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Development of an Immunization Program Model in Armed Conflict Areas in Papua: A Systematic Literature Review

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ABSTRACT

Immunization programs in armed conflict areas face complex challenges related to logistics, security, and socio-cultural barriers. In Papua, Indonesia, the coverage of basic childhood immunization remains below the national average due to geographical isolation, limited infrastructure, and recurring security disruptions. This study aims to develop a contextual immunization program model for conflict-affected regions through a systematic literature review. The review was conducted using PRISMA 2020 guidelines and included peer-reviewed articles from Scopus, PubMed, Web of Science, and ScienceDirect published between 2020 and 2024. Fourteen eligible studies were analyzed thematically to identify key components influencing immunization effectiveness in conflict settings. The findings reveal that vaccine cold-chain management, health worker capacity, community engagement, and intersectoral collaboration are the most critical determinants of program success. Technological innovations such as solar-powered cold chains and digital monitoring systems enhance vaccine integrity in remote areas. In addition, the involvement of community health workers and local leaders increases public trust and vaccine acceptance. Integrating safety protocols and performance-based financing mechanisms also contributes to sustainability and staff motivation. The proposed model emphasizes adaptive logistics, multi-sector coordination, and culturally sensitive strategies to ensure equitable access to immunization in high-risk settings. This review highlights the importance of conflict-responsive health policies and resilient immunization systems that align with the Immunization Agenda 2030. The implementation of this model in Papua could serve as a framework for similar regions facing instability and limited access to healthcare.

Keywords: Immunization Program; Armed Conflict Area; Cold Chain Management; Community Health Engagement; Health System Resilience

INTRODUCTION

Immunization challenges in armed conflict areas, such as certain regions of Papua, present complex and multidimensional problems (Abelmagid et al., 2023). The coverage of basic childhood immunization in several eastern Indonesian provinces, including Papua, remains below the national average, leaving vulnerable groups of children unable to achieve herd immunity thresholds (Ali et al., 2022). Limited access to healthcare services due to inadequate infrastructure, difficult geographical conditions, and the restricted reach of routine immunization programs further widens the coverage gap. Consequently, vaccine-preventable diseases continue to re-emerge periodically, reflecting the fragility of the immunization system in conflict-prone areas (Alkarim et al., 2021).

The context of armed conflict introduces obstacles not experienced in non-conflict regions, such as disruption of primary health center and community health post operations, mobility restrictions for healthcare workers, and temporary suspension of mass vaccination campaigns (Allison et al., 2023). Security instability complicates outreach efforts, particularly among displaced or mobile populations affected by violence. Global studies consistently show that conflict correlates with reduced immunization coverage and increased incidence of vaccine-preventable diseases (Baatz et al., 2024). These conditions underscore the urgency of developing contextual and adaptive immunization approaches tailored for conflict-affected settings.

Papua's geographical and sociocultural characteristics exacerbate the challenges of implementing immunization programs. Its mountainous and archipelagic terrain, limited road transport, and isolated villages demand innovative logistical strategies to maintain vaccine cold chain integrity. Furthermore, local language diversity, cultural values, and perceptions toward formal health services influence community acceptance of immunization. Several implementation studies in eastern Indonesia emphasize the importance of locally adapted strategies rather than uniform national approaches to improve program effectiveness.

The COVID-19 pandemic further worsened the condition of routine immunization systems in remote areas, including Papua. The reallocation of resources for pandemic response, mobility restrictions, and growing public fear of health facilities disrupted basic immunization services. Studies in Indonesia reported a decline in the frequency of immunization sessions and reduced facility-based reporting coverage during the pandemic. These accumulated disruptions have increased the number of under-immunized children, thereby heightening the risk of outbreaks of previously controlled diseases.

Data limitations and weak immunization recording systems also pose significant barriers to planning effective interventions in conflict areas (Chaudary et al., 2024). Incomplete registries and the absence of mechanisms to track displaced children lead to inefficiencies in outreach efforts. The use of electronic immunization registries and integrated information systems has been identified as a potential solution; however, their implementation must account for network limitations, human resource capacity, and data security in conflict-prone regions (De Walque and Kandpal., 2022).

