pfizer also did not follow typical U.S. medical guidelines for meningitis trial follow-ups and changed drug dosages from their initial proposal. Upon reviewing the results of the clinical trial to assess whether to approve Trovan as an epidemic drug, the Food & Drug Administration (FDA) identified dozens of issues with the clinical trials. As a result, the FDA only approved Trovan for use in adults. Trovan was later found to cause liver damage and death in patients and was ultimately pulled from the market (Stephens, 2000).

In 2000, *The Washington Post* published about the clinical trial disaster in Kano. This news story was the first time that the world and many Nigerians found out what happened in 1996. The result was an apparent drop in Nigerian child vaccination rates, by 11-27% (Archibong & Annan, 2021), and an investigation into the trial by the Federal Ministry of Health, which concluded that Pfizer violated Nigerian law, the Declaration of Helinski on Ethical Principles of Medical Research, and the U.N.'s Convention on the Right of the Child (Federal Ministry of Health, 2001). Subsequently, affected Nigerian families sued Pfizer, which eventually settled out of court without ever admitting liability (Pertwee et al., 2022).

Overview of Relevant ANT Work

Currently, this is the first paper to analyze how the 1996 Pfizer clinical trial contributed to, and strengthened, the Nigerian network of vaccine hesitancy using ANT. ANT is a sociotechnical framework that enables users to study a certain aspect of society as a network formed by the interconnectedness of different actors. These actors may take the form of animate or inanimate objects and ideas, all of which are considered equally important in forming the network (Cressman, 2009; Cresswell et al., 2010). In the case of the present research, the networks under analysis capture the aspect of vaccine hesitancy in Nigerian society and the actors consist of the animate Nigerian patients and religious leaders and the inanimate Western institutions, central Nigerian government, vaccines, and 1996 Trovan clinical trial. Few scholarly works focus on understanding the role of the trial, via ANT, in these Nigerian networks of general vaccine hesitancy, but rather examine the links between the trial and the polio boycotts of 2003. As a result, this section describes previous ANT analyses, regarding vaccines and clinical trials, that indirectly help shape the analysis presented in this paper.

Much of the current ANT research in the area of vaccine hesitancy has a Western-centric focus. For example, in Imbroguilo's undergraduate thesis, he employs ANT to claim that social media destabilizes vaccination networks because anti-vaxxers are connected to social media independently of doctors via a United States-based case study. His proposed network consists of HPV vaccines, patients, doctors, social media, and anti-vaxxers as the key actors. He specifically narrows in on using anti-vaccination comments on a Facebook post to study the destabilization of the network. Imbroguilo's work serves to highlight the importance of considering the media, as well as the difference between patients and anti-vaxxers. However, his conclusions have limited relevance to the present work as he is analyzing a society with values and a history

different than those of Nigeria. As a result, the generalization of these results to the Nigerian network may not hold. The applicability of Imbrogulio's research is further limited because he aims to analyze the destabilization of a network while this paper aims to analyze the strengthening of one (Imbrogulio, 2021).

Similar to Imbrogulio, Dimitrov provides an ANT analysis with a Western perspective on vaccine hesitancy, particularly pertaining to MMR vaccination campaigns in Australia. His work emphasizes the importance of not underestimating key actors, such as the media, parents, and healthcare workers when attempting to understand vaccination networks. However, again, the cultural differences between Australia and Nigeria limit the immediate usefulness of examining these actors as their role in vaccination networks does not necessarily translate to non-Western countries. Interestingly, Dimitrov's paper also makes a clear distinction between vaccine hesitancy and refusal, with his focus on vaccine-hesitant parents. In this work, hesitancy and refusal are used interchangeably. In a country like Nigeria, where child vaccination rates are low and herd immunity is unlikely, vaccine campaigns must target the entire population to ensure the best health outcome (Dimitrov, 2022).

Since anti-vaccination movements in Western countries are rooted in different ideas than those in SSA countries, the majority of vaccination ANT analyses, which are focused on the West, have limited usefulness in describing most vaccination networks. As a result, there is a large gap in the literature regarding the ANT-based study of vaccines and medicines in Africa. One of the few papers on this subject matter, written by Aggrey and Shrum, focuses on how the potential Ebola vaccine clinical trial in Ghana, an SSA country, destabilized the clinical trial network by breaking down trust. This work is particularly relevant to the vaccination hesitancy network in Nigeria, in which distrust as the result of a clinical trial is also a driving force.

