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Conceptual Readiness for DHIS2 Adoption in Yemen's NCD Program: SWOT, PESTEL.

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Abstract

In Yemen, years of conflict have weakened the health system, limiting access to essential health services and worsening the burden of NCDs. This study proposes a conceptual framework for NCD management in Yemen using the open-source District Health Information System 2 (DHIS2). The framework aims to establish an NCD database that strengthens health information systems to support evidence-based decision making. This study applies a PESTEL analysis of the external environment alongside a SWOT analysis of DHIS2 adoption to assess readiness to adopt this framework. By combining these approaches, the framework aims to close critical data gaps and mitigate NCD-related complications. The analysis results suggest that DHIS2 is a context-appropriate option for NCD programs.

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NCDs, DHIS2, health service delivery, health information systems, Yemen.

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1. INTRODUCTION

Non-communicable diseases (NCDs) are among the leading causes of morbidity and mortality worldwide. These diseases account for approximately 70% of global deaths [1]. The burden of NCDs is increasing rapidly and uncontrolled in the most fragile countries. Unfortunately, Yemen's health system has experienced the worst structural deterioration, including damage and non-functional health facilities, shortages of essential medicines, high turnover of health workers, and restricted access to healthcare services since the beginning of the conflict in 2014. Yemen currently lacks a robust health information system capable of systematically collecting, analyzing, and utilizing NCD-related data to inform planning and resource allocation [2]. In the absence of timely and reliable data, decision-makers struggle to allocate resources effectively or to design effective interventions. Local population-based data illustrate the level of the NCD burden in Yemen. A large household survey conducted in Sana'a City in 2017, which covered 241,310 households and a population of 1,592,646 individuals, reported that 24.48% of households had at least one member living with an NCD. The survey identified 70,178 cases. The overall prevalence of self-reported NCDs was estimated at 4.4% based on household reporting rather than clinical diagnosis. Although these findings are subject to reporting limitations, they highlight a substantial, largely under-monitored burden of chronic disease and underscore the urgent need for systematic NCD surveillance and improved data integration within the national health system [3]. A study [4] recommended that Yemen conduct a national STEPs survey and implement sustainable monitoring systems for NCDs. However, ongoing conflict, security issues, and Yemen's dire financial situation pose major challenges to implementation. Despite the growing burden of NCDs, Yemen does not yet have a comprehensive national strategy dedicated specifically to NCD prevention, surveillance, and management. National Health Strategy (2010–2025) outlines general health system priorities; however, NCDs are not addressed as a dedicated program [5]. The 2022 revision of the Minimum Service Package (MSP) acknowledged the growing importance of NCDs. It introduced initial measures, including the appointment of NCD focal points and the integration of selected screening services into primary healthcare [6].

Yemen needs to develop a National NCD Strategy

aligned with the World Health Organization's recommendations. This strategy should be supported by robust digital health platforms and integrated into broader health system strengthening efforts [7]. Globally, electronic medical record (EMR) systems are widely used in health information systems; however, these systems are often costly and difficult to implement in low-income countries [8]. Furthermore, most advanced digital health solutions require a robust ICT infrastructure, stable economic conditions, and well-developed health system capacities for a successful rollout [9].

The District Health Information System 2 (DHIS2) is one of the most widely used open-source health information systems. The DHIS2 has been implemented in more than 75 low- and middle-income countries, including Ethiopia and Rwanda [10–12]. DHIS2 is designed to support routine health data collection, visualization, and analysis. It provides configurable dashboards, automated reports, and modular program packages. These packages cover a range of health programs, including maternal and child health, immunization, nutrition, cause-of-death reporting, and hypertension management [12].

Healthcare in Yemen faces numerous challenges, including limited resources, fragmented services, and inadequate capacity. Training human resources is crucial for improving the quality of services. Earlier research conducted in the Yemeni setting has shown that "the quality of healthcare services is significantly affected by training, demonstrating that capacity development efforts are a successful strategy." [13]. Under this situation, the success of the implementation of digital health tools like DHIS2 is very much dependent on having enough qualified people. Apart from technology, the preparedness of the health systems is heavily reliant on having adequate skills within the health workforce to make use of the available health data. Thus, it can be concluded that capacity building is a critical factor in the implementation of health information systems in Yemen.

