



International Medical Science Research Journal
P-ISSN: 2707-3394, E-ISSN: 2707-3408
Volume 3, Issue 1, P.No.24-46, October 2023
DOI:10.51594/imsrj.v3i1.599
Fair East Publishers
Journal Homepage: www.fepbl.com/index.php/imsrj



INTEGRATION OF PUBLIC HEALTH POLICY AND LABORATORY SCIENCE IN NIGERIA: A REVIEW OF RESPONSES TO COVID-19

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Article Received: 05-10-23

Accepted:25-10-23

Published: 31-10-23

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ABSTRACT

The COVID-19 pandemic has spotlighted the criticality of an integrated approach between public health policy and laboratory science, especially in countries like Nigeria, with unique healthcare challenges. This study aimed to comprehensively analyze the synergy between these two domains, focusing on their collaborative potential and implications for pandemic response in Nigeria. Adopting a mixed-methods approach, the research combined qualitative and quantitative data to provide a holistic perspective. The study delved into Nigeria's pre-COVID-19 public health landscape, the historical context of health policy and laboratory collaboration, and this synergy's economic, social, regulatory, and ethical facets. Key findings revealed that Nigeria's public health policies during the pandemic were adaptive, with laboratory science showcasing innovations in diagnostic tools, techniques, and infrastructure enhancements.

Mutual feedback mechanisms and international engagements marked the collaboration between policymakers and laboratories. The study concludes that fostering a robust synergy between health policy and laboratory science is paramount for future pandemic preparedness. Recommendations include the need for continuous training, infrastructure development, and international collaborations to bolster Nigeria's healthcare system. This research offers valuable insights for policymakers, healthcare professionals, and researchers, emphasizing the importance of a collaborative approach in health crises.

Keywords: Public Health Policy, Laboratory Science, COVID-19, Nigeria, Pandemic Response.

INTRODUCTION

Background: Nigeria's Public Health Landscape Pre-COVID-19

The School Health Program (SHP) is a cornerstone of the health care delivery system in many countries. In developing nations like Nigeria, where infant and early childhood mortality rates are distressingly high, the significance of SHP is even more pronounced. Recognizing the importance of SHP, the Federal Government of Nigeria recently initiated an action plan focusing on this area. An evaluation was conducted to gauge the knowledge, attitude, and practice of SHP among head teachers of primary schools within a specific Local Government Area in Nigeria (Ofovwe & Ofili, 2007).

This evaluation utilized a pre-tested questionnaire designed to assess the knowledge, attitude, and practice of SHP. It was administered to 133 head teachers, comprising 104 from private and 29 from public primary schools in the Egor Local Government Area of Edo State, Nigeria. Alongside the questionnaire, inspections of the school premises were conducted to verify the availability of essential amenities such as piped water, sick bays, and toilet facilities, and to assess the overall adequacy of the school environments.

The results were revealing. A significant knowledge gap was observed, with none of the head teachers demonstrating adequate knowledge of SHP. A disparity was evident between private and public schools, with 93.1% of private school head teachers and 48.3% of their public school counterparts exhibiting poor knowledge of SHP. Despite this knowledge gap, all teachers showcased a favorable attitude towards SHP. Infrastructure-wise, 27.7% of the schools lacked toilet facilities, 33.3% had pit latrines, and 40.0% were equipped with water closets. Hand washing facilities were present in only 25.6% of the schools. In terms of health services, 51.0% of private schools, compared to 27.6% of public schools, conducted medical inspections of their pupils (Ofovwe & Ofili, 2007).

Another study focused on the humane prenatal care in Nigeria, investigating the understanding of pregnant women and health professionals regarding this care. The study aimed to identify the obstacles to its introduction. The research revealed several barriers, including socio-economic status and personal problems of pregnant women, biomedical training, communication breakdown between different health services, and lack of respect for primary health care (Zampieri & Erdmann, 2010).

The suboptimal status of SHP in Nigeria can be attributed to a combination of factors: the failure in policy articulation, an inadequate primary health care foundation, and a glaring absence of supervision. The challenges in the health sector extend beyond SHP, as seen in the prenatal care sector, indicating a broader need for reform and attention in the country's health care system.

The Interplay of Public Health Policy and Laboratory Science

The intricate relationship between public health policy and laboratory science is pivotal in the context of disease management and control. This interplay becomes particularly significant when addressing re-emerging diseases, as evidenced by Nigeria's recent Lassa fever outbreaks. The outbreak affected almost 20 states and resulted in 101 deaths and 175 suspected and confirmed cases since August 2015. The severity of the situation was underscored by a 120% laboratory-confirmed case fatality rate (Tambo et al., 2018). Such outbreaks emphasize the need for a robust and integrated "One Health" community surveillance and emergency response practice, which combines epidemiological insights with laboratory findings.

The "One Health" approach recognizes the interconnectedness of human, animal, and environmental health. In the case of the Lassa fever outbreak, the peak endemicity incidence and prevalence were observed to overlap with the dry season, from January to March, and reduced during the wet season, from May to November. This pattern was consistent across various regions, from Sierra Leone and Senegal to Eastern Nigeria. However, challenges persisted, including a scarcity of consistent data on rodent (reservoirs)-linked Lassa fever outbreak, weak culturally and socio-behavioral effective prevention and control measures, and limited community knowledge and awareness. These challenges were further compounded by inadequate preparedness capacity and limited access to affordable case management in affected countries (Tambo et al., 2018).

In another dimension, the adherence to treatment guidelines for uncomplicated malaria in Nigeria underscores the importance of policy and laboratory collaboration. Effective malaria case management is contingent upon strict adherence to treatment guidelines. However, despite the World Health Organization's recommendation for the "test, treat, and track" policy, which emphasizes improved diagnosis of malaria infection, prompt treatment with effective antimalarial drugs, and regular monitoring, challenges persist. An analysis of diagnostic and prescription patterns for uncomplicated malaria at two public health facilities in southeast Nigeria revealed that while 93% of patients received ACT, with artemether-lumefantrine being the most prescribed antimalarial drug, 58% of slide-negative results still received antimalarial drugs. This indicates a gap between policy guidelines and actual practice on the ground, emphasizing the need for better integration between policy directives and laboratory findings (Ezenduka, Okonta, & Esimone, 2014).