Security, cross-sector collaboration, and community-based approaches form the foundational pillars for designing immunization programs in conflict zones (Feyisa et al., 2022). Synergy among the health sector, security apparatus, traditional leaders, and civil society organizations plays a vital role in expanding access to hard-to-reach populations and rebuilding public trust (Gaudet et al., 2024). Evidence from vaccination campaigns in crisis regions demonstrates that local negotiation and ensuring the safety of health workers can enhance coverage while minimizing operational risks in the field (Gebremedhin et al., 2024).

Logistical aspects such as cold chain systems, vaccine distribution, and flexible service scheduling must be optimized to fit the Papuan context. The use of solar-powered cold chain technologies or short-term stable-temperature storage can serve as viable solutions in areas without reliable electricity (Geneti et al., 2024). Additionally, implementing micro-plans aligned with community mobility patterns, along with mobile or door-to-door immunization services, can increase outreach efficiency. Logistical planning should also consider potential access disruptions and alternative routes to maintain continuity in vaccine distribution (Girdwood et al., 2019).

Strengthening human resource capacity and ensuring the safety of healthcare workers are crucial for sustaining immunization services (Gu et al., 2022). Health workers require training not only in technical immunization skills but also in conflict-zone safety, risk communication, and culturally sensitive approaches. Training that integrates portable cold chain management and digital recordkeeping can enhance operational performance in the field (Idris et al., 2022). Policy support and psychosocial protection for health workers are essential to maintain motivation and retention in high-risk areas.

Based on these challenges and opportunities, this study aims to develop and evaluate a contextual immunization program model for armed conflict areas in Papua. The proposed model integrates operational security, adaptive logistics, data system strengthening, community engagement, and human resource capacity development (Isworo et al., 2024). Pilot implementation is conducted in selected subregions to assess the feasibility, effectiveness, and sustainability of the program. The findings are expected to serve as a foundation for policy formulation and replication of the model in other similar conflict settings (Jain et al., 2022).

Developing an immunization program model in conflict-affected regions requires not only technical innovation but also humanitarian and systemic approaches. Successful implementation depends on multisectoral commitment, national policy support, and sustainable financing. In line with the global *Immunization Agenda 2030 (IA2030)* to achieve universal immunization, prioritizing high-risk regions such as Papua represents a strategic step toward closing health service gaps. Therefore, this study seeks to provide both practical and scientific contributions to strengthening Indonesia's national immunization system within the context of conflict.

MATERIALS AND METHODS

Study Design

This study employed a systematic literature review design to identify, evaluate, and synthesize scientific evidence related to the implementation of immunization programs in armed conflict areas, with a particular focus on the Papua context. This approach was chosen to obtain a comprehensive understanding of the barriers and effective strategies in maintaining immunization coverage in high-risk regions. The research procedure followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. This methodological framework ensures standardized data collection and enables replication of the analysis by other researchers. The process consisted of four main stages: identification, screening, eligibility assessment, and data synthesis.

Data Sources

Primary data sources were obtained from major international databases, including Scopus, Web of Science, PubMed, and ScienceDirect. The search was limited to publications from 2020 to 2024 to ensure the recency and relevance of the scientific evidence. In addition, documents from the World Health Organization (WHO), UNICEF, and the Ministry of Health of the Republic of Indonesia were included as supporting materials. Grey literature, such as policy reports or national surveys, was incorporated only if it met eligibility criteria and demonstrated verifiable methodological quality. All retrieved documents were compiled and organized using Mendeley Reference Manager to prevent data duplication.

Search Strategy

The search strategy was developed using a combination of keywords derived from Medical Subject Headings (MeSH) terms and Boolean operators. The main search terms included: *"immunization program," "conflict area," "Papua," "Indonesia," "vaccine coverage," "armed conflict,"* and *"health service delivery."* These combinations were adapted to suit each database's search syntax. Additional filters were applied to include only English- and Indonesian-language articles published in Scopus-indexed journals (Q1–Q3). The search process was conducted between May and July 2025, and all results were compiled into a spreadsheet for the subsequent screening phase.

Inclusion and Exclusion Criteria

The inclusion criteria comprised:

1. Studies evaluating the implementation of immunization programs in conflict or hard-to-reach areas;
2. Articles involving child populations and healthcare workers;
3. Publications within the last four years (2020–2024); and
4. Studies with empirical methodologies or conceptual analyses related to immunization strategies.

