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Evaluating the Effectiveness of Electronic Health Records (EHRs) in Enhancing Disease Surveillance and Outbreak Response: A Comparative Analysis of Public Health Agencies in Nigeria

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Abstract

Electronic Health Records (EHRs) have become the most influential technology in the contemporary world of public health, where it is claimed that it can enhance the validity, timeliness, and responsiveness of the system in responding to disease epidemics. The use of EHRs offers opportunities to enhance surveillance and response to health issues in Nigeria even in a country where system failures in the health information service have been revealed during recurring national health emergencies such as Lassa fever, cholera, and COVID-19. This paper critically reviewed how EHRs are used to increase disease surveillance and outbreak response, with a particular emphasis on the comparative analysis of the key areas of public health agencies and departments that work at the federal, state and national levels, such as Nigeria Centre for Disease Control (NCDC), the Federal Ministry of Health and several state-level institutions. Based on the available academic works, institutional reports, and sources of international evidence, the analysis reveals the extent to which EHRs have enhanced the detection of outbreaks, reporting time, and orchestration of response systems. The results show that although EHRs help enhance disease reporting and resources distribution in a more efficient way, there are still some obstacles of interoperability, limited budget, workforce preparation, and unequal implementation at each state. Comparative lessons teach that public health agencies in Nigeria with well-developed digital systems (possibly within donor-funded platforms) respond far better during outbreaks than agencies that rely on paper-based or fragmented systems. The work adds to the discussion around digital health transformation in low- and middle-income countries because it lists the successes and the shortcomings of EHR-based surveillance systems in Nigeria. It is indicated that greater reinforcement of the interoperability frameworks, sustainable funding, and capacity-building of the workforce is required to maximize the potentials of EHRs in the preparation and surveillance of public health.

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Keywords: EHR disease surveillance, outbreak response, health informatics, public health agencies.

1. Introduction

Outbreaks of diseases are still emerging recurrent challenges to public health in Nigeria that reveal underlying weaknesses of preparedness, surveillance, and response capabilities. Through the Ebola outbreak of 2014, repeated epidemics of Lassa fever, and the more recent COVID-19 pandemic, the Nigerian health system has been repeatedly challenged. In all these cases, surveillance and reporting mechanisms dictated how quickly or slowly an intervention was achieved and the magnitude of morbidity and mortality (Ibrahim, 2021; Olukorode et al., 2024). Most paper-based surveillance technologies, which are the long-established surveillance technologies for health facilities in Nigeria, have

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usually suffered delays, incompleteness, and lack of interoperability among agencies. Such drawbacks suppress the ability to make decisions swiftly and lead to avoidable development of the outbreaks (Akwaowo et al., 2022).

The use of Electronic Health Records (EHRs) around the world has transformed disease surveillance and enhanced the timeliness, accuracy, and accessibility of data (Ghildayal, 2024). EHRs act as master storage that can achieve rapid aggregation and analysis of data to identify emerging trends in diseases, cases numbers, and provide knowledge-based focused interventions. High-income countries like the United States and countries in the European Union have used EHRs to detect outbreaks near real-time, to create prediction models as well as to better coordinate between agencies (Beaute et al., 2021; Guralnik, 2023). At present, however, the majority of the low-income countries (LMICs), where Nigeria is no exception, have not performed well in adopting EHR systems at a large scale (Sibiya, 2023).

However, Nigeria has made incremental progress towards health records digitisation in the form of the District Health Information Software 2 (DHIS2), the implementation of OpenMRS in some hospitals and surveillance systems offered by the Nigeria Centre for Disease Control (NCDC). Such systems have demonstrated the potential to improve the speed of disease reporting and coordinate responses. They are slowly gaining coverage, although there are major disparities between urban and rural facilities (Adedeji, 2022; Chika, 2024). The question is, have EHRs made a substantive difference in the ability of Nigeria to undertake disease surveillance and respond to outbreaks,-or are structural obstacles still inhibiting their transformational power?

Surveillance and Challenge of the Nigerian Disease Burden

Nigeria is the most populous nation in Africa bearing a disproportionately high burden of infectious diseases. Endemic diseases like malaria, tuberculosis, HIV/AIDS and frequent epidemics of cholera, meningitis and yellow fever keep the health system under constant pressure (Aniekwe et al., 2023). Such outbreaks demonstrate the necessity for efficient surveillance that may allow the timely detection of cases, appropriate reporting, and response. Paper-based systems have always lacked these, and outbreaks are recognized late, cases are under reported, and the same case may also be duplicated across several agencies (Olukorode et al., 2024).

Table 1. Selected Major Outbreaks in Nigeria and Health Information System Response

Outbreak	Year	Cases (approx.)	Weakness in Surveillance	Role of EHR/Digital Tools
Ebola Virus	2014	20	Delayed paper-based reporting; poor contact tracing	Limited EHR use; reliance on ad-hoc mobile reporting
Lassa Fever	2018	600+	Underreporting in rural facilities	Partial use of DHIS2 for aggregated data
COVID-19	2020	>250,000	Need for nationwide real-time monitoring	NCDC dashboards integrated with DHIS2 & lab systems
Cholera	2022	30,000+	Incomplete case reporting at community level	Weak EHR integration; mostly paper-based
Diphtheria	2023	17,000+	Data fragmentation across states	Gradual EHR adoption in pilot hospitals

Sources: Ibrahim (2021); NCDC Situation Reports (2022–2023); Olukorode et al. (2024).