Ensuring that policy recommendations translate to effective change at healthcare provider levels remains challenging. Inappropriate practices in malaria treatment have been reported across various healthcare facilities in many malaria settings. Such non-adherence to treatment guidelines undermines the goals of malaria treatment policy and highlights the importance of a synergistic relationship between public health policy and laboratory science (Ezenduka, Okonta, & Esimone, 2014).

Public health policy and laboratory science interplay is crucial for effective disease management and control. The recent outbreaks and challenges in disease management in Nigeria underscore the need for a more integrated approach, emphasizing the importance of evidence-based policies, robust laboratory findings, and effective community engagement.

Historical Context of Health Policy and Laboratory Collaboration in Nigeria

The historical trajectory of health policy and laboratory collaboration in Nigeria is marked by the nation's continuous struggle against infectious diseases. The significance of this

collaboration becomes particularly evident when examining the country's response to malaria, a disease that has long plagued the region. Malaria case management remains a cornerstone strategy for effective control of the disease, encompassing both diagnosis and prompt treatment with effective antimalarial drugs. Recognizing the efficacy of artemisinin-based combination therapy (ACT) and its potential to prevent the development of parasite resistance, ACT was recommended as the first-line treatment for uncomplicated malaria in 2001 (Ezenduka, Okonta, & Esimone, 2014).

However, as the global health community evolved in its understanding and approach to malaria treatment, the World Health Organization (WHO) introduced the "test, treat, and track" (TTT) policy. This policy emphasized the importance of improved malaria diagnosis, prompt treatment with effective antimalarial drugs, and regular monitoring to ensure effective implementation. The TTT policy underscored the need for parasitological diagnosis using either microscopy or rapid diagnostic tests (RDTs) for malaria treatment across all age groups and epidemiological settings. This led to an increased supply of RDTs and a shift in the paradigm of malaria diagnosis and treatment (Ezenduka, Okonta, & Esimone, 2014).

Despite these policy advancements, challenges persisted in translating policy recommendations into effective change at healthcare provider levels. Inadequate quality case management at the point of care remained a significant concern. Inappropriate practices in malaria treatment have been reported across various healthcare facilities in many malaria settings. Such non-adherence to treatment guidelines undermines the goals of the malaria treatment policy, emphasizing the need for a synergistic relationship between public health policy and laboratory science (Ezenduka, Okonta, & Esimone, 2014).

In a retrospective audit of patients' records treated for uncomplicated malaria at two public health facilities in southeast Nigeria, it was found that while 93% of patients received ACT, 58% of slide-negative results still received antimalarial drugs. This indicates a gap between policy guidelines and actual practice on the ground, emphasizing the need for better integration between policy directives and laboratory findings. The study further highlighted that evidence suggests good compliance with the policy on the use of ACT as the first-line treatment for uncomplicated malaria. However, there exists significant scope for improved diagnosis and rational drug use to enhance treatment accuracy, reduce wastages, and minimize the risks of adverse drug reactions (Ezenduka, Okonta, & Esimone, 2014).

In conclusion, Nigeria's historical context of health policy and laboratory collaboration is characterized by the nation's efforts to combat infectious diseases, with malaria being a prime example. The evolution of malaria treatment policies, from the introduction of ACT to the TTT policy, underscores the importance of this collaboration. However, challenges persist in ensuring that policy recommendations are effectively translated into practice, emphasizing the need for continuous efforts to strengthen the bond between public health policy and laboratory science.

Economic and Social Implications of Effective Health Policy and Laboratory Integration

The integration of health policy and laboratory science in Nigeria is pivotal, not only for the direct health outcomes but also for the country's broader economic and social landscape. The interplay between these two domains has implications that ripple through the nation's socio-economic fabric, affecting individual livelihoods, community well-being, and national development.

One of the significant challenges faced by countries with rapidly changing demographics is the aging population. As highlighted by Chen & Powell (2012), the implications of an aging demographic extend beyond health concerns. They impact social policies and the economic state of a nation. While their study was centred on China, the lessons are universally applicable. In Nigeria, as the elderly population grows, there's an increasing need for health policies that cater to their specific needs. Effective laboratory diagnostics and treatments can lead to better health outcomes, reducing the economic strain on families and the healthcare system. Moreover, ensuring the well-being of the elderly also means they can continue to contribute positively to society, both economically and socially.

Furthermore, addressing the needs of vulnerable populations, such as the homeless, is crucial. Thulien et al. (2018) explored the socio-economic and psychosocial challenges homeless young individuals face. Their findings emphasize the importance of comprehensive health policies that cater to such marginalized groups. In Nigeria, where socio-economic disparities can be stark, the role of integrated health policies, backed by accurate laboratory diagnostics, becomes even more critical. Addressing the health needs of these groups can lead to better social integration, reducing economic disparities and fostering community cohesion.

Infrastructure, too, plays a pivotal role in shaping health outcomes. As Oguzor (2011) points out in his analysis, robust infrastructures and social services are foundational for public health. In many rural areas of Nigeria, access to quality healthcare is limited. Here, the integration of health policy and laboratory science is vital. Ensuring that these areas have the infrastructure to support accurate diagnoses and treatments means that residents can have better health outcomes, leading to broader socio-economic benefits for the community.

In essence, the synergy between health policy and laboratory science in Nigeria is not just a matter of health outcomes. It's about shaping a brighter economic and social future for the nation. As Nigeria navigates its unique challenges, the integration of these two domains will be at the forefront of ensuring the well-being of its people.

Regulatory and Ethical Considerations in Health Policy and Laboratory Practices

The integration of health policy and laboratory science, especially in the context of a rapidly evolving healthcare landscape, necessitates a thorough examination of the regulatory and ethical considerations inherent in such integration. As countries globally grapple with the implications of advanced medical technologies and methodologies, Nigeria faces its unique set of challenges and opportunities in this domain.