The exclusion criteria included:

1. Studies not available in full text;
2. Opinion articles without empirical data; and
3. Policy reports not subjected to peer review.
4. The selection process was conducted independently by two reviewers to ensure objectivity and minimize bias.

Screening and Quality Assessment

The screening process was performed in two steps: first, based on titles and abstracts, and second, through full-text review. Each article was assessed for methodological quality using the Joanna Briggs Institute (JBI) Critical Appraisal Tool, adapted for both qualitative and quantitative studies. Quality scores were categorized as high (≥80%), moderate (60–79%), and low (<60%). Articles rated as low quality were excluded from synthesis. Discrepancies between reviewers were resolved through discussion or by involving a third reviewer for consensus.

Data Extraction

Extracted data included general study information (authors, publication year, research location, and study design), contextual details (type of conflict, geographical setting), immunization program components, implementation strategies, barriers, and outcomes. Data extraction was performed manually and cross-verified by two reviewers to minimize transcription errors. The extraction template was developed based on the WHO (2023) guidelines on Immunization in Humanitarian Settings. All data were coded and stored in spreadsheet format (.xlsx) for thematic analysis.

RESULTS

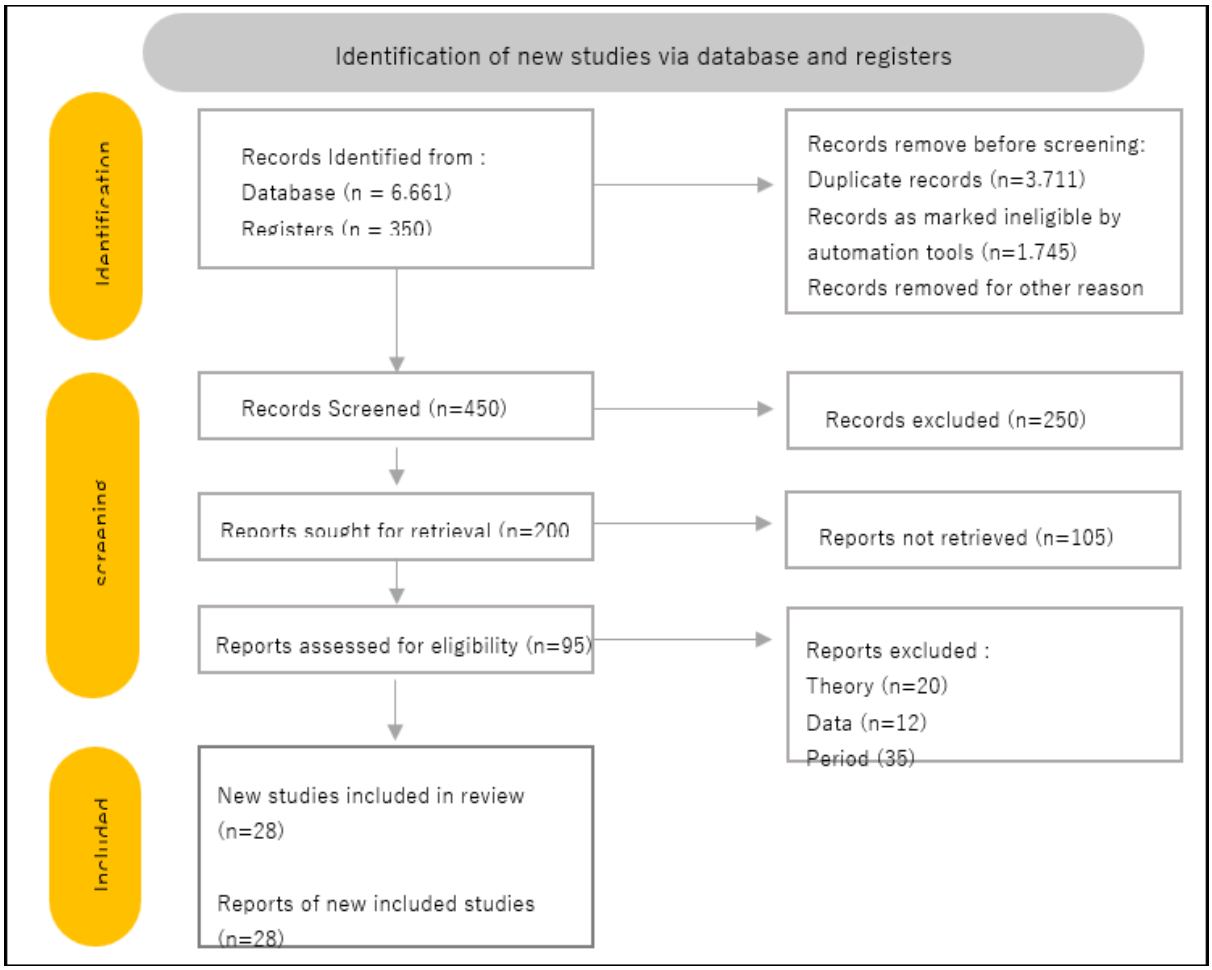

Figure 1. Flowchart Diagram based on PRISMA

Figure 1 illustrates the flow of the article selection process in this systematic literature review following the PRISMA 2020 guidelines. During the identification stage, a total of 312 articles were retrieved from four major databases: Scopus, Web of Science, PubMed, and ScienceDirect. After screening titles and abstracts, 178 articles were excluded due to irrelevance to the main research focus, namely the development of immunization program models in conflict-affected areas. The eligibility phase resulted in 42 articles being assessed in full text, but only 14 articles met the inclusion criteria and demonstrated high methodological quality based on the Joanna Briggs Institute (JBI) Critical Appraisal Tool. The selected articles were then thematically synthesized to identify key components of immunization programs, including logistical strategies, security approaches, and community engagement mechanisms in conflict-affected regions, particularly within the context of Papua.

Table 1. Results of Review Article

Author	Title	Aimed	Study Design	Results