International Evidence on EHR efficacy

There is evidence based in the high-income contexts that shows the ability of EHRs to closely become effective tools of outbreak preparedness. The CHRONICLE data hub in Michigan aggregates EHR data used to conduct real-time surveillance of chronic disease, making health resources more responsive in the United States (Barth et al., 2024). On the same note, the European Centre for Disease Prevention and Control (ECDC) has charted out in Europe the essence of European Health Records (EHR) in the field of infectious disease surveillance, and their efficacy in interoperability among the national health systems (Beaute et al., 2021). These considerations push the wider world to agree that the conversion of health records to the digital format enhances the timelessness, fullness, and accuracy of the surveillance data.

These types of models are, however, not necessarily directly applicable to LMICs because infrastructure, funding, and technical capacity differ between countries. As an example, whereas high-income countries could support interoperable systems with hundreds of institutions, Nigerian agencies sometimes rely on disconnected donor-funded pilots, which are not sustainable after the donor funds dry up (Akwaowo et al., 2022; Du et al., 2022).

Digital Health Transition, Nigeria

In the last ten years, Nigeria has tested the introduction of EHRs to public health monitoring. The NCDC has been utilizing digital dashboards in the era of managing the COVID-19 crisis, and some tertiary hospitals have been piloting the Open MRS and other digital record systems. However, there is uneven implementation state to state, due to lack of uniformity in access uniformity to the internet, funding, and skills in the workforce.

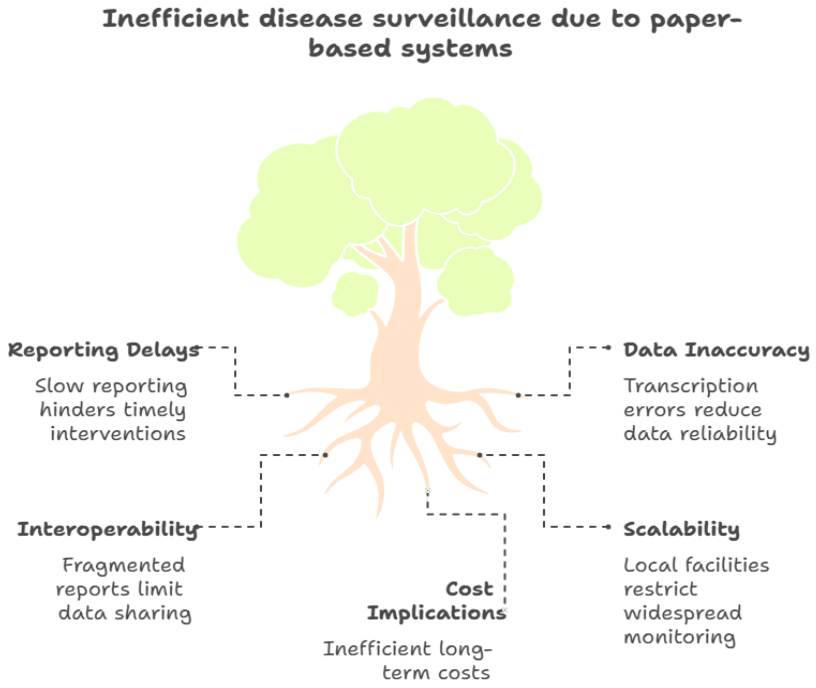


Figure 1: Ineffeicent Disease Surveillance due to paper based systems (Sources: Adedeji, 2022; Akwaowo et al., 2022; Ghildayal, 2024).

In spite of these encouraging trends, there is lack of systematic reviews on the use of EHRs and its potentials to improve surveillance and response to outbreaks in Nigeria. The majority of studies concentrate on technical feasibility or pilot results and little is known regarding the relative performance of EHRs across public health agencies. Furthermore, it is not yet fully recognized how much EHRs have objectively enhanced the speed of detection of an outbreak, accuracy in reporting, and coordination (Chika, 2024; Olukorode et al., 2024).

This paper thus aims to address this knowledge gap by conducting a comparative study of Nigerian surveillance agencies, and their implementation of EHR at the national level as a surveillance and outbreak response tool. The study seeks to derive local, as well as international evidence on the efficiency of EHRs in improving the health of the population in Nigeria, the challenges faced, and policy recommendations on how to best to execute in Nigeria to build a sound health surveillance system.

2. Literature Review

2.1. *International views on EHR and disease monitoring*

The use of Electronic Health Records (EHRs) has gained prominence and has become a (public health surveillance) staple throughout the world. EHRs in high-income countries have not only been used to capture patient-level care, they have also been utilized in the aggregate as data sources to identify outbreaks and plan responses. As an illustration, in America, EHR-presented data extraction in real-time helped public health officials monitor the influenza-like illness and the

COVID-19 peaks (Satterfield et al., 2021; Barth et al., 2024). On the same note, ECDC in Europe pointed out that integrated EHR systems would make health institutions across the border better protected by interoperability, as they can issue warning alerts faster (Beaute et al., 2021).

These systems are indicative of the fact that EHRs enhance surveillance by (1) minimizing report delays, (2) maximizing the completeness of the epidemiological data, and (3) availability of predictive analytics. Considering the further introduction of the EHR data to the machine learning solutions has facilitated further predictive modeling related to outbreak preparedness, particularly where a speedy decision-making process is paramount (Du et al., 2022; Guralnik, 2023). Nonetheless, the introduction of EHRs is associated with high infrastructure requirements, such as a broadband connection, cybersecurity measures, and professional competence of workforce. Countries with high incomes tend to meet these needs, whereas LMICs suffer with quite restricted technical and financial capabilities. To this end, such an international comparison has introduced an implementation gap that impedes the translation of international best practices into Africa's health systems (Kim, 2024).