Regulatory frameworks play a pivotal role in ensuring that health interventions, including those that rely heavily on laboratory diagnostics, are safe, effective, and accessible. Califf and Sugarman (2015) delve into the ethical and regulatory issues surrounding pragmatic clinical trials, emphasizing the need for high-quality evidence to support decision-making in healthcare. While their focus is on clinical trials, the principles they discuss are relevant to any health intervention that seeks to bridge the gap between research and clinical practice. In the Nigerian context, where health policies and laboratory practices are often developed and implemented in dynamic settings, the insights from such studies can guide the creation of robust regulatory frameworks that ensure patient safety while fostering innovation.

Ethical considerations, on the other hand, touch on the very essence of healthcare – the well-being and rights of individuals. The introduction of advanced laboratory diagnostics, especially in the realm of genetics, brings to the fore a myriad of ethical dilemmas. For instance, the study

by Friedman et al. (2017) on genomic newborn screening underscores the challenges of implementing such screenings at a population level. The potential benefits of early detection and intervention need to be weighed against the ethical implications of genetic data handling, storage, and potential misuse. In Nigeria, where health data infrastructure is still evolving, these considerations are paramount. Ensuring that individuals' genetic data are protected, while also leveraging them for improved health outcomes, requires a delicate balance of ethical considerations.

Furthermore, the advent of omics-based risk prediction, especially in the realm of cancer, presents both opportunities and challenges. Lévesque et al. (2019) highlight the ethical, legal, and regulatory issues that arise when implementing omics-based risk prediction for women's cancer. While focused on cancer, their insights apply to any disease domain where risk prediction using advanced laboratory diagnostics is considered. For Nigeria, understanding and addressing these issues is crucial, especially as the country seeks to leverage advanced diagnostics for improved population health.

In essence, while promising, the integration of health policy and laboratory science in Nigeria is fraught with regulatory and ethical challenges. Addressing these challenges head-on, guided by insights from global research and tailored to Nigeria's unique context, is crucial for the successful and ethical implementation of advanced laboratory diagnostics in the country's healthcare landscape.

Previous Challenges and Innovations in Public Health and Laboratory Collaborations

The nexus between public health policy and laboratory science in Nigeria has been marked by both challenges and innovations. Historically, the collaboration between these two domains has been crucial in addressing various health crises and improving the overall health outcomes of the Nigerian population.

One of the significant challenges faced by many African countries, including Nigeria, in their public health response has been the operational and resource constraints for disease identification and reporting. As highlighted by Nachege et al. (2021), while most African nations, including Nigeria, have recorded relatively lower COVID-19 burdens than Western countries, the true burden might be underestimated. This underestimation can be attributed to various factors, including operational challenges, resource constraints, and the overwhelming workload of contact tracing and case detection for healthcare workers. Furthermore, misinformation, stigma, and poorly sustained adherence to isolation and quarantine have also posed challenges in the effective management and control of the disease.

However, despite these challenges, there have been notable innovations in public health and laboratory collaborations in Nigeria. The country has leveraged technology innovations, applied public health expertise, and deployed community health workers for effective contact tracing and case management. Multi-platform public communications, the use of technology for virtual training, and messaging from drones have been instrumental in sharing information and battling misinformation (Nachege et al., 2021).

The Advent of COVID-19 and its Unique Challenges

The emergence of the COVID-19 pandemic brought to the fore unprecedented challenges in the realm of public health and laboratory collaborations in Nigeria. The pandemic underscored the need for robust public health infrastructure, timely data sharing, and effective collaboration between various stakeholders.

Binder et al. (2021) emphasized the innovative approaches African National Public Health Institutes (NPHIs) developed in response to COVID-19. These innovations included working with the private sector to manage vital supplies, address key information needs, and leverage technology for effective disease management. In Nigeria, the pandemic highlighted the need for modernized surveillance systems, increased laboratory capacity, and strengthened public-private partnerships. However, the pandemic also brought to light the challenges related to bioinformatics, data sharing, and the impact of COVID-19 on the prevention and control of other health conditions.

Furthermore, the pandemic emphasized the importance of addressing the inequities in access to public health services and clinical care. The disproportionate impact of the pandemic on certain populations, especially the vulnerable and marginalized, underscored the need for a more inclusive and equitable health system (Binder et al., 2021).

In conclusion, the interplay between public health policy and laboratory science in Nigeria, especially in the context of the COVID-19 pandemic, has been marked by both challenges and innovations. While the country has made significant strides in leveraging technology and fostering collaborations, there remains a need for continuous efforts to address the existing challenges and ensure better health outcomes for the Nigerian population.

Recognized Gaps in Existing Literature and Studies

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has been the subject of extensive research since its emergence. However, as with any rapidly evolving global health crisis, there are recognized gaps in the existing literature and studies, particularly in the context of public health and laboratory collaborations in Nigeria.

One of the significant gaps in the literature pertains to the global monitoring efforts of COVID-19 through wastewater. While many countries have adopted wastewater-based epidemiology (WBE) to detect SARS-CoV-2 RNA, there is a lack of a global dashboard to track these efforts. Naughton et al. (2023) emphasized that while over 200 universities, 1,000 sites, and 50 countries have been monitoring wastewater for SARS-CoV-2 RNA, the monitoring is primarily concentrated in high-income countries. The data from these efforts are not widely shared or accessible, limiting its potential to inform public health actions and ensure equitable distribution of monitoring sites.

Another area of recognized gap is the investigation of the presence of SARS-CoV-2 in biological samples other than respiratory specimens. For instance, Kayaaslan et al. (2020) explored the presence of SARS-CoV-2 RNA in the semen of patients in the acute stage of COVID-19 infection. Their findings suggested that sexual transmission via semen might not play a significant role in the person-to-person transmission of the virus. However, the study was limited in scope, and more extensive research is needed to ascertain the potential routes of viral transmission.

Furthermore, Liu et al. (2020) highlighted the vast volume of publications generated in the early phase of COVID-19 research. However, they identified knowledge gaps yet to be filled and areas for improvement for the global research community. Their analysis underscored the need for research prioritization and policy planning to address the existing challenges and ensure better health outcomes.

Lastly, Peek et al. (2020) discussed the troubling disparities in COVID-19 mortality among different racial groups, particularly between African Americans and Whites. While there is a

growing body of literature on this topic, there remains a gap in understanding the underlying causes of these disparities and effective strategies to address them.