In Yemen, DHIS2 has already been piloted in immunization and nutrition programs, with coverage extending to approximately 4,800 health facilities and more than 260 facilities submitting data electronically [14]. Notably, with support from the Health Information Systems Program (HISP) and development partners, the DHIS2 Tracker has been successfully used by the Nutrition Cluster to monitor malnutrition cases through sentinel sites, enabling longitudinal follow-up from admission to discharge. By December 2022, more than 90,000 individuals had been screened nationwide, with screening results reported through DHIS2 and used to inform near-real-time programmatic decision-making Chart(1). This experience demonstrates the feasibility of deploying DHIS2 in Yemen's fragile context and highlights its potential applicability to other priority health programs [15].

DHIS2 hypertension package

The DHIS2 also offers a hypertension package, which was piloted in Nigeria between 2021 and 2022. Through this package, approximately 16,000 patients were registered and followed up across 104 primary healthcare facilities [17]. This implementation demonstrates DHIS2's adaptability for chronic disease monitoring.

As shown in Chart (2), the basic DHIS2 hypertension registry workflow in health facilities begins with the clinical diagnosis of hypertension, followed by recording the patient profile in the facility's registration system. Routine follow-up visits are a critical component of hypertension care, as the condition requires long-term monitoring to identify uncontrolled cases and trigger timely referral or emergency intervention when needed [19].

Methodology

The study adopted a qualitative, conceptually analytical method based on secondary data, primarily using a structured literature review. The low feasibility informed the decision to use this method for primary data collection in Yemen's fragile state. The study employed a structured literature review to identify and synthesize relevant evidence on health information systems, DHIS2 implementation, and NCD surveillance in fragile settings. This method involved a systematic search for relevant literature across various academic databases, including Google Scholar, ScienceDirect, IEEE Xplore, and Web of Science. The literature reviewed included articles from 2010 to 2025. The criteria for selecting the literature for the research were health information systems, DHIS2 implementation, and NCD surveillance in low- and middle-income countries. The literature selection criterion for this study excluded literature on unrelated technologies and not relevant to health information systems. About 30-40 studies were identified based on relevance, as determined by title and abstract screening. The data from the identified literature were systematically analyzed and synthesized to identify recurring themes across various aspects of health systems, digital health implementation challenges, and enabling factors. The study established a conceptual framework based on two different methods: PESTEL and SWOT analysis. The PESTEL analysis examined external macro-environmental factors affecting DHIS2 implementation, including political, economic, social, technological, environmental, and legal factors. Simultaneously, the study used the SWOT method to analyze internal and external factors affecting DHIS2 implementation, including opportunities and threats to its success. The study provides a conceptual framework for assessing the feasibility of implementing DHIS2 for NCD management in Yemen, rather than