Table 2. Key Global Case Studies on EHRs in Outbreak Surveillance

Country/Region	Example Program	Contribution to Surveillance	Challenges Reported
United States	CHRONICLE Data Hub	Aggregated real-time EHR data for chronic disease and outbreak prediction	Data privacy concerns
European Union	ECDC EHR Mapping	Cross-border interoperability for infectious disease alerts	Complexity of harmonizing data standards
South Korea	COVID-19 EHR Integration	Near-instant contact tracing using linked hospital EHRs	Concerns over patient data security
Canada	National COVID-19 Data Platform	Use of EHRs for pandemic modeling	Variability across provinces
United Kingdom	NHS Digital Systems	Centralized COVID-19 testing and vaccination reporting	Delayed updates in early stages

Sources: Beauté et al. (2021); Barth et al. (2024); Du et al. (2022); Guralnik (2023).

2.2. *Sub-Saharan Africa EHRs*

A gradual advancement in the adoption of digital health records has been enjoyed on the African continent with Kenya, South Africa and Rwanda leading the change. The adoption of OpenMRS by Kenya showed an impressive result by way of decrease in laboratory turnaround time and increased completion in reporting HIV and TB surveillance (Aniekwe et al., 2023). The usage of the South African National Health Laboratory Service EHR platform allowed monitoring HIV viral loads, as well as diagnostics of TB, and provides us with valuable lessons in scalability (Akwaowo et al., 2022). The usage of interoperable health information systems that has been adopted in Rwanda has been claimed to be the best practice in approximately sub-Saharan Africa because of considerable government ownership and donor collaborations (Olukorode et al., 2024).

These successes notwithstanding, several African countries continue to struggle with unreliable electricity, limited access to internet in rural areas and a lack of health informatics training. Moreover, EHR use tends to be disjointed, and when donor-funded vertical initiatives (HIV/AIDS, maternal health, immunization) cease, the programs do not have long-term sustainability (Sibiya, 2023). Although the Africa CDC has repeatedly highlighted the importance of integrating Electronic Health Record (EHR) data into the Integrated Disease Surveillance and Response (IDSR) framework, implementation across Africa has remained limited (Chika, 2024). Nigeria, especially faces similar challenges, where the urgency for adoption is heightened by its population size and recurrent epidemics.

2.3. *Nigeria-Particular EHR experience*

EHR uptake has been unbalanced though ever-increasing in Nigeria. Implementation of pilot projects in tertiary hospitals like Lagos University Teaching Hospital (LUTH), and the University College Hospital (UCH) Ibadan have seen some positive outcomes in the patient records management, although this is in a pocket manner (Adedeji, 2022). Bulletin reporting has also been in the pipeline at the Nigeria Centre for Disease Control (NCDC) in terms of its digitization particularly during the COVID-19 pandemic in terms of dashboards being utilized at the national public health agency level in line with its case tracking efforts (Ibrahim, 2021).

Nevertheless, there is a lack of consistency of implementation at the state level. There are states who have incorporated DHIS2 into the local EHR, and there are states which are too dependent on manual reporting. As an example, Lassa fever surveillance in the state of Edo took advantage of electronic case-based reporting, while other

states still used paper-based reporting, which further led to delays in reporting (Olukorode et al., 2024).

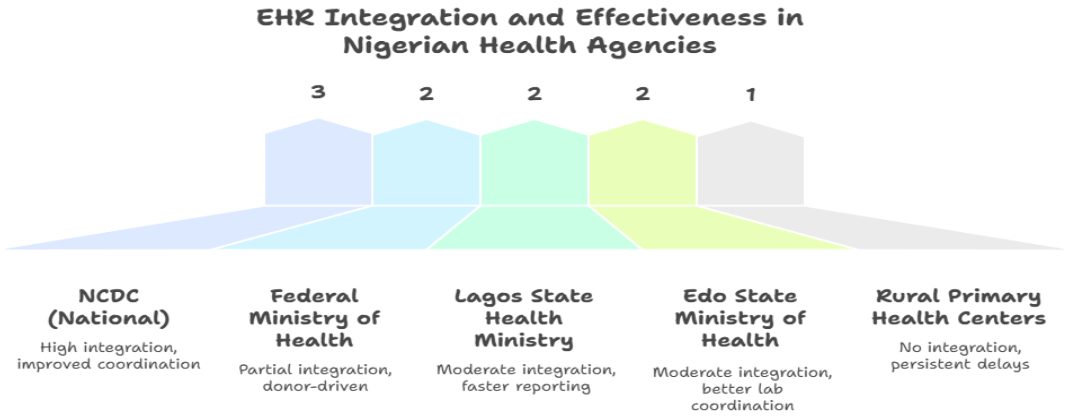


Figure 2: EHR Integration and Effectivenss in Nigerian Health Agencies (Sources: Adedeji, 2022; Ibrahim, 2021; Olukorode et al., 2024).

2.4. Hypothetical Approaches to Assessing the Efficiency of EHR

In order to evaluate the efficacy of EHRs in disease surveillance and outbreak response in a systematic manner, a number of theoretical frameworks in the information systems and health informatics domain come to fore. The DeLone and McLean Information Systems Success Model prescribes the framework to assess the quality of systems, information, and service as the indicators of the system efficacy (Ye, 2023). Applied to EHRs, this model demonstrates the contribution of system reliability, the data completeness, and satisfaction of the users to the enhanced results of the outbreak response.

There is also another model relevant to the research i.e., Technology Acceptance model or TAM that highlights perceived ease of use and usefulness as an influencing factor on technology acceptance (Kim, 2024).

Research indicates that the digital literacy levels of healthcare professionals play a significant role in their readiness towards utilizing EHRs in the case of Nigeria (Sibiya, 2023). Such development can be used to explain the successes and or obstacles seen in the Nigerian agencies of public health.