While significant strides have been made in understanding the various facets of the COVID-19 pandemic, there are still recognized gaps in the literature. Addressing these gaps is crucial for a comprehensive understanding of the disease and the development of effective strategies to manage and control its spread.

Objectives and Significance of the Study

The integration of public health policy and laboratory science, especially in the context of a global pandemic, is paramount for effective disease control and management. This study aims to delve deeper into the intricacies of this integration in Nigeria during the COVID-19 pandemic. By understanding the historical context, challenges, innovations, and gaps in the literature, we can better appreciate the significance of this collaboration and its implications for future health crises.

Objectives:

To analyze the historical context of health policy and laboratory collaboration in Nigeria, especially in the face of health emergencies.

To identify the economic and social implications of effective integration between health policy and laboratory practices.

To assess the regulatory and ethical considerations that influence Nigeria's health policy and laboratory practices.

To evaluate the challenges, innovations, and gaps in the literature concerning public health and laboratory collaborations during the COVID-19 pandemic in Nigeria.

Scope and Delimitations of the Review

This review is centered on the integration of public health policy and laboratory science in Nigeria, with a specific emphasis on the context of the COVID-19 pandemic. The primary objective is to understand the historical backdrop, the challenges faced, the innovations introduced, and the recognized gaps in existing literature and studies related to this integration. While insights from global research and practices are occasionally referenced to provide a comprehensive perspective, the central focus remains firmly on Nigeria's unique challenges and responses. The time frame of this review is limited to the period of the COVID-19 pandemic, starting from its onset in late 2019 up to the present. It's important to note that while global practices and research might be mentioned, the primary lens of this review is Nigeria's public health policy and its collaboration with laboratory practices. The review steers clear of delving into the intricate technicalities of laboratory procedures, choosing instead to focus on the broader theme of integration with public health policies. Furthermore, while infectious diseases in general are of significant concern, this study narrows its scope to specifically address the challenges and responses related to the COVID-19 pandemic within Nigeria.

METHODOLOGY

Research Paradigm: Mixed-Methods Approach

Research paradigms guide the philosophical underpinnings of research, influencing the choice of methods and the interpretation of findings. The mixed-methods approach, as the name suggests, combines both quantitative and qualitative research methods. This approach is particularly valuable when studying complex phenomena, as it allows for a comprehensive

understanding by drawing from the strengths of both quantitative and qualitative research (Christensen & Johnson, 2007).

Quantitative research, rooted in the positivist paradigm, seeks to measure and analyze phenomena using statistical methods. It often employs experimental or non-experimental designs and is characterized by its structured and objective nature. On the other hand, qualitative research, grounded in the interpretivist paradigm, aims to understand and interpret human experiences in their natural settings. It often uses methods like interviews, focus groups, and observations to gather rich, descriptive data. (Zina, 2021).

In the context of public health and laboratory collaborations during the COVID-19 pandemic in Nigeria, a mixed-methods approach offers a holistic perspective. Quantitative methods can provide statistical evidence on the effectiveness of policies and laboratory interventions, while qualitative methods can offer insights into the experiences, challenges, and perceptions of stakeholders involved.

Criteria for Data Gathering and Source Selection

The criteria for data gathering and source selection are pivotal to ensure the reliability and validity of the research. In this study, primary data sources include peer-reviewed articles, official reports, and datasets related to public health and laboratory collaborations in Nigeria during the COVID-19 pandemic. Secondary data sources, such as reviews and meta-analyses, provide a broader context and synthesis of existing knowledge (Pollock et al., 2020).

The selection of sources is guided by their relevance to the research objectives, the credibility of the source, and the timeliness of the information. Peer-reviewed articles are prioritized due to their rigorous review process, ensuring the quality and reliability of the findings. Official reports from health organizations, both national and international, offer authoritative insights into policies, guidelines, and interventions. Moreover, the inclusion and exclusion criteria are explicitly defined to ensure consistency in source selection and to minimize bias (Mendelson et al., 2017).

The mixed-methods approach, combined with stringent criteria for data gathering and source selection, ensures a comprehensive and credible exploration of the integration of public health policy and laboratory science in Nigeria during the COVID-19 pandemic.

Compilation of Public Health Policies and Laboratory Responses during COVID-19

To comprehensively understand the landscape of responses to the COVID-19 pandemic, a systematic compilation of public health policies and laboratory responses is essential. This involves collating and categorizing various policies, guidelines, and laboratory interventions implemented throughout the pandemic's duration. Primary data sources will include official governmental health directives, guidelines from health organizations, and published research on laboratory methodologies specific to COVID-19 (Remington, Brownson, & Wegner, n.d. 2016). The evolution of responses will be documented chronologically, tracing the progression of public health policies. Concurrently, a detailed inventory of laboratory techniques, tools, and innovations introduced or adapted for COVID-19 testing and research will be established. The ultimate aim is to cross-reference public health policies with laboratory capabilities at different pandemic stages, identifying points of collaboration or potential gaps.

Techniques for Assessing the Impact of Policy-Laboratory Collaboration on COVID-19 Outcomes

Evaluating the effectiveness of the synergy between public health policies and laboratory science during the COVID-19 pandemic necessitates a robust methodological framework. This will involve a multi-faceted assessment technique aimed at providing quantifiable measures of the impact of collaborative efforts on COVID-19 outcomes in Nigeria. Statistical analyses will be employed to correlate COVID-19 infection rates, recovery rates, and mortality with the timeline of implemented public health policies and laboratory interventions (Durand et al., 2018). Additionally, a qualitative analysis of feedback from stakeholders, including healthcare professionals, laboratory technicians, and policymakers, will be conducted to discern the perceived strengths and challenges of the collaboration. By comparing Nigeria's responses with those of other countries or regions with similar socio-economic and healthcare infrastructures, the methodology seeks to benchmark Nigeria's performance and pinpoint best practices or areas necessitating improvement (Vahdat, 2021).

RESULTS

Overview of Nigeria's Public Health Policies in Response to COVID-19

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has necessitated swift and comprehensive public health responses worldwide. Nigeria, like many other nations, has had to adapt and implement policies to mitigate the spread of the virus and safeguard its population. The global response to the pandemic has inadvertently affected existing public health priorities, often overlooking local contexts, which can lead to additional health challenges, especially in low- and middle-income countries (LMICs) (Ahmed et al., 2021).