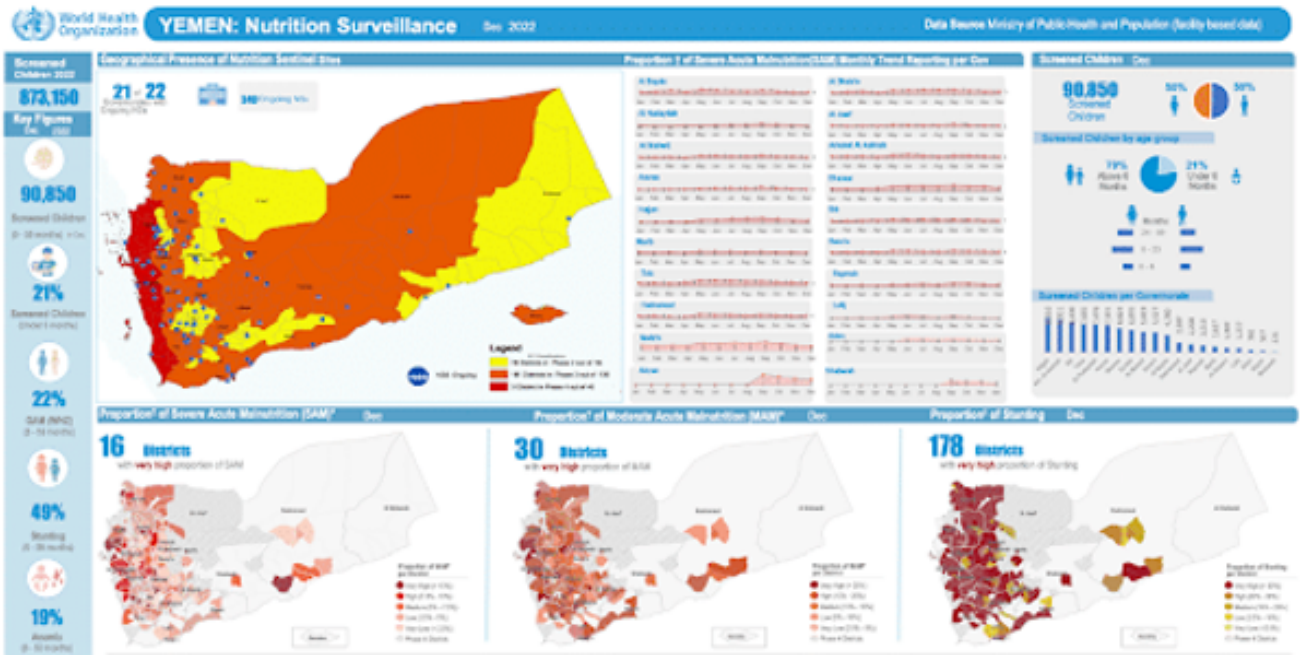

Chart 1.snapshot from the WHO dashboard highlighting the state of nutrition in Yemen after applying DHIS2, December 2022 [16].

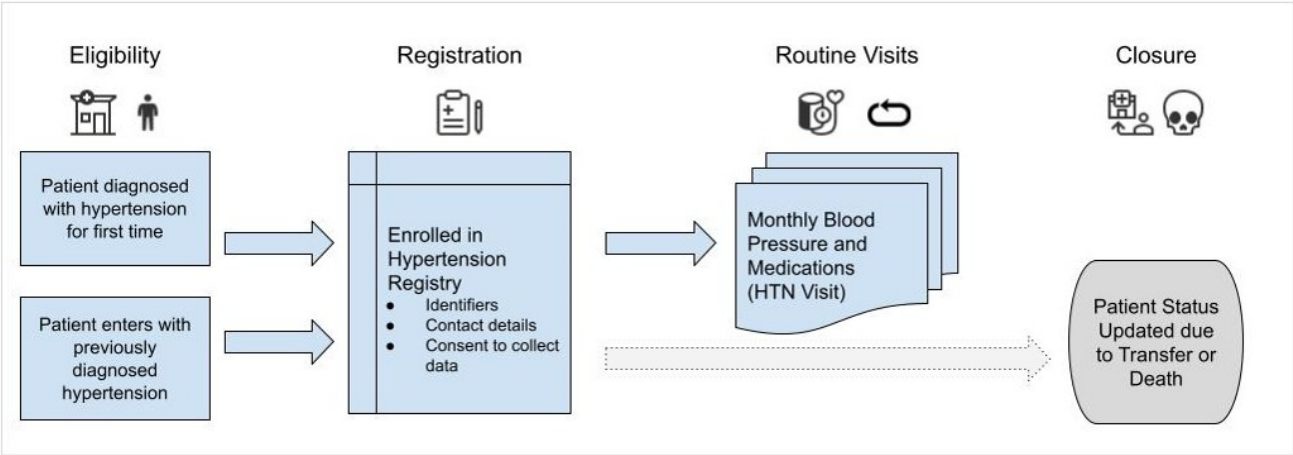

Chart 2.Basic Hypertension registry workflow [18]

conducting empirical studies to assess DHIS2 readiness for implementation. In conducting the literature review, a systematic approach was adopted, in which the relevant studies were carefully analyzed for emerging themes on health systems capacity, obstacles to implementing digital health solutions, and factors contributing to the successful implementation of interventions. The identified themes were systematically aligned with the PESTEL analysis to determine the effects of the macro-environment, and with the SWOT analysis to assess the implementation of DHIS2 in such circumstances. The method enabled the researcher to undertake a conceptually based analysis supported by existing knowledge.

Proposed NCD DHIS2 conceptual framework

Building on the successful implementation of DHIS2 as an open-source platform for nutrition and immunization programs in Yemen, there is a strong opportunity to extend this experience to noncommunicable disease (NCD) programs. The customization of the DHIS2 hypertension package provides a practical foundation for developing a comprehensive NCD conceptual framework.

As shown in Figure (1), the NCD framework that uses DHIS2 technology operates within a tiered architecture. Data generation occurs at the data source layer using patient-level data from healthcare delivery facilities, including diagnosis, demographics, and treatment information. The data capture layer involves entering patient data into the DHIS2 Tracker using standardized electronic forms for NCD data collection, including information on hypertensive cases. The data management layer involves ensuring data validation and quality checks using DHIS2's built-in validation features, as well as con-