However, while the Ghanaian network is destabilized by distrust, the Nigerian network proposed in the present work is strengthened by distrust (Aggrey & Shrum, 2020). Consequently, the following network analysis aims to fill in the identified gaps in research regarding vaccine hesitancy in non-Western countries.

Network Analysis on the Effects of the Trovan Clinical Trial

The network of vaccine hesitancy in Nigeria is primarily driven by widespread distrust in Western institutions and the central Nigerian government, as well as by the perceived association of the West and the government with vaccines. While this distrust has been well established since Nigeria became a self-governed country, Pfizer's Trovan clinical trial served to enhance distrust, with the help of religious leaders, in the West, the government, and vaccines. Further analysis suggests that targeting religious leaders will be a key method in boosting the efficacy of future vaccination campaigns in Nigeria.

Pre-1996: Development of Hesitancy Network

The post-colonial, pre-1996 time period saw the formation of the vaccine hesitancy network, primarily through the lasting effects of British colonialism. Colonial influences largely governed how the relevant actors interacted to develop vaccine hesitancy and distrust. At the time, the actors were Western institutions, the central Nigerian government, religious leaders, vaccines, and patients (Figure 1). Understanding the connections between each of these actors and their relation to Nigerian vaccine hesitancy lays the foundation and context for considering how the clinical trial further strengthened vaccine hesitancy in Nigeria.

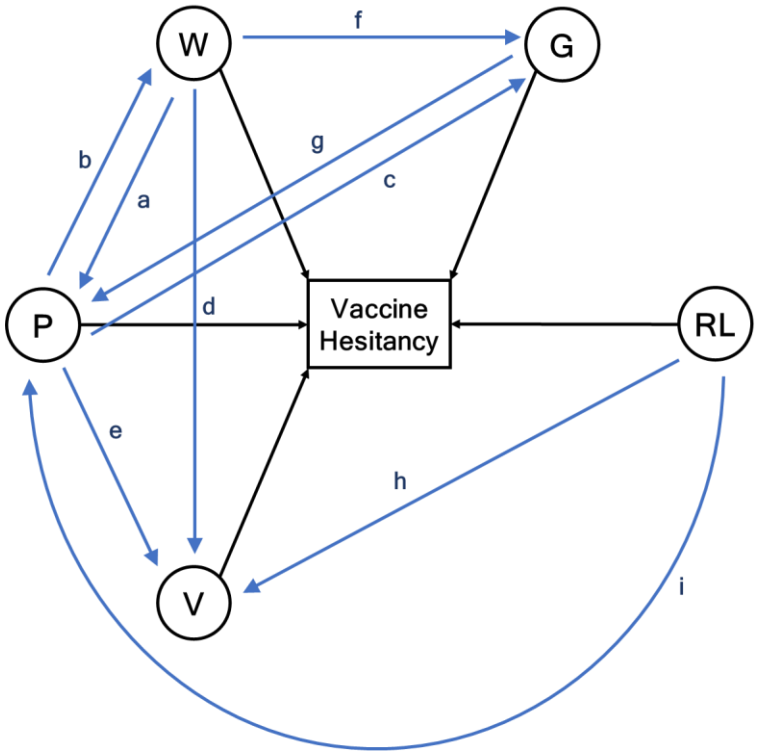

Figure 1. Pre-1996 Nigerian Vaccine Hesitancy Network (Jayaraman, 2023)

Note. This diagram represents the connections between the main actors in the Nigerian vaccine hesitancy network during 1960-1996. Tables A1 and A2 (Appendix) list the meanings of the labeled actors and connections.