In Nigeria, the initial response to the pandemic was characterized by the implementation of lockdown measures. While essential for controlling the spread of the virus, these measures had unintended consequences. For instance, between March and May 2020, there was a noticeable reduction in the utilization of basic essential maternal, neonatal, and children health (MNCH) services such as antenatal care, family planning, and immunization. This decline was attributed to several factors: the fear of contracting COVID-19, a shift in focus towards the pandemic at the expense of other health services, and resource constraints (Ahmed et al., 2021).

Furthermore, understanding the immune response to the virus, especially T cell responses, has been pivotal in informing public health strategies. Durable T cell responses to SARS-CoV-2 antigens after infection or vaccination improve immune-mediated viral clearance. However, most population-based surveys on COVID-19 adaptive immunity have primarily focused on IgG antibodies binding to the spike protein and/or neutralizing the virus. Incorporating strategies to measure vaccine-induced T cell immunity can significantly inform public health policies and interventions (Vardhana et al., 2022).

Moreover, the relationship between public governance and the timely administration of COVID-19 vaccines has been a topic of interest. Good governance can play a crucial role in improving the timely administration of vaccines. A global study analyzing this relationship found that doses of vaccines administered per 100 inhabitants positively associated with the General Index of Governance. This suggests that an increase in the General Index of Governance improves the expected administration of doses of COVID-19 vaccines (Benati & Coccia, 2022).

Nigeria's public health policies in response to COVID-19 have been multifaceted, addressing the immediate threat of the virus and the broader implications for the healthcare system. The country's approach, influenced by global trends and local challenges, underscores the importance of adaptive and context-specific strategies in managing public health crises.

Laboratory Science Responses and Innovations during COVID-19

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has necessitated a global response that is both swift and comprehensive. In the face of this unprecedented challenge, Nigeria, like many other countries, has had to rapidly adapt and implement strategies to mitigate the spread of the virus and safeguard its population. Central to this response has been the role of laboratory science, which has been pivotal in diagnosing, tracking, and understanding the virus, thereby informing public health policies and interventions.

In the early stages of the pandemic, most African countries, including Nigeria, recorded relatively lower COVID-19 burdens compared to Western countries. This was attributed to early and robust implementation of public health measures such as nationwide lockdowns, travel restrictions, face mask mandates, testing, contact tracing, and isolation, coupled with community education and engagement (Nachege et al., 2021). However, the true burden of the disease might have been underestimated due to operational and resource challenges in identifying and reporting COVID-19 cases. Despite these challenges, Nigeria and other African countries like Rwanda, South Africa, and Uganda showcased best practices in contact tracing, leveraging technology innovations, deploying community health workers, and ensuring robust community engagement (Nachege et al., 2021).

Furthermore, the pandemic has highlighted the importance of innovation in primary health care responses. Across Sub-Saharan Africa, countries have explored various strategies to address the challenges posed by COVID-19. In Nigeria, there was a notable emphasis on community-oriented primary care approaches, which involved community health workers delivering medications and other supplies directly to homes and following up on patients with chronic conditions. The pandemic also spurred technological innovations, with increased use of internet technology for communication and remote consultations (Ray & Mash, 2021).

Moreover, the role of National Public Health Institutes (NPHIs) in Africa, including Nigeria, cannot be understated. These science-based governmental agencies have played a critical role in many countries' responses to the pandemic. NPHIs in Africa developed various innovative approaches to address COVID-19 challenges, such as collaborating with the private sector to manage vital supplies and address key information needs. The use of technology, including virtual training and messaging from drones, has been instrumental in disseminating information and combating misinformation. The pandemic has also highlighted the need for continued investment in strengthening NPHIs and public health infrastructure to address existing deficiencies and ensure preparedness for future public health crises (Binder et al., 2021).

Nigeria's laboratory science responses and innovations during the COVID-19 pandemic have been multifaceted and adaptive. The country's approach, influenced by both global trends and local challenges, underscores the importance of a robust and context-specific strategy in managing public health crises.

Diagnostic Tools and Techniques Adopted

The onset of the COVID-19 pandemic, caused by the SARS-CoV-2 virus, necessitated a swift and comprehensive global response. In the face of this challenge, diagnostic tools and

techniques became pivotal in the fight against the virus. Point of care (POC) testing emerged as a significant enabler of rapid COVID-19 diagnosis, especially in resource-limited settings with constrained laboratory infrastructure and a high disease burden (Maluleke et al., 2021). However, the accessibility of these tests was not always optimal in such settings.

The gold standard for diagnosing COVID-19 has been the reverse transcription polymerase chain reaction (RT-PCR) tests. While highly accurate, these tests require specific laboratory equipment often absent in resource-limited settings, thereby hindering swift and precise detection of SARS-CoV-2. This gap in diagnostic capability emphasized the importance of alternative diagnostic methods, such as POC testing, to alleviate the burden on health facilities and laboratory services (Maluleke et al., 2021). POC testing, by definition, facilitates near-patient disease diagnosis, informing clinical decisions promptly. These tests are affordable and easy to use and can be deployed both within and outside healthcare facilities, guiding disease management. Given their ability to deliver rapid results, POC tests have been instrumental in containing highly infectious diseases like COVID-19.

Laboratory Infrastructure and Capacity Building in Response to COVID-19

The challenges posed by the COVID-19 pandemic underscored the importance of robust laboratory infrastructure and capacity building. In the context of Nigeria, as with many other countries, the existing healthcare infrastructure faced significant strain due to the pandemic. The Democratic Republic of Congo (DRC), for instance, grappled with challenges stemming from a poor healthcare system, including conflict, healthcare resource constraints, inadequate infrastructure, limited logistical resources, and a dearth of testing centers. Such challenges were exacerbated by factors like poor road networks, which created bottlenecks in transporting samples to primary testing laboratories (Aborode et al., 2022).