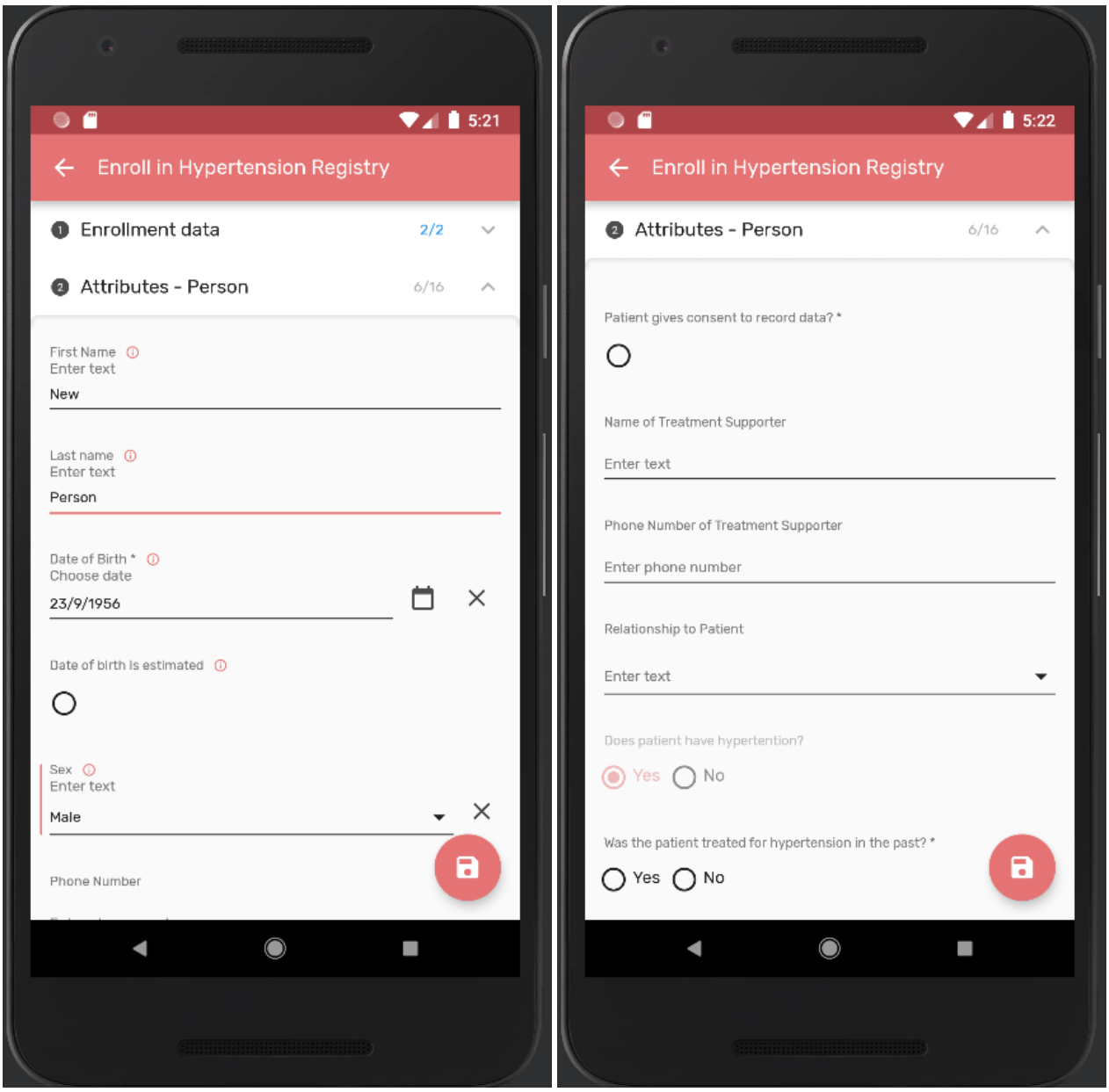

Chart 3.Hypertension forms a mobile setting [18]

ducting regular data quality audits.

Analytics occur within the analytics layer, where the collected data can be visualized and analyzed through dashboards and reports to guide decision-making. Some analytics in this case would include follow-ups, treatment compliance, and disease trend data.

The governance layer involves coordination among the Ministry of Health, implementing partners, and regional health authorities to ensure data safety, policy coherence, and sustainability of the system. The operationalization of this framework occurs within three implementation tiers:

1. Facility level – data entry and patient management.
2. District level – aggregation and supervision.
3. National level – policy planning and budgeting.

In the DHIS2 Tracker, follow-ups can be easily facilitated through longitudinal data records, which enable healthcare providers to assess disease progression and schedule follow-up appointments. Medication tracking is achieved by incorporating structured data on medication prescriptions, dosage changes, and adherence follow-up. To further assess the external contextual environment influencing the proposed framework, a PESTEL analysis was performed.