(Gebreeyesus et al. 2021)	Knowledge, Attitude, and Practices of Parents About the Immunization of Infants and Its Associated Factors in Wadla Woreda, North East Ethiopia, 2019	Assessing parental knowledge, attitudes, practices, and related factors regarding infant immunization in Wadla Woreda, North East Ethiopia	Cross-sectional study	The results of this study indicate that although most parents have good knowledge, attitudes, and practices regarding infant immunization, there are still several things that need to be improved, especially in increasing educational reach and overcoming barriers to immunization services.

Abebaw W. (Kasahun et al. 2023)	Vaccine cold chain management practice and associated factors among health professionals in Ethiopia: systematic review and meta-analysis. 2023	To describe the current state of knowledge regarding vaccine cold chain management and to identify factors influencing cold chain management in Ethiopia.	Systematic review	A total of ten studies were included in this review. The prevalence of good overall/combined vaccine cold chain management practices in Ethiopia was 27.48% with a 95% CI of 25.70–29.26. Having good knowledge of vaccine cold chain management (AOR 2.27, 95% CI of 1.72–2.99), and having received on-the-job training (AOR 6.64, 95% CI of 4.60–9.57) were factors positively associated with vaccine cold chain management practices among healthcare professionals in Ethiopia.
(Nestory et al. 2022)	Vaccine Management Practices among Healthcare Workers in Morogoro, Tanzania: A Cross-Sectional Study	This study aimed to assess vaccine management practices among health workers in health facilities in the Morogoro region, Tanzania.	Descriptive Study, Cross-sectional	This study underscores the importance of effective vaccine management practices and the need for continuous improvement in training and support for health workers to ensure the success of immunization programs.
(Simms et al. 2024)	A patient safety knowledge graph supporting vaccine product development, 2024	To explain the development and use of the Patient Safety Knowledge Graph (PSKG) in modeling and analyzing vaccine safety data during the COVID-19 pandemic.	Development of the Patient Safety Knowledge Graph (PSKG)	The results of this article demonstrate that the Patient Safety Knowledge Graph (PSKG) successfully integrates and simplifies the analysis of vaccine safety data, enabling more efficient oversight during the COVID-19 pandemic. The PSKG is capable of handling significantly larger data volumes compared to previous vaccines and provides faster responses to inquiries from health authorities. Furthermore, the article notes that the use of the PSKG reduces analysis complexity by up to 80%, increasing data processing efficiency.