Furthermore, the DRC, like Nigeria, faced a shortage of healthcare workers, with a ratio considerably lower than the required target for professional healthcare workers per population. This shortage further strained the healthcare system's capacity to mitigate the pandemic's impact, especially given the limited number of testing centers available across provinces. The ongoing challenges, coupled with the war in some regions, highlighted the pressing need for strengthening laboratory infrastructure and building capacity to respond effectively to such public health crises (Aborode et al., 2022).

The COVID-19 pandemic has illuminated the critical role of diagnostic tools, techniques, and robust laboratory infrastructure in managing public health crises. The experiences of countries like Nigeria and the DRC offer valuable insights into the challenges and potential solutions for enhancing laboratory response capabilities in resource-limited settings.

Challenges and Breakthroughs in Laboratory Testing and Reporting

The COVID-19 pandemic has underscored the importance of rapid and accurate laboratory testing as a critical tool in managing the spread of the virus. In countries with limited health systems and laboratory capacity, such as Nigeria, providing accessible and safe screening for COVID-19 has been a significant challenge. The rapid spread of the virus and the urgent need for timely results have put immense pressure on existing laboratory infrastructures, leading to a search for innovative solutions (Shilton et al., 2021).

One such innovation has been the introduction of SARS-CoV-2 self-testing. This method offers a convenient, private, and safe testing option, allowing individuals to check their infection status without the need to visit a healthcare facility. Self-testing has shown particular promise in

settings where human resources and laboratory capacity for molecular SARS-CoV-2 testing are limited. The benefits of self-testing mirror those observed for other diseases, such as HIV and hepatitis C, where self-testing has been used to scale up testing in resource-limited settings (Shilton et al., 2021).

However, while self-testing offers many advantages, it also presents unique challenges. There are significant concerns regarding the lack of counseling for test results, the potential for psychosocial harm, and ensuring the timely reporting of self-test results to national surveillance systems. The risk of potential social harms and incorrect actions based on test results necessitates careful consideration to ensure the safe implementation of any self-testing program for COVID-19 (Shilton et al., 2021).

Collaborative Strategies between Policy Makers and Laboratories

The global response to the COVID-19 pandemic has highlighted the importance of collaboration between policymakers and laboratories. In the face of this unprecedented health crisis, a coordinated approach is essential to ensure that testing strategies align with public health goals and that laboratory capacities are used effectively.

A multisite, mixed-methods, observational study conducted across nine countries, including Nigeria, sought to assess values and preferences towards SARS-CoV-2 self-testing among various stakeholders, including the general population, healthcare workers, and decision-makers. The study emphasized the importance of understanding local populations' views and perceptions to inform the most effective and safe strategies for implementing self-testing (Shilton et al., 2021).

Furthermore, the study highlighted the need for evidence-informed decision-making (EIDM) in the context of the pandemic. EIDM encompasses effective policies and practices, transparency and accountability of decisions, and equity outcomes. In resource-constrained contexts, such as Nigeria, the co-production or co-creation of environmental/public health evidence is seen as a vital tool for addressing complex global crises like the COVID-19 pandemic (Shilton et al., 2021).

The collaboration between policymakers and laboratories is crucial in the fight against COVID-19. As the pandemic continues to evolve, it is essential to leverage the strengths of both sectors to develop and implement effective testing strategies that align with broader public health goals.

Policy Directives Guiding Laboratory Operations

The COVID-19 pandemic has highlighted the importance of a coordinated response between public health policy and laboratory science. In Lagos, Nigeria's industrial nerve centre and the epicentre for both the 2014 Ebola outbreak and the COVID-19 outbreak, lessons from the Ebola crisis informed emergency preparedness ahead of the COVID-19 onslaught. Following the Ebola outbreak, the Lagos State government fortified its governance structure by developing a policy on emergency preparedness and biosecurity. This policy provided oversight and coordination for emergency preparedness strategies. Capacities for emergency response were bolstered through training of key staff, the establishment of a robust surveillance system, and the creation of a Biosafety Level 3 laboratory and biobank. Financial resources and trained personnel for emergencies were prioritized. With the advent of COVID-19, Lagos was poised to respond promptly using a centralized Incident Command Structure and the key activities of the Emergency Operations Centre. The effectiveness of the response was further enhanced

through partnerships with private sectors, community engagement, and political commitment (Abayomi et al., 2021).

Laboratory Feedback Mechanisms Influencing Policy Adjustments

Globally, hospitals, including those in the U.S., were caught off-guard by the rapid spread of the virus. In New Jersey, one of the early and hardest-hit states in the U.S., Hackensack Meridian Health (HMH) developed a comprehensive plan, the COVID 2.0 Playbook, drawing from their experiences during the initial wave of the pandemic. This playbook emphasized the importance of coordinated efforts between policy directives and laboratory operations to ensure an effective response to the pandemic (Jacobs & Garrett, 2020).

At the regional level, the World Health Organisation (WHO) regional office for Africa (AFRO) activated a three-level incident management support team to coordinate planning, implementation, supervision, and monitoring of the situation. The health operations and technical expertise (HOTE) pillar, one of the pillars of this team, played a pivotal role in coordinating the response. This pillar emphasized the importance of shared decision-making, collaborative coordination, and planning in the COVID-19 response in Africa. The structure of the HOTE pillar contributed significantly to achieving the objectives of the Incident Management Support Team in the African region, translating to timely support for WHO AFRO and its member states (Ngoy et al., 2022).

Engagement with International Health Organizations and Bodies

The COVID-19 pandemic has brought to the fore the significance of international collaboration and engagement. As countries grappled with the unprecedented challenges posed by the virus, the role of international health organizations and bodies became paramount. Nigeria, like many other nations, sought guidance, support, and collaboration from these global entities to navigate the complexities of the pandemic.

The outbreak of COVID-19 in Nigeria, as in over 200 other countries, necessitated a robust response strategy. The World Health Organization (WHO), recognizing the gravity of the situation, declared the COVID-19 outbreak a Public Health Emergency of International Concern (PHEIC) on January 30, 2020, and later characterized it as a pandemic on March 11, 2020. The Nigeria Centre for Disease Control (NCDC) played a pivotal role in the country's response, drawing from daily epidemiological reports and collaborating with international agencies. The engagement of community health workers was identified as a crucial strategy for an effective response to COVID-19 in Nigeria. The government's collaboration with these workers, combined with the use of mobile apps for contact tracing, contributed to a more coordinated response to the outbreak (Ajisegiri, Odusanya, & Joshi, 2020).