1- External Environment Analysis (PESTEL) for the adoption of the Proposed NCD conceptual framework.

As shown in Table (1), despite Yemen's fragile economy, weak ICT infrastructure, and environmental challenges, the successful implementation of DHIS2 in nutrition and immunization programs demonstrates the readiness to adopt the same platform for NCD. While PESTEL analysis highlights external environmental constraints,

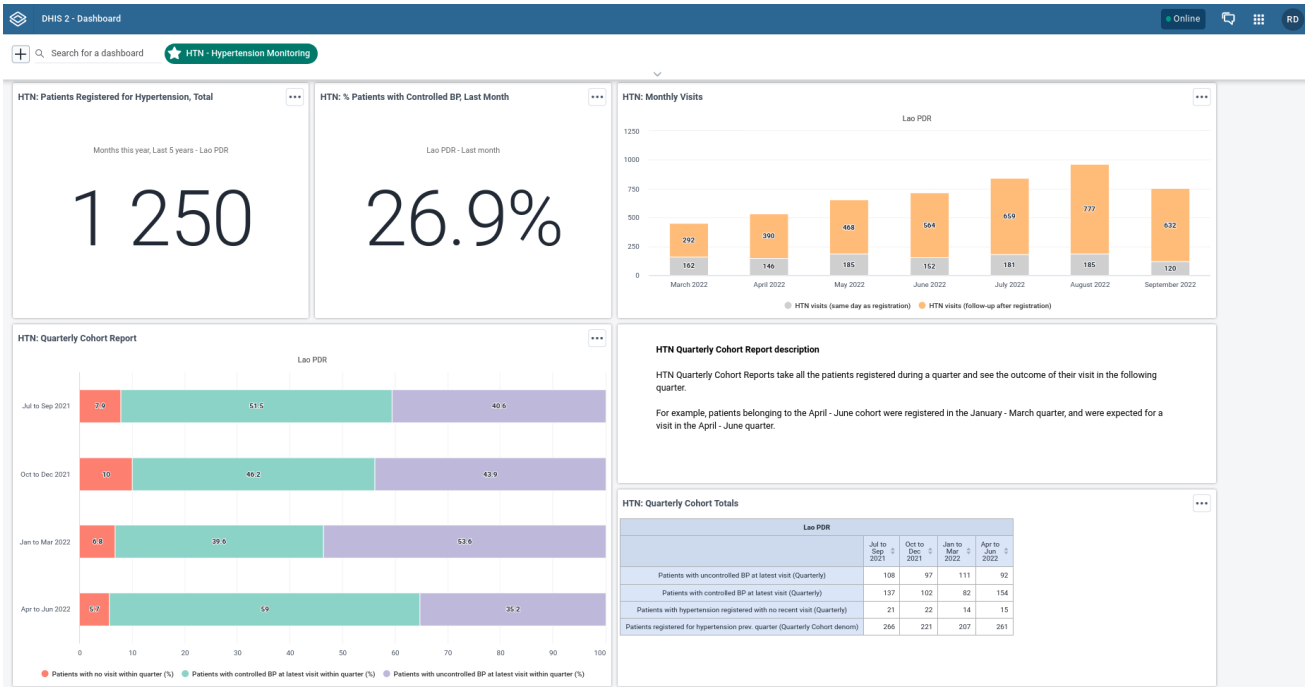

Chart 4.Hypertension monitoring dhis2 dashboard [18]