Network development began amidst British colonialism in Nigeria, during which time Nigerians developed distrust in and negative perception of Western powers. In the early 20th century, Western-educated Nigerians, who were subjected to racist governmental policies in Nigeria (connection a), began to rally around the belief that British colonial rule was arbitrary and unjust. Over time, Nigerians came together to fight the imposed hardships that prevented them from attaining benefits proportional to their abilities. Eventually, they created the Nigerian nationalism movement. The movement's ultimate goal was to promote the "indigenization" of the Nigerian government, with more Nigerian representation and more just policies. Although Nigeria eventually became a fully sovereign state with an independent, elected government in 1960, the negative perceptions of Western institutions, which were developed through racist

treatment from Britain (connection b), persisted (Heaton & Falola, 2008b). For example, in 1986, Nigeria was facing a period of economic instability (Bouchat, 2013) and needed to pay large debts. At the time, the International Monetary Fund (IMF) was offering Structural Adjustment Program (SAP) plans that would provide countries with loans on the condition that the countries restructured their economy per IMF guidelines. While accepting aid from the IMF would have provided a quick fix for Nigeria's economic troubles, Nigerians largely believed that accepting the IMF's SAP plan would be equivalent to compromising their sovereignty for Western aid. As a result, Nigeria opted to implement its own SAP (Heaton & Falola, 2008a). These actions demonstrate that freedom from Western influence was a value that many Nigerians held.

Not only did British colonialism instill distrust in Western powers, but it also prompted distrust in the post-colonial Nigerian government. The racist policies and governance of Nigeria by the British resulted in Nigerians developing a general dislike of governing bodies. For example, when colonial rule attempted to eliminate the high ethnic diversity, Nigerians formed a variety of antigovernmental organizations opposed to central rule (Anyanwu, 1982). Following the end of British rule, these general negative attitudes towards a central government persisted, even though the new government was Nigerian-controlled (connection c). Consequently, post-colonial Nigeria faced a positive feedback loop with extreme economic and political instability and distrust in the government. As poverty rates soared and regimes alternated between elected and authoritarian, antigovernment sentiments rose, further dividing the country and motivating political and economic instability (Bouchat, 2013).

The negative perceptions of the government and Western powers initiated a longstanding history of vaccine distrust, which has only grown through the interactions between Western institutions, the central government, and Nigerians as patients. Vaccination programs were

initially introduced to Nigerians during colonial rule. For example, during 1903-1960, the colonial government attempted to vaccinate against smallpox and meningitis with vaccines imported from Britain (connection d). The close association between Western institutions and vaccines resulted in Nigerians viewing the Smallpox Eradication Program and Global Polio Eradication Initiative, two programs aimed at increasing vaccination rates, as vehicles of postcolonial Western intervention (connection e) (Renne, 2017).

When the Nigerian Ministry of Health attempted to implement vaccine initiatives, Nigerians opposed the government as they viewed the initiatives as a collaboration with the West (connection f). The government, however, responded to such opposition with harassment of critics and the threat of arrest (connection g), further destroying an already tenuous relationship between Nigerians and their central government (Renne, 2017). In the 1980s, the Babangida administration adopted a population policy that limited the number of children per family. The policy, as well as the combined distrust of the government and vaccines as Western products, led to some Nigerians believing that vaccinations were meant to sterilize patients as a method of population control (Jegede, 2007).

These negative perceptions of vaccines, formed primarily through the interaction between the central government, Britain, Nigerians, and vaccines themselves, established a strong vaccine hesitancy culture prior to 1996. Religious leaders, notably Islamic leaders and imams, also played a small role in promoting distrust in vaccines (connection h) as they viewed Western medicine as a vehicle of the Christian crusade (Ghinai et al., 2013). As a result, they pushed the idea that prayer was sufficient to cure illnesses (connection i) (Renne, 2017). Prayer as an alternative to vaccination was likely attractive to many Nigerians, as prayer, unlike vaccines, did

not have negative connections to the government and the West. The result, as of 1996, was a well-established vaccine hesitancy network in Nigeria.

Post-1996: Hesitancy Network After Trovan Clinical Trial

The 1996 Trovan clinical trial and its outcomes strengthened the vaccine hesitancy network by bolstering preexisting distrust towards the West and central government, as well as by allowing religious leaders to play a more influential role in amplifying distrust. The primary change between the pre- and post-networks was the addition of the clinical trial to the post-1996 network (Figure 2). Since the 1996 trial is still in recent memory for many Nigerians, including parents who make vaccination decisions for their children (Garba & Paquette, 2021), understanding the mechanism by which the network was strengthened may also be the key to destabilizing the network and allowing for higher vaccination rates.