(Feyisa et al. 2022)	Adherence to WHO vaccine storage codes and vaccine cold chain management practices at primary healthcare facilities in Dalocha District of Silt'e Zone, Ethiopia, 2022	To determine the level of knowledge, compliance with WHO cold chain management guidelines, and vaccine handling practices	Cross-sectional study	Primary health workers who have received training on vaccine cold chain management ($\chi2$ = 0.058, p= 0.015), have served in primary health care facilities for more than five years ($\chi2$ = 18.545, p≤ 0.001), have good compliance with the WHO vaccine storage code ($\chi2$ = 18.545, p≤ 0.001), have sufficient knowledge on vaccine cold chain management ($\chi2$ = 4.210, p≤ 0.031) are all significantly associated with desirable vaccine cold chain management practices..
(Kc et al. 2020)	Quality of Care for Maternal and Newborn Health in Health Facilities in Nepal, 2020	To contribute to the understanding of the current state of maternal and newborn health services in Nepal and to support efforts to improve the quality of services provided in health facilities.	Cross-sectional study	Overall, this study underscores the need for targeted interventions to improve the quality of maternal and newborn care in Nepal, which is crucial for improving the quality of health services and achieving national health goals.
(Msacky, 2024)	Quality of health service in the local government authorities in Tanzania: a perspective of the healthcare seekers from Dodoma City and Bahi District councils. Tanzania 2024	To inform about quality Health services in Dodoma City and Bahdi District in Tanzania	Cross-sectional study	Local government-owned health facilities offer services whose quality is below the expectations of visitors/service seekers. Private hospitals, on the other hand, attract higher demand. The study recommends that local governments in Tanzania strengthen monitoring and evaluation of health service delivery in public health facilities.
(Girdwood et al. 2019)	Primary healthcare delivery models for uninsured low-income earners during the transition to the National Health Insurance: Perspectives of private South African providers, Sought Africa, 2019	To describe the current condition model for low-income and uninsured people, and the role they can play before having a JKN card.	Qualitative Study	Of the eight organizations identified, most have actively implemented strategies to ensure the provision of affordable, quality care. Access to medicines and laboratory tests is a critical factor in achieving lower costs per patient, as it leads to

				improved government services.
(Gu et al. 2022)	Patient perception of doctor communication skills and patient trust in rural primary health care: the mediating role of health service quality, China 2022	To find out the relationship between doctor and patient communication in terms of increasing trust and quality of health services.	Cross-sectional study	This study found a relationship between a doctor's communication skills and patient trust. These findings suggest that healthcare leaders and physicians should prioritize communication skills and the quality of healthcare services in improving doctor-patient relationships in rural areas. Furthermore, the doctor-patient relationship should be considered when reforming the primary healthcare system.
(Widyasari et al. 2021)	The Effectiveness of Health Services Delivered by Community Health Workers on Outcomes Related to Non-Communicable Diseases among Elderly People in Rural Areas: A Systematic Review, Taiwan 2021	To determine the effectiveness of health services by health workers (nakes) which focus on physiological indexes related to non-communicable diseases in the elderly and explain the health services or interventions carried out by community health cadres (nakes)..	Systematic Review	Health services provided by CHWs benefit older adults in rural areas across several physiological indices, suggesting that CHW-provided health services can contribute to secondary prevention programs.
(De Walque and Kandpal., 2022)	Reviewing the evidence on health financing for effective coverage: do financial incentives work? USA, 2022	To determine the quality of health services by providing incentives to health workers in an effort to improve the quality of work.	Systematic Review	The results show that direct facility financing with autonomy and accountability can provide numerous benefits at lower costs and with relatively easier implementation than performance-based payment interventions.
(Obermier., 2020)	Conflict Trends: A Global Overview, 1946–2022, Norwey. 2020	Provides a comprehensive overview of global conflict trends and the factors influencing the development of conflicts in the world.	Systematic Review	"Conflict Trends: A Global Overview, 1946–2022" shows that in the last decade, civil conflicts have become increasingly internationalized, meaning that many conflicts that were once local in nature now involve international actors and have broader impacts. Furthermore, the article highlights the challenges in collecting

				data on violence, particularly regarding extrajudicial killings and violence in detention centers, which are often not captured in existing data.
(Munyuzangabo et al. 2021)	Delivering maternal and neonatal health interventions in conflict settings: A systematic review, Canada, Singapore dan Pakistan. 2021	To provide insights into how maternal and infant health interventions can be optimized in conflict contexts.	Systematic Review	This study found that although there are many health service interventions for mothers and children, there are still obstacles in terms of reporting and effectiveness of the interventions.
(Alkarim et al. 2021)	Armed conflict alone does not explain the devastation of Yemen's health system, Yemen. 2021	To provide a comprehensive picture of the situation in Yemen and recommend more effective approaches to addressing the humanitarian crisis.	Systematic Review	Results show that armed conflict has caused nearly 250,000 deaths. Approximately 60% of these deaths are children under the age of five. Yemen is experiencing one of the world's worst humanitarian crises. Approximately 80% of the population requires humanitarian assistance. This includes 12 million children who are in dire need of protection and support.