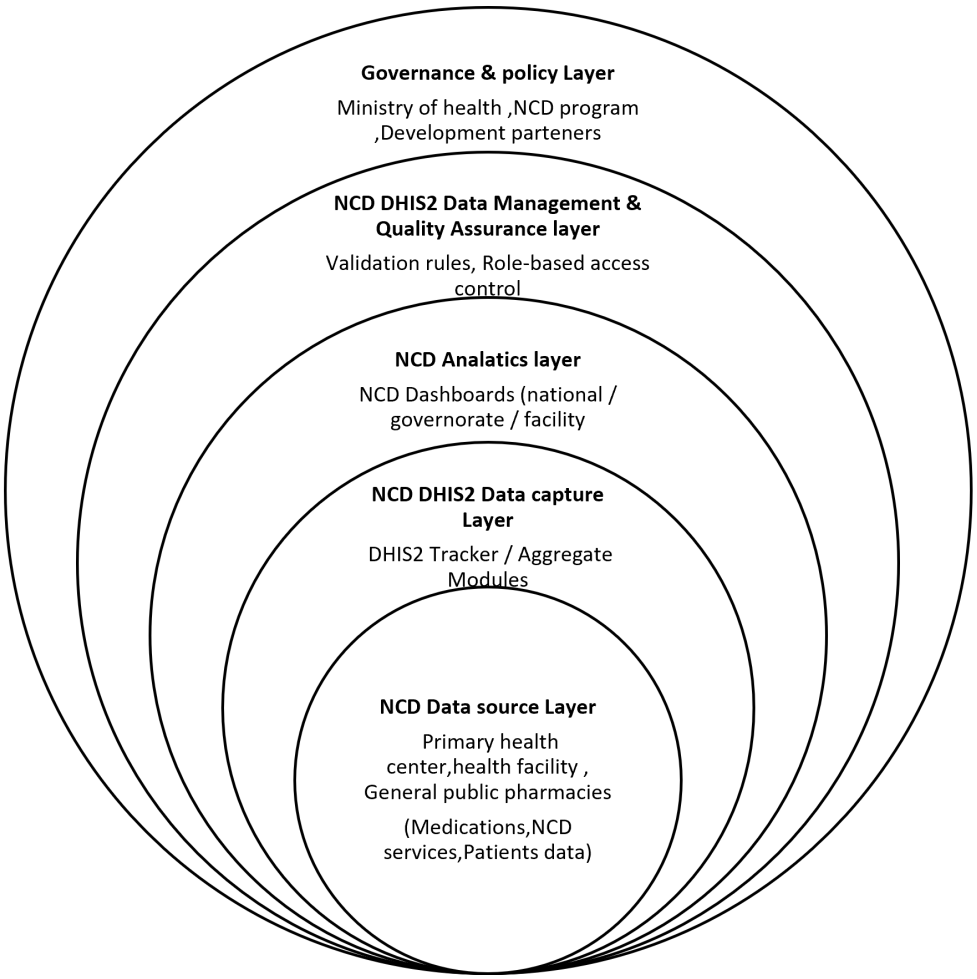

Figure 1. NCD-specific conceptual framework using DHIS2.

SWOT analysis provides a complementary perspective by examining internal system capabilities and strategic positioning.

Table[1]: PESTEL analysis for the adoption of the Proposed NCD DHIS2-Based Model in Yemen

Factor	Analysis
Political	Since 2014, the ongoing armed conflict has significantly disrupted the stability of health service delivery in Yemen. Nevertheless, the successful rollout of DHIS2 in nutrition and immunization programs—spanning over 4,000 health facilities—illustrates the system's potential for effective implementation in NCD management, even within fragile and conflict-affected settings [7].
Economic	Being an open-source platform, DHIS2 eliminates the financial barriers associated with proprietary systems. By utilizing existing infrastructure and building on prior implementation experience, it enables cost-efficient scaling to include NCDs. Donor organizations are particularly inclined to support DHIS2, especially in low-income and conflict-affected settings, given its demonstrated success in enhancing health systems' resilience and effectiveness [19].
Social	Resistance to digital transformation may emerge in rural or underserved regions, primarily due to limited digital literacy [20]. However, prior training in DHIS2 for healthcare workers significantly enhances their preparedness [21]. Additionally, building community trust in DHIS2-based initiatives is anticipated to foster broader acceptance, ensuring the successful integration of digital health solutions in fragile settings [19, 22]
Technological	Weak ICT infrastructure and unstable internet connectivity present challenges. Nevertheless, DHIS2's offline functionality has proven effective in similar environments [23, 24]. Training from earlier DHIS2 programs supports integration into NCD management [19]
Environmental	Yemen encounters environmental challenges, including floods, inconsistent electricity, and unreliable internet access in remote regions [25]. DHIS2's ability to collect data offline and synchronize it later offers a robust solution, ensuring continuity even in these difficult conditions [19].
Legal	Yemen lacks a comprehensive national legal framework for the protection of health data. However, DHIS2 implements a strong security infrastructure, featuring role-based access controls and HTTPS encryption [26]. Until national legislation is established, data protection protocols from existing nutrition and immunization programs can be adapted, alongside the development of ethical guidelines and confidentiality policies [19].

2- SWOT analysis for the NCD DHIS2 conceptual framework

This analysis offers a systematic approach for identifying Strengths, Weaknesses, Opportunities, and Threats, facilitating a comprehensive evaluation of the health system's existing capabilities and the challenges posed by the ongoing conflict. In this paper, the SWOT analysis highlights the internal strengths and weaknesses of Yemen's health information system, such as infrastructure gaps [27] and institutional readiness. Opportunities include international support for DHIS2 implementation and donor engagement [28]. Threats highlight political instability and security concerns [29]. This framework allows for a clear understanding of how DHIS2 adoption can be strategically pursued to support NCD management in Yemen.