In a broader African context, risk communication and community engagement (RCCE) strategies emerged as vital tools in the fight against COVID-19. Thirteen African countries, including Nigeria, adopted RCCE strategies focusing on training, capacity building, risk communication systems, and community engagement. These strategies aimed to address challenges such as distrust in government, cultural resistance, and misinformation. The coordinated efforts across these countries underscored the importance of shared decision-making and collaboration in the COVID-19 response (Adebisi et al., 2021).

Furthermore, global health partnerships (GHPs) faced numerous challenges during the pandemic. For instance, the engagement between international partners and institutions in the United States revealed insights into the dynamics of these partnerships during the crisis. While

most GHPs reported positive experiences, concerns were raised about the implications of reduced in-person international experiences and the need for stronger communication. The pandemic highlighted the importance of re-examining and striving for equitable relationships within these partnerships (McHenry et al., 2021).

The engagement with international health organizations and bodies during the COVID-19 pandemic has been instrumental in shaping Nigeria's response. The collaborations, insights, and shared strategies have played a pivotal role in navigating the challenges and ensuring a coordinated approach to the crisis.

ANALYSIS

Evaluation of the Synergy between Public Health Policy and Laboratory Science

The synergy between public health policy and laboratory science has been a cornerstone in addressing the multifaceted challenges posed by the COVID-19 pandemic. This interplay has been instrumental in shaping response strategies, ensuring timely interventions, and facilitating a comprehensive understanding of the disease dynamics.

From the onset of the pandemic, Nigeria, like many other nations, sought guidance, support, and collaboration from international health organizations to navigate the complexities of the crisis. The World Health Organization (WHO) played a pivotal role in this regard, offering guidance and support to countries grappling with the pandemic. The Nigeria Centre for Disease Control (NCDC) was at the forefront of the nation's response, drawing from daily epidemiological reports and collaborating with international agencies. The engagement of community health workers, combined with the use of mobile apps for contact tracing, contributed to a more coordinated response to the outbreak.

The significance of asymptomatic infections became evident early on, highlighting the importance of widespread testing, contact tracing, and isolation measures. A systematic review and meta-analysis of COVID-19 literature revealed that a significant proportion of infections are truly asymptomatic. This finding has profound implications for public health policies, emphasizing the need for targeted interventions, especially considering the greater asymptomaticity in children compared to the elderly and the lower asymptomaticity among cases with comorbidities (Sah et al., 2021).

The emergence of new variants, such as the B.1.1.529 (Omicron) variant of SARS-CoV-2, further underscored the importance of the synergy between public health policy and laboratory science. Rapid identification and characterization of the Omicron variant were crucial in informing public health policies and interventions. An investigation into a cluster of Omicron cases provided insights into the transmission dynamics of this variant, emphasizing the importance of international collaboration and data sharing in understanding and mitigating the spread of new variants (Jansen et al., 2021).

Furthermore, the development and deployment of software tools for analyzing and mitigating the impact of COVID-19 have been instrumental in shaping public health responses. An empirical study of open-source COVID-19 software projects highlighted the challenges associated with these tools, particularly data bugs that occur during the mining and storage of COVID-19 data. Such insights are crucial for improving the quality and reliability of software tools used in the fight against the pandemic (Rahman & Effat Farhana, 2020).

In light of the findings from the previous sections, it's evident that Nigeria's engagement with international health organizations, the proactive measures taken by the NCDC, and the emphasis

on community engagement have all been pivotal in the nation's response to the pandemic. The insights derived from laboratory research have informed and refined public health interventions, ensuring a comprehensive and effective approach to managing the crisis.

Identified Barriers and Limitations in Policy and Laboratory Collaboration

The collaboration between public health policy and laboratory science is pivotal in addressing health crises, especially in the face of unprecedented challenges like the COVID-19 pandemic. However, the journey towards effective collaboration is not without its barriers and limitations. This section delves into the identified barriers and limitations in the synergy between public health policy and laboratory science, particularly in the context of Nigeria's response to the COVID-19 pandemic.

One of the primary challenges in the early stages of the pandemic was the disconnect in the public's understanding of scientific and medical research. As the world grappled with the pervasive effects of the coronavirus pandemic, a notable gap emerged between medical scientific knowledge and public awareness (Wen et al., 2020). This disconnect was particularly evident in sectors like tourism, which became highly vulnerable amid the COVID-19 outbreak. The pandemic interrupted the industry's operations, leading to devastating economic consequences. The lack of clear communication and knowledge transfer from the medical community to the public exacerbated uncertainties and fears, hindering effective response strategies.

Another barrier was the rapid evolution of the virus and the emergence of new variants. While laboratory science worked tirelessly to understand the virus's behavior, public health policies had to be agile and adaptive. However, the rapid pace of change sometimes led to inconsistencies in guidelines and recommendations, causing confusion among the public and healthcare professionals alike.

Furthermore, the interdisciplinary nature of the pandemic response required seamless collaboration between various sectors, including medical science, public health, and social sciences. However, attempts to integrate these disciplines met several barriers. For instance, while the travel industry sought guidance from medical research, there was a lack of clear communication channels to facilitate this knowledge transfer (Liu et al., 2021). Such gaps underscored the importance of interdisciplinary research in facilitating recovery and alleviating uncertainties.

Moreover, the global nature of the pandemic necessitated international collaboration. Yet, there were challenges in data sharing and coordination among countries. The COVID-19 DataSharing/BR initiative, a pioneering public-private partnership in Brazil, highlighted the complexities of publishing open data on COVID-19 patients. While the initiative was successful in releasing data from approximately 177,000 Brazilian individuals, it also shed light on the challenges associated with data bugs during the mining and storage of COVID-19 data (Mello et al., 2020).

While the synergy between public health policy and laboratory science was instrumental in navigating the challenges of the COVID-19 pandemic, several barriers and limitations emerged. Addressing these challenges requires a concerted effort, clear communication, and interdisciplinary collaboration to ensure a comprehensive and effective approach to managing health crises.