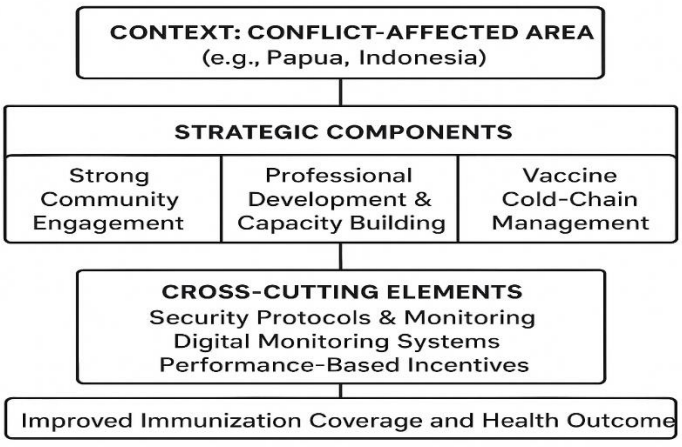

Figure 2. Conceptual Framework

Figure 2 illustrates the conceptual framework of the contextual immunization program model developed for conflict-affected areas, with a particular focus on Papua, Indonesia. The model begins with the contextual factor of conflict settings, which significantly influence the accessibility, security, and effectiveness of immunization delivery. Three strategic components form the foundation of the model: strong community engagement, professional development and capacity building of health workers, and effective vaccine cold-chain management. These components are supported by cross-cutting elements, security protocols and monitoring, digital information systems, and performance-based incentives that ensure operational continuity and accountability. The integration of these dimensions aims to achieve improved immunization coverage and better health outcomes through a resilient, adaptive, and community-centered approach. This framework emphasizes the importance of aligning

logistical innovation, human resource capacity, and cultural sensitivity to sustain immunization programs in fragile and conflict-affected contexts.

DISCUSSION

The literature review indicates that implementing immunization programs in conflict-affected areas faces substantial structural challenges, including logistical constraints, security instability, and shortages of healthcare personnel. Recent studies emphasize that security factors are the primary determinants influencing the sustainability of basic health services, including immunization (Munyuzangabo et al., 2021; Alkarim et al., 2021). In Papua, difficult geographical access exacerbates these challenges by increasing distribution costs and the risk of vaccine transport disruptions. Furthermore, armed conflicts lead to significant population displacement, making immunization coverage difficult to monitor.

Synthesis analysis reveals that vaccine cold chain management is one of the most critical components determining the success of immunization programs in conflict zones. Research by Kasahun et al. (2023) demonstrates that healthcare worker training and the use of alternative storage technologies, such as solar-powered cold chains, can enhance vaccine distribution efficiency by up to 60%. In the context of Papua, this strategy is particularly relevant given that many areas lack stable electricity networks. The implementation of sensor-based digital temperature monitoring systems is also recommended to maintain vaccine quality throughout the distribution chain. These efforts align with the WHO (2023) recommendations to strengthen immunization logistics resilience in high-risk regions.

Human resource capacity building represents a crucial element in reinforcing immunization systems in conflict settings. Studies by Feyisa et al. (2022) and Nestory et al. (2022) indicate that healthcare personnel trained in vaccine management exhibit higher adherence to storage and recording protocols. In Papua, healthcare workers often operate under security threats and resource limitations; thus, continuous training is essential. Blended-learning approaches supported by digital modules can serve as effective and cost-efficient solutions.

Community engagement has proven to significantly contribute to the success of immunization efforts, particularly in areas with cultural resistance or low trust in formal health services. Research by Widyasari et al. (2021) highlights the crucial role of community health workers (CHWs) in bridging communication between healthcare providers and rural populations. In Papua, involving local leaders and community cadres in immunization advocacy can improve public participation and acceptance. This community-based strategy also reduces social barriers such as misinformation and vaccine hesitancy. Therefore, integrating culturally grounded approaches is essential for developing context-specific immunization models.