Based on the analysis presented in Table (2) and given the risks posed by potential economic collapse and the uncertainty surrounding donor funding, prioritizing the development of local capacity to maintain the DHIS2 is essential. The growing global interest in supporting DHIS2 offers a unique opportunity to expand its implementation, particularly by providing ICT infrastructure that ensures sustainability in rural areas. However, political instability poses a significant threat to the national coordination of DHIS2. To mitigate this challenge, adopting a decentralized governance model supported by regional technical hubs to foster localized management and ensure smoother system integration and maintenance is recommended.

Results and Discussion

1. Conceptual Framework Findings

The proposed framework is congruent with general health system strengthening frameworks and the principles of digital health implementation. It covers all elements of health information system development, including data creation, integration, management, and decision-making. Moreover, this framework accounts for socio-technical aspects by considering the interplay among technical systems, human resource capabilities, and organizational contexts, particularly in fragile environments. To enable the evaluation and application of the framework, it can be assessed using key performance indicators, such as data completeness, report timeliness, patient follow-up rates, and system use. These indicators provide a basis for evaluating the performance of the system. This is based on the assumption that standardized data elements and structured reporting are used in DHIS2, enabling data collection and interoperability. The introduction of the proposed framework is likely to proceed in a phased approach, beginning with piloting its use in some facilities and gradually scaling up to districts and, ultimately, to the country level. This phased process will facilitate adjustments based on contextual considerations, build capacity, and improve the systems. Data protection issues are addressed through role-based access control, secure data transmission, and ethical data-handling practices. Although there are no national data protection laws, DHIS2's current security features provide basic protection.

2. PESTEL Analysis and Interpretation

A PESTEL analysis was conducted to assess the relative importance of major external factors influencing the

Table[2]: DHIS2 SWOT analyses

Strengths	Weaknesses
• Earlier success in DHIS2 implementation in Yemen (Nutrition, EPI) programs. • Free Open-Source and Flexible Platform support • DHIS2 provides a data quality tool that supports improving data quality [30]. • Scalability and integration, DHIS2 can be scaled across different levels of care (community, district, national).	• Weak ICT infrastructure. • Fragile economic situation. • Dependency on Donor Support.
Opportunities	**Threats**
• International support for DHIS2 implementation. • Donors' engagement in developing DHIS2 as a tool to strengthen the health system in low-income countries. • Integration with Humanitarian Health Programs.	• Security concern. • Political instability • Dual authority that can cause system fragmentation. • Uncertainty of Donor Commitment. • Economic Collapse and Limited National Funding, which can cause health systems failure.

Table[3]: PESTEL Risk Assessment Matrix

Factor	Likelihood	Impact	Risk Level
Political instability	High	High	Critical
Economic constraints	High	Medium	High
ICT infrastructure	High	High	Critical
Social resistance	Medium	Medium	Moderate
Environmental challenges	Medium	Medium	Moderate
Legal gaps	High	Medium	High

use and implementation of the DHIS2. Political instability represents a major structural constraint; however, prior DHIS2 implementation demonstrates the system adaptability in fragile contexts. Yemen's economic environment is characterized by resource scarcity. This challenge can be addressed through DHIS2's open-source nature. In addition, the social environment, including people's attitudes towards change, poses challenges. However, the available training programs and healthcare workers' previous exposure to DHIS2. In terms of technological factors, limited ICT infrastructure and lack of Internet services represent significant constraints. However, DHIS2's offline capabilities may be a solution to this problem. Environmental factors, including natural instability, may threaten the adoption and sustainability of DHIS2. This PESTEL analysis shows that, despite the challenges to the adoption and sustainability of DHIS2 in NCD management in Yemen, these challenges are not insurmountable.

As shown in Table (3), several risks at high and medium priority levels can affect the implementation of DHIS2 for NCD management in Yemen, especially those linked to political instability, ICT constraints, and economic risks. The fact that DHIS2 has been successfully implemented in nutritional and immunization programs despite these risks indicates a considerable level of adaptability of the system to the local context. This indicates the possibility of extending the system's use to manage NCDs, even in the context of limited resources and an unstable political situation in Lebanon. However, the risks must be properly accounted for to facilitate effective adaptation during system implementation.