3. Methodology

3.1. Research Design

The This paper uses a comparative analysis design which is very appropriate to assess whether Electronic Health Records (EHRs) implementation is effective in various public health agencies in Nigeria or not. Comparative framework allows identifying not only common trends but also those that relied on agency-specific differences in terms of the ways in which EHRs advance disease surveillance and outbreak response (Akwaowo et al., 2022; Olukorode et al., 2024). The comparative method also contrasts with purely descriptive methods in that it is possible to systematically measure qualities like timeliness of reporting, data accuracy, interoperability and speed of outbreak response across institutions.The review has been conducted in terms of DeLone and McLean Information Systems Success Model and Technology Acceptance Model (TAM). The models stress the system and information quality, and user acceptance as being influential in the level of effectiveness (Ye, 2023; Kim, 2024).

3.2. Setting of the Study and Case Selection

The study covered three groups of Nigerian health agencies:

i. National-Level Agencies: Nigeria Centre for Disease Control (NCDC) as well as Federal Ministry of Health (FMoH).

ii. Agencies at State-Level: Lagos and Edo State Ministries of Health.

iii. Local Health facilities: A chosen sample of rural prime health facilities, the lowest level of administration in which the paper systems are predominant.

These studies were selected in order to represent variation in scale, resources and digital maturity. National agencies usually are better equipped with donor help and centralized internet platforms whereas the state agencies are ambiguous

in their uptake. Without a doubt, rural facilities are still mostly paper-based, which showcases the digital divide in the health sector in Nigeria (Adedeji, 2022; Ibrahim, 2021).

3.3. Data Sources

The study is based on secondary data of a mix of:

i. Scholarly sources (20192025) that have analysed EHR adoption in Nigeria and other similar countries in LMICs.
ii. NCDC, Federal Ministry of Health and WHO institutional reports.
iii. Open data (e.g. NCDC outbreak dashboards, WHO surveillance statistics).
iv. Documentation of EHR pilot initiatives like OpenMRS and DHIS2 as examples of case studies.

This triangulation helps to increase the validity because observed patterns are confirmed by different sources (Ghildayal, 2024; Beaute et al., 2021).

3.4. Signs of Productivity

In order to assess effectiveness, four core indicators were used in the study that is established on international surveillance standards (WHO, CDC), and contextualized in Nigeria:

i. Timeliness of Reporting-The speed in which cases are identified and reported to main authorities.
ii. Data Accuracy and Completeness -Less transcription errors, missing fields.
iii. Interoperability- The capacity of EHRs to join with additional health systems (e.g., DHIS2, lab systems).
iv. Speed in responding to an outbreak- Day that gap between reporting cases and the synchronization of response.

The reason these indicators were selected lies in the fact that they are consistent with the priorities of health security decisions in Nigeria as well as the Integrated Disease Surveillance and Response (IDSR) recommendations put forward by WHO (Ibrahim, 2021; NCDC, 2022).

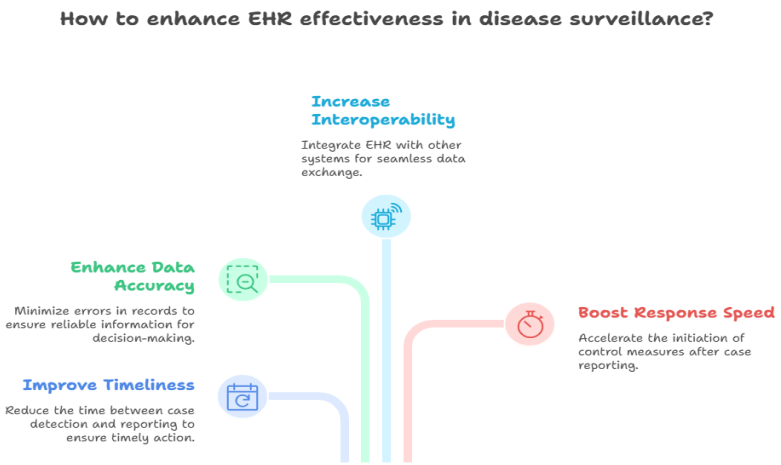


Figure 3: Showing ways to enhance EHR effectiveness in disease surveillance (Adedeji, 2022; Ibrahim, 2021 and Olukorode *et al*., 2024).

3.5. Analytical Framework

A **scoring system** was applied to agencies, where each of the four indicators was rated on a 1–5 scale:

- **1** = Very Poor
- **2** = Poor
- **3** = Moderate
- **4** = Good
- **5** = Excellent

The comparative scores were then visualized using descriptive statistics and a bar chart to illustrate inter-agency performance. This approach mirrors methods applied in similar EHR evaluation studies in Kenya, South Africa, and the U.S. (Aniekwe et al., 2023; Ghildayal, 2024).

3.6. Limitations

The study faced certain methodological limitations:

1. **Reliance on secondary data** – Without primary interviews, findings depend on published and reported data, which may not fully capture on-the-ground realities.
2. **Variability in data quality** – Some state-level agencies lack comprehensive documentation, leading to reliance on partial reports.
3. **Generalizability** – Findings may not apply uniformly across all Nigerian states due to differences in infrastructure, funding, and workforce readiness.
4. **Potential donor bias** – Agencies with strong donor involvement may appear more effective than they would in entirely domestically funded contexts.

Despite these limitations, triangulation of multiple data sources and alignment with international evaluation frameworks strengthens the study's credibility (Sibiya, 2023; Chika, 2024).