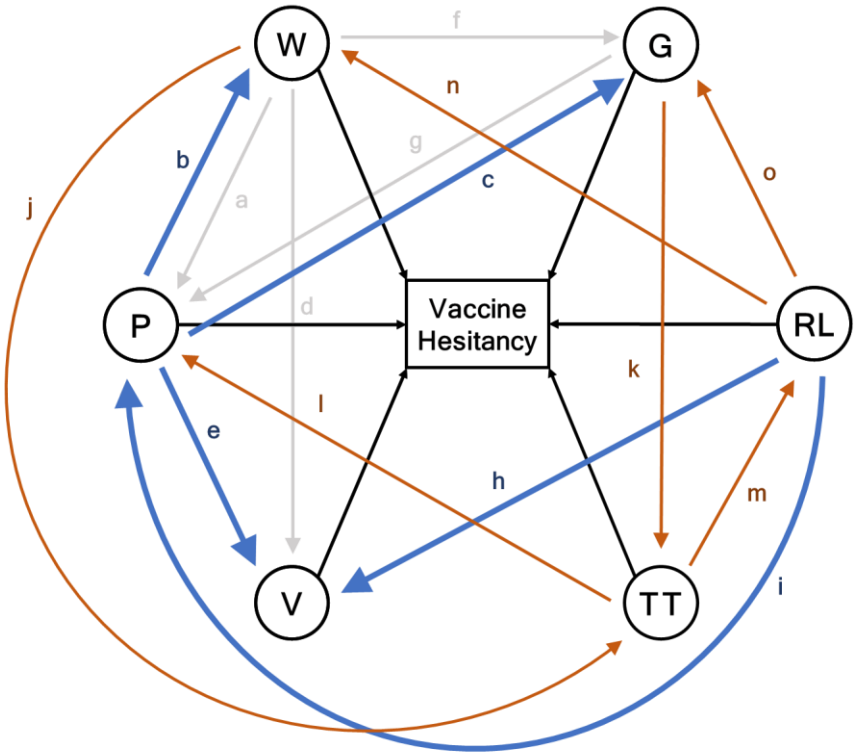

Figure 2. Post-1996 Nigerian Vaccine Hesitancy Network (Jayaraman, 2023)

Note. This diagram represents the connections between the main actors in the Nigerian vaccine hesitancy network after the 1996 clinical trial. The greyed-out connections are those, from the pre-1996 network, that still exist but largely remain unchanged between the networks. The weighted blue arrows represent connections that were strengthened or reinforced from the pre-1996 network. The orange arrows represent new connections between actors. Tables A1 and A2 (Appendix) list the meanings of the labeled actors and connections.

The interconnections between the Trovan clinical trial and Western institutions, the central Nigerian government, and Nigerian patients served to increase distrust in vaccines. The clinical trial, held in Kano, Nigeria for six weeks in 1996, was designed and executed by Pfizer, an American multinational pharmaceutical company (connection j), and was initially approved by the Nigerian Federal Ministry of Health (connection k) (Federal Ministry of Health, 2001; Pertwee et al., 2022). The results of the unethical trial were disastrous, with many children dying or developing life-altering disabilities (connection l) (Garba & Paquette, 2021; Stephens, 2000). The effects on the children, along with Pfizer's malpractice, significantly strengthened Nigerians' distrust in Western institutions, like Pfizer, which were seen as harming individuals. Similarly, distrust in the central government increased as it was seen as enabling the harm perpetrated by Pfizer (Ghinai et al., 2013; Jegede, 2007). In 2005, one farmer in Kano went as far as to claim that Nigerians "cannot trust the white man or our federal government because many years ago they were in partnership when they brought medicine to poison our people" (Yahya, 2006), where "white man" is a representative for Western institutions. The distrust of the West is long-lasting as, in 2023, a resident from Nasarawa, Nigeria mentioned that "since the incident of paralysis and deaths of children, [he] can never trust any vaccines or medicine from Europe" (Adebowale-Tambe, 2023b). Due to the association between Western institutions, the central government, and vaccines, with Western institutions producing and the central government distributing vaccines, Nigerians have grown even more distrustful of vaccines.