3. SWOT Analysis and Strategic Insights

The SWOT analysis provides significant insights into the internal and external factors that affect the adoption and sustainability of DHIS2 for NCD management in Yemen. The key strengths identified in this analysis include the prior experience of implementing DHIS2 at the national level in Yemen, its open-source nature, and its ability to incorporate data quality features. These strengths provide a strong operational foundation for DHIS2 expansion in Yemen for NCD management. The key weaknesses identified in this analysis include limited ICT infrastructure, economic instability and dependence on donor funding. This is a weakness in creating a

Table[4]: TOWS Strategic Matrix for DHIS2 Implementation in Yemen

Strategy Type	Strategic Direction
SO (Strength–Opportunity)	Leverage existing DHIS2 experience and international support to expand NCD programs using scalable and cost-effective solutions.
ST (Strength–Threat)	Use DHIS2 flexibility and decentralization to mitigate governance fragmentation and political instability.
WO (Weakness–Opportunity)	Address ICT infrastructure gaps through donor-supported capacity building and integration with humanitarian programs.
WT (Weakness–Threat)	Reduce reliance on donors and mitigate system fragility by developing local capacity and implementing in phases.

favorable environment for the adoption and sustainability of the NCD-DHIS2 in Yemen. The key opportunities identified in this analysis include access to global support, collaboration with donors, and humanitarian health programs. This presents a significant opportunity to create a favorable environment for the adoption and sustainability of DHIS2 for NCD management in Yemen. The key threats identified in this analysis include political instability in Yemen, the presence of dual government structures, and donor inaction. This is a significant threat to providing a favorable environment for the adoption and sustainability of the NCD-DHIS2. The strategic implications of this analysis suggest that capacity building in local governments and decentralization of DHIS2 governance structures can help create a favorable environment for NCD-DHIS2 adoption and sustainability.

4. Integrated Strategic Implications

Based on this analysis, the DHIS2 is a feasible solution for enhancing NCD surveillance in Yemen. However, introducing such a mechanism must be done progressively because of numerous implementation challenges, including inadequate infrastructure and human capacity. To implement this solution, the following strategic actions are needed: the creation of national technical capacity, a decentralized governance structure, an ICT infrastructure, an ICT workforce, and robust data governance to enhance the security of the information collected. Although empirical testing cannot be conducted at this time because of limited research findings, the above concept is likely to guide the application of the solution.

The findings are highly consistent with lessons from fragile states, which have successfully used DHIS2 not only for regular reporting but also in disease-focused programs such as NCD programs. For instance, the implementation of hypertensive registers in Nigeria using DHIS2 technology demonstrated that the tracker feature can effectively monitor patient progress. Furthermore, as lessons from Ethiopia and Rwanda indicate, adopting DHIS2 in these countries could help create a more effective HIS despite their inadequate infrastructure. These lessons suggest that, despite potential governance challenges, introducing DHIS2 into NCD management aligns with emerging trends in digital health in fragile countries. Such governance requires collaboration between the MOH, partners, and local administrations, along with the implementation of a decentralized approach. Sustainability is also a major issue, as Yemen relies on external funding to support its public health activities. Some risks include fragmented systems, unstable funding, and weak infrastructure issues.

Conclusion

Yemen has taken important steps to strengthen its health information system by implementing DHIS2 in its nutrition and immunization programs. DHIS2 supports routine reporting and program monitoring. This study presents a foundation for extending DHIS2 to address the substantial burden of non-communicable diseases (NCDs). The proposed NCD-DHIS2 conceptual framework offers a scalable, context-adaptable approach for establishing an NCD database. The proposed framework supports patient follow-up and facilitates the tracking of medications. It enables structured reporting and analytical dashboards that support evidence-based decision-making across levels of care. The analysis indicates that DHIS2 is a "conceptually suitable and strategically relevant option for strengthening NCD surveillance in Yemen," although further empirical validation is required to confirm this. The proposed framework may contribute to improved NCD surveillance and health system resilience. Beyond Yemen, this approach may be relevant to other fragile countries seeking cost-effective digital solutions to strengthen NCD monitoring.

Limitations

This study relies entirely on secondary sources (WHO reports, government documents, and published studies). No primary data collection was conducted because of the conflict and fragile security situation in Yemen. The SWOT and PESTEL analyses are based on the current context of Yemen. Empirical validation methods, such as stakeholder interviews and field assessments, were not included in this study. Hence, the findings of this study may not be generalizable to a broader context. Future studies should include empirical validation methods to

support this framework.

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Conflict of Interest

The author(s) declare (s) no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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