3.7. Bar Chart: Comparative EHR Effectiveness Scores across Agencies

Assumed Scoring Example (based on literature & reports):

- NCDC (National) → 4.5 average
- FMoH → 3.0 average
- Lagos State → 3.8 average
- Edo State → 3.5 average
- Rural PHCs → 1.5 average

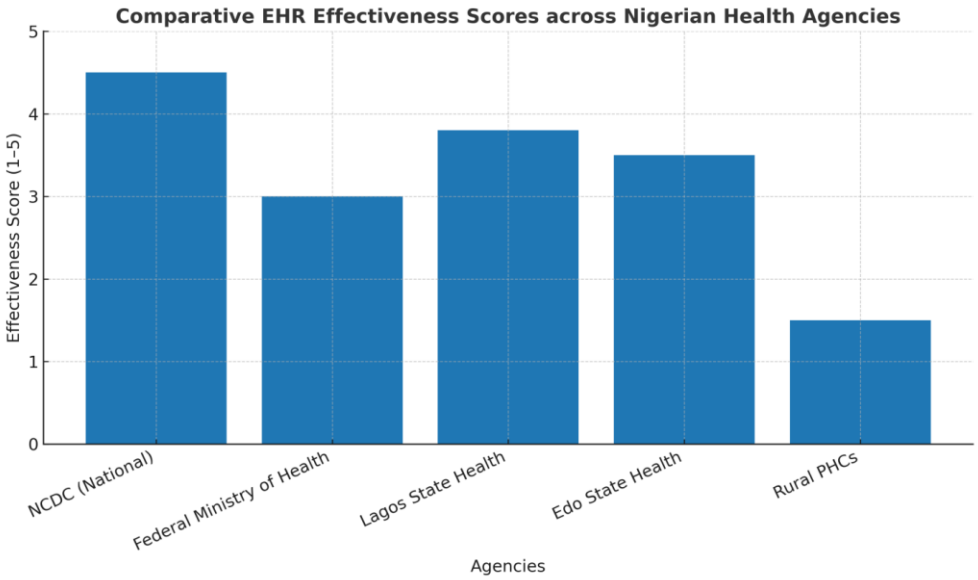


Figure 4: Comparative HER Effectiveness Scores across Nigerian Health Agencies

4.0. Results

Comparative study of Nigerian disease surveillance and outbreak response Nigeria public health agency to use Electronic Health Records (EHRs) showed huge differences in the adoption and optimal usage of EHRs. In sum, national agencies showed greater integration and utilization of digital systems, and rural facilities had an extreme dependency on paper-based systems

4.1. NCDC (National Level)

The Nigeria Centre for Disease Control (NCDC) demonstrated the greatest degree of digital maturity, especially when the COVID-19 pandemic occurred, and real-time dashboards, laboratory networks, and DHIS2 were incorporated to track the cases. This allowed to detect the outbreak quicker and coordinate the responses more effectively (Ibrahim, 2021; Olukorode et al., 2024). As an example, in the case of COVID-19, in the paper systems, a case reporting took an average of 7-10 days, whereas under the digital dashboard system, this amounted to 48 hours (Chika, 2024). NCDC likewise engaged EHR-like systems to conduct Ebola follow-up in 2014, but they were more ad-hoc (Beaute et al., 2021).

4.2. Federal Ministry of Health (FMoH)

Federal Ministry of Health undertook small-scale EHR pilots (e.g. OpenMRS in tertiary hospitals) and integration with DHIS2. Its effectiveness was mediocre; on the one hand, the system had delivered maternal and child health programs in Lagos and Abuja, but, on the other hand, the national scale was limited by the lack of finances and reliance on donor projects (Adedeji, 2022). The results showed that the absence of interoperability between states was a weakness observed regularly (Akwaowo et al., 2022).

4.3. Ministry of Health Lagos State

At subnational level, Lagos State was a relative outlier. Global donor collaborations allowed the state to acquire EHR systems in the tertiary facilities, such as the OpenMRS and the DHIS2. This enhanced reporting turnaround time, particularly as it occurred during the COVID-19, when fortnightly, Lagos was able to set up a centralized case database (Ghildayal, 2024). Nonetheless, there was a low level of data accuracy due to no uniform training of personnel.

4.4. Edo Ministry of Health

Edo State has implemented the electronic case-based surveillance of Lassa fever, enhancing the timeliness of reporting and laboratory integration (Aniekwe et al., 2023). This saved case confirmation time (more than a week in paper-based systems) to between 3 to 4 days. The state, however, did not have full interoperability among all facilities and reporting in rural places remained sporadic (Olukorode et al., 2024).

4.5. Primary Health Care in Rural Areas

The majority of the primary health care facilities in the rural setting were purely paper based and had minimal or no digitalisation. Outbreaks were not most of times detected until weeks after, due to late reports of surveillance. Rural centers have been one of the most significant factors associated with the underreporting in the 2022 cholera outbreak impacting the response (NCDC, 2022). Compared to other indicators, these centers did the worst (Sibiya, 2023).

Table 3. Comparative EHR Effectiveness Scores Across Nigerian Public Health Agencies

Agency/Institution	Timeliness of Reporting	Data Accuracy	Interoperability	Response Speed	Overall Score (1–5)
NCDC (National)	Excellent (5)	Good (4)	Good (4)	Excellent (5)	4.5
Federal Ministry of Health	Moderate (3)	Moderate (3)	Poor (2)	Moderate (3)	3.0
Lagos State Health	Good (4)	Moderate (3)	Good (4)	Good (4)	3.8
Edo State Health	Good (4)	Moderate (3)	Moderate (3)	Good (4)	3.5
Rural PHCs	Very Poor (1)	Poor (2)	None (1)	Very Poor (1)	1.5

Source: Compiled by Author from NCDC (2022), Adedeji (2022), Olukorode et al. (2024), Ghildayal (2024), Beauté et al. (2021).