In addition to increasing vaccine hesitancy by directly affecting patients, the clinical trial, along with the global events of the early 21st century, indirectly increased hesitancy by helping religious leaders play a more active role in the vaccine hesitancy network. Since Kano is a majority Muslim state, the children and families affected by the clinical trial were mainly Muslim (connection m). As a result, Islamic leaders largely believed that the clinical trial was a conspiracy by the Western world against Muslims (connection n). This sentiment was heightened by the fact that in the early 2000s, shortly after the events in Kano were made public, the United States went to war in Afghanistan and Iraq, both predominantly Muslim countries (Chutel & Fisher, 2021; Ghinai et al., 2013). The idea that Muslims were under attack from the West allowed the original belief that the Babangida administration was sterilizing the population with vaccines to transform into a different conspiracy. Specifically, Nigerians and religious leaders began to believe that the West was attempting to sterilize and eliminate Muslim populations. The Supreme Council for Sharia in Nigeria asserted a similar idea and the council, along with other Islamic leaders, disseminated the theory to its constituency (Jegede, 2007; Yahya, 2007).

Islamic leaders also influenced vaccination sentiments by clashing with the central government (connection n). In 1998, the Nigerian government switched to an elected government, centered in the Christian-majority south, from an authoritarian government, centered in the Muslim-majority North (Heaton & Falola, 2008a; Jegede, 2007). As a result, there was strong tension between the Muslims in the northern states and the central government, which deemed Sharia law unconstitutional (Ghinai et al., 2013). The result of the tensions between religious leaders and the government, as well as sterilization conspiracy theories, was the 2003 boycotts, led by northern religious leaders, against the government-sponsored polio vaccination campaign (Jegede, 2007; Yahya, 2007).

The ability of the religious leaders to influence a large number of Nigerians to distrust vaccinations demonstrates their power in motivating Nigerian distrust. While the Trovan clinical trial directly played a direct role in increasing vaccine hesitancy from its pre-1996 state, religious leaders significantly amplified the preexisting distrust in the West and the government, and consequently vaccines. This network strengthening by the Pfizer clinical trial remains strong decades later. For example, in 2018, northern Nigeria had the lowest childhood vaccination rate (8-26%) in the country, below the national average of 31% (Adeyanju et al., 2022). In 2023, at least 30% of residents of Kano are refusing COVID-19 vaccinations, citing distrust in Western medicine as a primary reason (Adebowale-Tambe, 2023b).

Techniques to Destabilize Hesitancy Network

The analysis of Nigerian vaccine hesitancy identifies religious leaders as the key amplifiers of distrust in the hesitancy network, suggesting that they have great power over their constituency. As a result, religious leaders are a key target to destabilize the network. Destabilizing a network consists of modifying the crucial connections between actors that help form the network. In the context of the hesitancy network, the most effective method for destabilization may be changing the attitudes of religious leaders towards vaccines, specifically by educating religious leaders on vaccines and enhancing their trust in Western medicine. Doing so will allow religious leaders to use their preexisting link to Nigerians (connection i) to promote, instead of discourage, vaccination. Similarly, improving relationships between religious leaders and the Western world and the central Nigerian government may be used to improve Nigerians' trust in the same institutions, thus decreasing the apparent negative connections with vaccines. Ultimately, these methods may destabilize the given vaccine hesitancy network and promote long-term vaccine acceptance in Nigeria.

The idea of mobilizing religious leaders as agents for network destabilization is supported by research and successes in modern Nigerian vaccination campaigns. A longitudinal study on the drivers of vaccine hesitancy in pregnant women suggests that religion is a key component in decision-making among inhabitants of sub-Saharan Africa. The study also recommends that religion should be integrated into attempts at medical interventions to decrease hesitancy (Adeyanju et al., 2022). Evidence for success with the integration of religion is present in the results of the late 2000s polio immunization campaign. By engaging the Sultan of Sokoto, the spiritual leader of Nigeria's Muslims, and local imams, the government and healthcare workers were able to encourage parents to vaccinate their children, suggesting that involving religious leaders is an effective method for countering vaccine hesitancy (Nasir et al., 2014). More recently, religion has prompted many residents in Kano, a location where vaccine hesitancy is still strong, to get vaccinated against COVID-19. To visit Saudi Arabia for hajj, an annual pilgrimage Muslims must take once in their life per the pillars of Islam, Nigerians must present proof of vaccination. As a result, those who previously claimed that they would never get vaccinated due to distrust in Western medicine have changed their stance (Adebowale-Tambe, 2023a). The success of using religion to improve vaccination rates serves to demonstrate how powerful religious leaders are in the hesitancy network.