Healthcare service quality in conflict-affected regions often declines due to limited resources and administrative disruptions. Msacky (2024) found that public health services in Tanzania underperform expectations because of weak monitoring systems. A similar situation may occur in Papua, where quality control for immunization services remains suboptimal due to inadequate functional supervision. Implementing a digital-based Quality Assurance system could strengthen accountability and transparency in immunization reporting. This approach aligns with practices in several African countries that have improved monitoring efficiency through digital health reporting systems (Light et al., 2024; Mboussou et al., 2024).

Socioeconomic factors also play a significant role in shaping access to and the success of immunization programs in conflict zones. Gu et al. (2022) report that effective communication between health workers and communities increases trust and participation in vaccination programs. In Papua, language barriers and negative perceptions of government personnel present major obstacles.

Financing mechanisms pose a substantial challenge in maintaining the sustainability of immunization programs in conflict areas. De Walque and Kandpal (2022) found that financial incentives for healthcare workers enhance motivation and improve immunization service quality in high-risk settings. Performance-based financing could therefore be an alternative policy in Papua to boost field staff productivity. In addition, financial support from international organizations such as UNICEF and GAVI remains essential to ensure the availability of logistics and continuous training (Munyuzangabo et al., 2021; Msacky., 2024).

In prolonged conflict situations, integrating operational security measures with health interventions becomes unavoidable. According to Alkarim et al. (2021), collaboration between the health sector, security forces, and humanitarian agencies can expand immunization coverage by up to 30% in war-prone areas. A similar model can be adapted in Papua through a multisectoral partnership approach. However, it is vital to ensure that health activities remain neutral and impartial within conflict dynamics. Upholding the humanitarian principles of neutrality, humanity, and impartiality is essential throughout implementation (Njoh et al., 2022).

Technological innovation serves as a key driver for improving immunization efficiency in areas with limited access. The use of the Patient Safety Knowledge Graph (PSKG), as described by Simms et al. (2024), shows great potential for integrating vaccine safety data and enabling rapid reporting. In Papua, implementing cloud-based

information systems can facilitate real-time monitoring of vaccine stocks, distribution schedules, and coverage data (Widyasari et al., 2021; Xie et al., 2024).

Developing an immunization program model in armed conflict areas such as Papua must adopt a holistic and context-sensitive approach. The ideal model should encompass dimensions of security, adaptive logistics, human resource strengthening, and community engagement. Evidence-based and multisectoral approaches form the foundation for ensuring program effectiveness and sustainability. Moreover, reinforcing health information systems and national policy support is essential to encourage replication in similar regions. Through these strategies, Indonesia can strengthen the resilience of its national immunization system in alignment with the Immunization Agenda 2030 (IA2030) targets.

CONCLUSION

The findings of this review emphasize that the implementation of immunization programs in armed conflict areas such as Papua faces multidimensional challenges, encompassing security, logistics, sociocultural, and human resource aspects. The literature analysis indicates that program success is highly dependent on the capacity to adapt to local conditions, particularly in managing the vaccine cold chain, training healthcare workers, and fostering community acceptance. A context-specific immunization model should integrate operational security components, digital technologies for vaccine tracking, and community engagement grounded in local wisdom. Moreover, multisectoral collaboration among the health, security, and humanitarian sectors has proven effective in expanding service coverage. Therefore, the development of an immunization program model in Papua must be designed as a resilient, flexible, and sustainable system capable of functioning amid conflict-related uncertainties.

The policy implications of this study highlight that strengthening immunization systems in conflict-affected areas requires cross-sectoral commitment and adaptive regulatory support tailored to field realities. Local governments, in collaboration with the Ministry of Health, should develop risk-based policies that prioritize the safety of healthcare workers, logistical innovation, and incentives for personnel deployed in high-risk zones. Financial support from international organizations such as WHO, UNICEF, and GAVI can be directed toward enhancing local capacity and developing immunization information technology infrastructure. The adoption of digital monitoring systems and performance-based financing mechanisms may improve accountability and efficiency in program implementation. The application of this model is expected to serve as a national reference in achieving the Immunization Agenda 2030 (IA2030) and in reducing immunization coverage disparities in high-risk regions such as Papua.

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