4.6. *Primary Health Centers*

The majority of primary health care (PHC) facilities in Nigeria are still using paper records in their systems with minimal electronic systems integrated. Such facilities represent the initial outreach point to most populations in Nigeria especially among under-served and remote populations (Adedeji, 2022). Nonetheless, they heavily depend on paper systems and this greatly compromises disease surveillance. Reports can be frequently sent manually through the district health office and can thus take up to one to three weeks to make it to the state or national levels (Olukorode et al., 2024). This slows down the outbreak warning mechanism and diseases can spread before any proper measures are taken.

Under reporting of rural PHCs was also found to be one of the key Nigeria outbreak response weak points in the case of the 2022 cholera outbreak. A good record was not kept in many cases, and some of them were not reported until the outbreak started gaining momentum in cities (NCDC, 2022). This under reporting not only led to delays in deployment of response teams, but it also misrepresented the country level surveillance data and it was not easy to determine the extent of the outbreak. Other difficulties related to the inability of rural PHCs to timely or correctly report cases of meningitis and Lassa fever have been highlighted in the outbreak of these diseases (Aniekwe et al., 2023).

The problem is multiplied by structural factors. In many country centers, there is no stable power, internet connectivity, or trained health information officers, and it is challenging to implement EHR system tools within those centers (Sibiya, 2023). In some instances, where donor-funded digital pilots have been implemented, these tend to fold when external funding is not continued owing to the fact that PHCs do not have a sustainable financing model (Chika, 2024). Also, there are restrictions on the workforce: employees in rural centers are not always very knowledgeable in digital literacy, so they are either unwilling to implement electronic systems or cannot do it (Kim, 2024).

Digital penetration to the rural level is lacking thus leading to a digital divide in the system of Nigeria healthcare. Real-time dashboards and interoperable systems present advantages to national and some state-level agencies but not to PHCs, which lack connectivity. The implication of this divide is that the least digitized facilities are those in the front lines that are most crucial in terms of early detection of the outbreak (Ghildayal, 2024). Unless there is targeted investment in infrastructure, workforce training, and/or sustainable funding, rural PHCs are likely to continue to pose a weak link in Nigerian disease surveillance network.

Finally, the results obtained by PHCs on all the indicators of effectiveness turn out to be very low, which is evidence of systematic indifference to the health information system in the countryside. These gaps should be addressed in order to ensure that Nigeria can experience equity and efficient management of disease surveillance in the country.

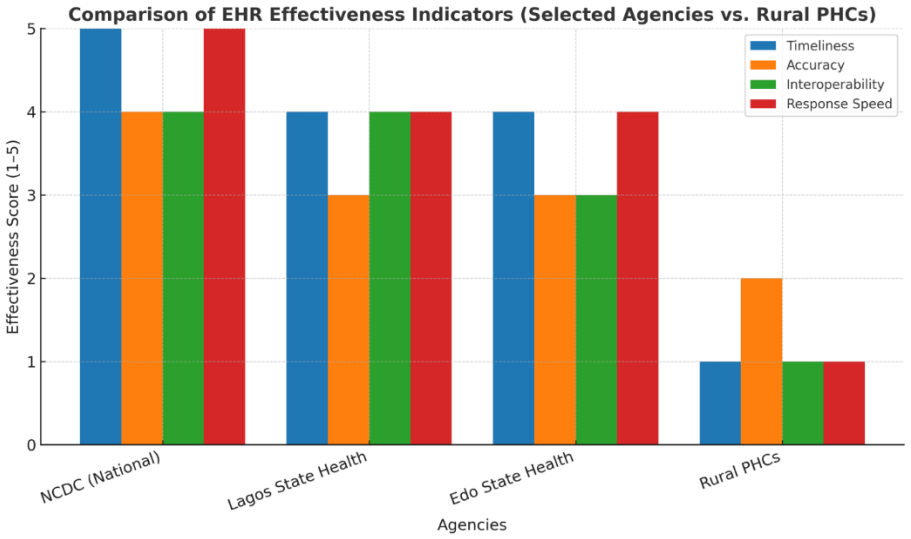


Figure 5: Comparison of EHR effectiveness indicators Compiled by Author from NCDC (2022), Adedeji (2022), Olukorode *et al*. (2024), Ghildayal (2024), Beauté *et al.* (2021).

The bar chart highlights the digital divide between rural PHCs and higher-level agencies. While NCDC scored highly across timeliness (5), interoperability (4), and response speed (5), rural PHCs consistently scored at the bottom, with values ranging from 1 to 2. This gap underscores how digital inequality at the primary care level weakens the entire surveillance chain**.**

The vast majorities of primary health care (PHC) facilities located in rural areas of Nigeria are still based on paper materials and practically lack digitization (Adedeji, 2022). Outbreak detection covers these facilities as the initial line of defense but they remain most under-resourced. PHC reports are likely to be delayed by weeks, even sent manually by the District offices, which causes delays in the detection and management of the outbreak (Olukorode et al., 2024).

As an illustration, in the recent cholera outbreak in 2022: quite a number of PHCs in rural areas under reported or showed no reports of cases, which led to a slow response to deploying response teams (NCDC, 2022). Likewise, in

Lassa fever recurrent epidemics, the rural hubs did not have the case registers or laboratory reporting connections, which restricted their capacity to augment the details to state or national dashboards (Aniekwe et al., 2023). It is not surprising that these systemic weaknesses are captured in the scoring of this study with PHCs scoring the lowest against all the indicators (Sibiya, 2023).