Analysis Limitations & Future Directions

There are a variety of limitations in the analysis of how the Trovan clinical trial strengthened the Nigerian vaccine hesitancy network. The primary limitation is that it is difficult to isolate the effect of just the clinical trial from the effects of other local and global events on the vaccine hesitancy network. Since the aftermath of the clinical trial unfolded over a decade, it is impossible to discuss the trial without events and actors that are not explicitly included in the

actor-network diagrams (Figures 1 and 2). This inability to include all relevant actors, such as the media or the wars in the Middle East, is a general flaw of ANT. Actors have also evolved over time. An ideal comparison between the pre- and post-networks would assume that all of the actors, except the clinical trial, stay constant. However, as discussed previously, the state of the government and the relevant Western powers are different between the two networks. As a result, future research may benefit from integrating ANT with a more time-dependent framework, such as Technological Momentum, which may allow for a better understanding of and control over network changes over time.

In addition to the confounding effect of time on the network analyses, the pre-1996 hesitancy network is likely incomplete. Unfortunately, there are only a few accessible sources regarding post-colonial, pre-1996 Nigeria. Almost none of these sources are primary sources, suggesting there is a high likelihood that the information used to construct the network is influenced by the Western perspective. While there are more sources regarding post-1996 Nigeria, most are also likely to include Western bias. As a result, the network analysis and comparison performed in this paper do not necessarily tell the full story.

Future research in the field of vaccine hesitancy should focus on groups in previously colonized countries, where a history of negative relationships with the West may impact patient willingness to receive Western medical interventions. ANT and network analysis may be used to identify the hesitancy network's crucial strengthening actors, who may also serve as the key to destabilizing the same network. Research should also consider the integration of media, which appears to be a key actor in Western networks (Dimitrov, 2022; Imbrogulio, 2021), to uncover additional useful connections that may also be targeted for network destabilization. With these

extensions to the current research, researchers may be able to formulate public health plans that effectively eliminate hesitancy as a barrier to vaccinations.

Conclusion

The 1996 Pfizer Trovan Clinical Trial strengthened a preexisting network of Nigerian vaccine hesitancy by directly and indirectly, through the influence of religious leaders, amplifying Nigerians' distrust in the central government and Western institutions. The distrust in both institutions, which were seen as producers and distributors of vaccines, consequently led to heightened vaccine hesitancy and distrust. However, the strength of influence that religious leaders have in enhancing the network may be repurposed into influence for destabilizing the network. Current research and success in vaccination campaigns support the idea that engaging religious leaders to disseminate vaccine acceptance ideas is an effective approach to improving vaccination rates in Nigeria. Ideally, mobilizing religious leaders, to lessen distrust in the West and the government, will promote long-term vaccine acceptance in Nigeria. Similar analysis methods may be applied to other post-colonial countries to help public health officials identify key hesitancy-network actors that, like Nigerian religious leaders, may be repurposed for weakening vaccine hesitancy. Hopefully, these efforts will eventually lead to the global elimination of hesitancy as a barrier to widespread vaccination.

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Appendix

Table A1

Key for Actor Labels

Actor Label	Actor Name
W	Western Institutions
G	Central Nigerian Government
P	Nigerian Patients
V	Vaccines
RL	Religious Leaders
TT	1996 Trovan Clinal Trial

Table A2

Key for Actor Connectors

Connector Label	Connection
a	Racist and oppressive governing of colonial Nigeria (pre-1960)
b	Distrust of Western world and institutions
c	Distrust of central Nigerian government
d	Manufacture vaccines
e	Distrust of vaccines
f	Supply vaccines
g	Distributes vaccines and executes vaccine initiatives
h	Distrust of vaccines
i	Advise Nigerian followers
j	Implemented the clinical trial and directly administered Trovan to children
k	Authorized clinical trial to take place in Kano, Nigeria
l	Adverse outcomes for patients and no informed consent
m	Predominantly affected Muslim population
n	Distrust Western world and institutions
o	Clash of views with central Nigerian government