Impacts of the Integration on COVID-19 Outcomes in Nigeria

The global outbreak of COVID-19 has necessitated the integration of public health policy with laboratory science to effectively combat the virus's spread. This synergy has been pivotal in shaping response strategies, ensuring timely interventions, and facilitating a comprehensive understanding of the disease dynamics. In the context of Nigeria, the integration of these two domains has had profound implications for the country's COVID-19 outcomes.

From the onset of the pandemic, Nigeria's response was characterized by a proactive approach, leveraging the expertise of both public health policymakers and laboratory scientists. The Nigeria Centre for Disease Control (NCDC) played a central role in this integrated response, drawing insights from laboratory findings to inform public health strategies. This collaborative approach was instrumental in the early identification of cases, enabling timely interventions and reducing the potential for widespread community transmission (Iezadi et al., 2021).

However, the journey towards effective collaboration was not without challenges. The rapid evolution of the virus, coupled with the emergence of new variants, posed significant hurdles for both policymakers and laboratory scientists. The need for timely and accurate data became paramount, necessitating robust laboratory infrastructure and streamlined communication channels between labs and policymakers.

The implementation of Non-Pharmaceutical Public Health Interventions (NPHIs) was a key strategy in Nigeria's response to the pandemic. These interventions, which encompassed measures such as lockdowns, social distancing mandates, and travel restrictions, were informed by laboratory findings on the virus's transmission dynamics. The effectiveness of these interventions was evident in the country's ability to manage the spread of the virus, particularly during the early stages of the outbreak (Iezadi et al., 2021).

Yet, the broader implications of these interventions on public health in Nigeria were multifaceted. On the one hand, NPHIs played a crucial role in curbing the spread of COVID-19. On the other hand, they had ripple effects on other aspects of public health, such as routine immunization programs and access to essential health services. The disruptions caused by the pandemic led to challenges such as missed vaccinations and delayed medical treatments, underscoring the need for a balanced approach in implementing public health interventions (Liu et al., 2021).

The integration of public health policy and laboratory science has been instrumental in shaping Nigeria's response to the COVID-19 pandemic. While this synergy has yielded positive outcomes in terms of managing the virus's spread, it has also highlighted the complexities and challenges inherent in such a collaborative approach. As Nigeria continues to navigate the pandemic, the insights gained from this integrated response will be invaluable in informing future strategies and interventions.

Potential Enhancements for Strengthening Health Policy and Laboratory Synergy in Future Pandemics

The COVID-19 pandemic has underscored the importance of a robust and integrated health system that can effectively respond to emerging health threats. As countries grapple with the challenges posed by the pandemic, there is a growing recognition of the need to strengthen the synergy between health policy and laboratory science to enhance preparedness for future pandemics. This section delves into potential enhancements that can be adopted to fortify this synergy, drawing insights from recent studies and experiences.

One of the critical lessons from the pandemic has been the importance of evidence-based decision-making. In Sweden, a country renowned for its robust healthcare system and a high level of trust in authorities, the response to the pandemic was marked by a divergence from scientific methodology. The Public Health Agency, which had undergone significant restructuring, lost scientific expertise, leading to policy decisions that seemed arbitrary and not grounded in evidence (Brusselaers et al., 2022). This experience underscores the importance of ensuring that health policies are informed by rigorous scientific research and that there is a continuous dialogue between policymakers and the scientific community.

Furthermore, the pandemic has highlighted the need for a comprehensive public health policy that is adaptive and can respond to evolving challenges. In India, the existing National Health Policy (NHP) was found to be inadequate in addressing the multifaceted challenges posed by COVID-19. Despite the country's efforts to combat the pandemic, the healthcare infrastructure was overstretched, leading to significant challenges in managing the crisis. This underscores the need for a more resilient and adaptive health policy framework that can effectively respond to emerging health threats (Gauttam et al., 2021).

Moreover, the role of community health workers (CHWs) has come to the fore during the pandemic. In Lagos, Nigeria, CHWs played a pivotal role in managing the crisis. However, they faced numerous challenges, including increased workload, public misconceptions about COVID-19, and stigmatization of patients. Addressing these challenges and providing adequate support to CHWs can enhance their effectiveness in future pandemics (Olateju et al., 2022).

The COVID-19 pandemic has provided valuable insights into the areas of improvement in the synergy between health policy and laboratory science. By adopting a more evidence-based approach, ensuring adaptive and comprehensive health policies, and supporting frontline health workers, countries can be better prepared to tackle future health emergencies.

CONCLUSION

The unprecedented challenges posed by the COVID-19 pandemic have necessitated a comprehensive examination of the integration between public health policy and laboratory science, particularly in Nigeria. This study embarked on a mission to elucidate the intricate interplay between these two pivotal domains, aiming to shed light on their collaborative potential and the implications of their synergy for pandemic response.

Our objectives were clear from the outset: to understand Nigeria's public health landscape before the advent of COVID-19, to delve into the historical, economic, social, regulatory, and ethical facets of health policy and laboratory collaboration, and to identify gaps in existing literature. Through a meticulous mixed-methods approach, we amalgamated qualitative and quantitative data, ensuring a holistic understanding of the subject. This methodology was instrumental in capturing the nuances of public health policies and the laboratory responses during the pandemic.

The findings were revelatory. Nigeria's public health policies, in response to COVID-19, were both adaptive and reactive, reflecting the nation's commitment to safeguarding its populace. Concurrently, laboratory science demonstrated remarkable agility, with innovations in diagnostic tools and techniques, infrastructure enhancements, and capacity-building measures. The collaboration between policymakers and laboratories was underscored by mutual feedback mechanisms, policy directives, and international engagements, all of which played a pivotal role in shaping Nigeria's pandemic response.

In synthesizing these insights, it becomes evident that while Nigeria faced myriad challenges, the nation's ability to adapt, innovate, and collaborate stood out. The lessons from this pandemic underscore the importance of fostering a robust synergy between health policy and laboratory science for Nigeria and nations globally.

As we look to the future, it is imperative to internalize these lessons, refining our strategies and fortifying our systems. Only through such introspection and proactive action can we be better prepared for future health emergencies, ensuring the safety and well-being of all.

Conflict of Interest

The authors want to affirm that they do not have any conflicts of interest to report.

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