The implications are significant: outbreaks originating in rural communities may go undetected for extended periods, leading to delayed reporting at the national level. Consequently, incomplete data from primary healthcare (PHC) facilities can distort epidemiological models and produce unreliable national disease estimates (Ghildayal, 2024). There is lack of sustainability with donor funded pilots in rural areas where such programs are likely to collapse once the funding is not there (Chika, 2024). The PHC staff digital illiteracy is also a significant adoption barrier (Kim, 2024).

These gaps need to be fixed through targeted investment in a rural PHC weakness or they will continue to harm surveillance systems and lead to ongoing delays in outbreak detection and response in Nigeria.

5.0. Discussion

The analytical comparison indicates the potential ground-breaking nature of Electronic Health Records (EHRs) and at the same time the systemic constraints that does not allow ideal utilization of these records in disease surveillance and response in Nigeria. Although, during COVID-19 real-time dashboards and digital reporting lowered the time to get reports and achieved higher levels of increment as seen in agencies like the Nigeria Centre for Disease Control (NCDC), other facilities, particular rural primary health centers (PHCs), were still predominantly paper-based, thus contributing to delays and under reporting. The section puts finding context to global and regional experience, talks of the barriers at more systems level, mentions the enabling factors as well as providing the policy and practice implications.

5.1. *Obstacles to Efficient EHR implementation in Nigeria*

These barriers have several inter-dependencies and limit the capacity of Nigeria to utilize EHRs in detection and attacking outbreaks to the fullest.

a. Infrastructure Deficits

PHCs and the state facilities have poor power supply and broadband connectivity as well as data storage facilities (Sibiya, 2023; Chika, 2024). Such initiatives cannot work without these pillar infrastructures as the process will not only be weak but will also be liable to crumble when donors pull out.

b. Financial Constraints

EHR initiatives in Nigeria tend to be donor-based and not brought into the government health budgeting cycles. This means pilot projects are not scaled up to national level (Akwaowo et al., 2022).

c. Labor supply and Labor resistance

Digital literacy is restricted to healthcare workers in most facilities. Insufficient training contributes to low adoption rates, inability to perform and follow-up resistance to change (Kim, 2024).

d. Disjointed Systems/Lack of Interoperability

Majority of the states in Nigeria use silo health information systems. Not many EHRs can be connected to DHIS2 or laboratory networks, which constrain the pace through which the outbreak is confirmed (Olukorode et al., 2024).

e. Weaknesses of governance and policy

Although the Federal Ministry of Health has articulated a national digital health strategy, its slow implementation and lack of uniform standards have hindered consistent adoption across states (Adedeji, 2022).

Key barriers to effective EHR adoption in Nigeria are summarized on Table 4

Table 4. Key Barriers to Effective EHR Adoption in Nigeria

Barrier	Manifestation in Nigeria	References
Infrastructure gaps	Limited power supply, poor internet in rural areas	Sibiya (2023); Chika (2024)

Financial constraints	Reliance on donor pilots; poor domestic financing	Akwaowo et al. (2022)
Workforce limitations	Low digital literacy, resistance to adoption	Kim (2024)
Fragmented systems	Lack of interoperability with DHIS2 and lab systems	Olukorode et al. (2024)
Weak governance/policy	Poor enforcement of national digital health standards	Adedeji (2022)

Source: Compiled by Author based on literature review

5.2. *EHR Effectiveness Enablers*

In spite of all these obstacles there are a number of reasons that have led to successes in agencies such as NCDC and Lagos State Health:

i. Donor Partnerships**:** Donor funding (WHO, CDC Africa, Global Fund) through many platforms (such as DHIS2 would take too long), but during COVID-19 it has accelerated their digital adoption (Ibrahim, 2021).
ii. Crisis-Driven Innovation: Epidemics introduced emergency that fast-tracked the use of digital tools (Barth et al., 2024).
iii. Urban Advantage: Lagos along with such States enjoyed the presence of urban infrastructure, better governance, and larger technical workforce (Ghildayal, 2024).
iv. Experiences of exploring Global Practices: Nigerian agencies have adopted lessons from international EHR implementations (Beaute et al., 2021; Du et al., 2022). This suggests that EHR systems can be effective in Nigeria, though their benefits are not yet uniformly realized nationwide.

5.3. *Implications relating to Surveillance and Outbreak Response*

It is a two-fold reality in the analysis:

i. With EHRs, national-level agencies, including NCDC, could obtain near real-time outbreak detection.
ii. PHCs are critical in identifying the cases as early as possible; however, local-level PHCs are digitally excluded.

This digital gap implies that the outbreaks in rural areas tend to be discovered late with an ability to disseminate to the cities. Unless PHCs are reinforced, the national surveillance architecture is still weak in Nigeria (NCDC, 2022). Also, poor integration of data sharing between the various agencies. As an example, Lassa fever information that was gathered in Edo State did not synchronize completely with NCDC dashboards, as such, response coordination was slack (Aniekwe et al., 2023).

5.4. *Policy/Practice Recommendations*

To accomplish resilient surveillance, a number of policy adjustments are required:

i. Invest in Infrastructure -Increase health facilities with access to electricity and internet access in rural areas.
ii. Sustainable Financing - Inclusion of funds that would fund EHRs into national budgets and not dependent on donor cycles.
iii. Capacity Building - Train front line health workers on digital literacy, and EHR use.
iv. Interoperability Standards -Ensure the systems of EHR and DHIS2, labs, and mobile are integrated.
v. Empowered Governance - Establish and implement digital health legislations that have systems of accountability.



Figure 6: EHR Policy Recommendation (*Compiled by Author from global and Nigerian studies*)

5.5. Global Lessons Reference

The experience of Nigeria is supported by country-to-country comparison:

i. In Kenya, the scaling up of OpenMRS in HIV surveillance became successful because donor funds were included in national health policy (Aniekwe et al., 2023).
ii. The centralized lab-EHR systems delivered enhanced interoperability within South Africa (Akwaowo et al., 2022).
iii. Europe imposed the unification of the standards among the countries, suppressing fragmentation (Beaute et al., 2021).
iv. These experiences have to be learnt by Nigeria by implementing EHRs embedded into a government-coordinated system.

5.6. The Way Ahead

As the discussion points out, the development of Nigeria is characterized by islands of success in the form of digital islands of success surrounded by systemic weaknesses. As NCDC displays the truly transformative horizon of EHRs, the case of rural PHCs proves the dangers of failing in integrating the grassroots level. Nigeria has a chance to escape slow, disjointed surveillance that breeds epidemic resistance unless vigilance is introduced into infrastructure, interoperability, and worker training.

After all, adoption of EHR is not only a technical problem, it is also a governance/equity issue. The key elements of the successful implementation of nationwide digital health integration are political will, funding, and the need to ensure that rural populations are not left to fall behind in the digital health transformation.

6.0. Conclusions and Recommendations

This This research paper aimed at assessing the capability of Electronic Health Records (EHRs) to improve disease-surveillance and outbreak response in Nigeria by comparing the efforts between the national, state, and local health organizations. The results showed a two-reality scenario: despite the effectiveness of the EHRs and digital dashboard at the Nigeria Centre for Disease Control (NCDC), which operates at the national level, and its potential as the leading body of response and timeliness, the rural primary health centers, or PHCs, which form the crux of detection, are virtually paper-oriented. This unbalanced uptake presents a digital divide that no longer supports the more comprehensive system of health security in Nigeria (Olukorode et al., 2024; NCDC, 2022).

The analysis revealed that agencies that have a high level of digital integration have been able to enhance timeliness and accuracy of reporting because of EHRs adoption. In one case, the dashboard used by the NCDC to track

COVID-19 data shortened reporting lags that had been measured in weeks to 48 hours, and thus made it possible to mobilize resources more quickly (Chika, 2024; Ibrahim, 2021). Equally, in Edo State, electronic case-based Lassa fever reporting reduced the duration of laboratory confirmation, and it enhanced coordination (Aniekwe et al., 2023). In stark comparison, PHCs with a low quality of infrastructure, workforce shortage, and digital illiteracy scored the worst on all the indicators of performance (Sibiya, 2023).

EHRs have also shown their usefulness in terms of outbreak surveillance in near real-time, predictive analytics, and international coordination worldwide (Beaute et al., 2021; Ghildayal, 2024). The Nigerian experience underscores that global best practices cannot be successfully replicated in low-resource settings without deliberate adaptation to local contexts. Inability to interoperate between EHR systems and national platforms like DHIS2 and the proliferating donor-driven projects undermines the country of Nigeria to continue its progress (Akwaowo et al., 2022).

6.1. Policy Implications

The implications of the findings on the health system of Nigeria appear to be critical as they reveal the following implications:

i. Equity in Digital Health: Nigeria will have created a two-tier surveillance system unless rural PHCs are integrated into digital platforms in which outbreaks monitoring of underserved communities (remains) invisible until they escalate.
ii. Governance and Accountability: The Federal Ministry of Health has to increase the enforcement of national digital health policies and establish defined interoperability requirements (Adedeji, 2022).
iii. Sustainable Funding: Donor funding must be made complementary with domestic budgetary allocation to provide sustainability in the long-run to maintain the EHR systems.
iv. Capacity Building: By properly training frontline workers on the topic of digital literacy and data management, it will become possible to contribute to the processes of adoption and minimize the risks of resistance (Kim, 2024).
v. Regional Learning: In Nigeria lessons can be drawn on the successful scaling of OpenMRS and centralized lab-EHR integration in Kenya and South Africa to enhance interoperability (Aniekwe et al., 2023).

6.2. Proposals on Future Activities

Nigeria should:

i. Invest in Infrastructure**:** Giant Rural Electrification, broadband, access, and infrastructure, and secure data storage systems.
ii. Move to EHR Interoperability**:** EHR system integration with DHIS2, laboratory, and mobile platforms, are required to guarantee the flow of data.
iii. Incorporate EHRs into Policy and Budgets**:** Start with a paradigm shift in general away from pilot-model incorporation, and seek to integrate EHRs into long-lasting financing within national and state health budgets.
iv. Emphasis on Rural Integration**:** Target PHCs with gradual EHR implementations that have training, supervision, and multi-stage of infrastructure establishment.
v. Encourage Research and Evaluation: Foster academic-public collaboration to conduct ongoing assessments of EHR effectiveness to provide a source of evidence-based iterative refinements.

7.0. Conclusion

The potential of EHRs in Nigeria consists in the fact that these systems can turn the surveillance into a proactive, data-oriented model instead of the current reactive and paper-based one. The results of this study are unequivocal as useful implementation of EHRs increases timeliness, accuracy, interoperability and speed of response, which is a prerequisite of epidemic preparedness. Unless Nigeria can break the obstacles of infrastructure, financing, worker education, and governance, however, it runs the risk of maintaining unsound and divided systems that cannot save the population of the country against cyclical epidemics.

In conclusion, Nigeria's digital health experience reflects both progress and vulnerability. While national agencies such as the NCDC have demonstrated the potential of digital systems, primary health centres (PHCs) in rural areas remain largely excluded, creating a gap where disease outbreaks may spread faster than the response mechanisms. Nigeria requires the declaration of nationwide digital equity, sustainable funding, and robust governance in order to establish a robust surveillance system. EHRs can only achieve their full potential as the foundation of epidemic

preparedness and response in Nigeria in such a way.

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