Article:
Hakim, Muhammad, Afaq, Saima, Khan, Bilal Ahmad et al. (2026) Strategies for enhancing vaccine uptake among children under two years of age in low and middle-income countries (LMICs):A scoping review. International Journal of Infectious Diseases. 108376. ISSN: 1878-3511

https://doi.org/10.1016/j.ijid.2026.108376

International Journal of Infectious Diseases 164 (2026) 108376

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Review

Strategies for enhancing vaccine uptake among children under two years of age in low and middle-income countries (LMICs): A scoping review ☆

Muhammad Hakim [1], Saima Afaq [1,2,*], Bilal Ahmad Khan [3], Sara Imtiaz [4], Farhad Ali [1], Zia ul Haq [1]

[1] Institute of Public Health and Social Sciences (IPH&SS), Khyber Medical University (KMU), Peshawar, Pakistan
[2] Department of Health Sciences, University of York, York, UK
[3] Office of Research, Innovation and Commercialization (ORIC), Khyber Medical University, Peshawar
[4] Health Promotion Foundation, Karachi, Pakistan

ARTICLE INFO

Article history:
Received 7 November 2025
Revised 24 December 2025
Accepted 7 January 2026

Keywords:
Strategies
Children
Vaccine uptake
WHO Health System
LMICs

ABSTRACT

Introduction: Over 14.5 million infants remain unvaccinated globally, predominantly in low- and middle-income countries (LMICs), where health system gaps and inequities impede progress toward the Immunisation Agenda 2030.
Objective: This scoping review synthesised health system strengthening strategies aligned with the WHO Health Systems Framework to enhance vaccine uptake among children under two years of age in LMICs.
Methods: Following the PRISMA-ScR guidelines, six databases were searched until January 2025.
Results: Of 2897 records, 53 studies met the inclusion criteria: 54.7% from lower-middle-income and 41.5% from low-income countries, with 81.1% being community-based interventions. The mean intervention duration was 39.3 months (SD = 62.1). Health information systems (83.0%), leadership and governance (79.2%), and service delivery (60.4%) were the most frequently targeted, while the health workforce was the least addressed (35.8%). The key strategies included data monitoring (88.7%), coverage tracking (86.8%), and data-driven decision-making (86.8%). Community-centred, data-informed interventions improved service accessibility (67.9%) and quality (41.5%).
Conclusion: Multiple interventions addressing multiple WHO building blocks have demonstrated better outcomes. Strengthening workforce capacity, adopting an integrated health system approach, and addressing financing barriers are essential for achieving the Global Immunisation Agenda 2030.

Introduction

Globally, one in five children lack access to routine immunisation programmes. Vaccines prevent an estimated 3.5-5 million deaths annually [1] and are projected to avert over 50 million deaths between 2021 and 2030. Despite successful global programs, nearly 14.5 million children worldwide miss essential routine vaccines, with the majority residing in LMICs [2,3]. Post-COVID-19 pandemic, an additional 2.7 million children under 1 year received no routine vaccines, the "zero-dose" children, where health system gaps and inequities impede progress toward the Immunisation Agenda 2030 [4]. This alarming situation in routine vaccination rates continues to pose significant global health challenges, with coverage remaining suboptimal particularly in resource-limited settings [5].

Most zero-dose children live in Africa and Southeast Asia, with over half in ten countries: Angola, Afghanistan, the Democratic Republic of Congo, Ethiopia, India, Indonesia, Nigeria, Pakistan, the Philippines, and Sudan [2]. This clustering highlights systemic delivery weaknesses, where geographic, socioeconomic, and structural barriers hinder equitable immunisation access in the region.

☆ Registration: This scoping review was registered with the Open Science Framework (OSF). The registration details are available at https://doi.org/10.17605/OSF.IO/M3WUK.

* Corresponding author: Dr. Saima Afaq, Department of Health Sciences, University of York, Heslington East, York YO10, UK.
E-mail address: saima.afaq@york.ac.uk (S. Afaq).

https://doi.org/10.1016/j.ijid.2026.108376

Each dollar spent on immunisation yields an estimated return of US$52, costing only US$18 per child, demonstrating both health and economic benefits [6].

The WHO Immunisation Agenda 2030 aims to maximise vaccine impact through better equity [6]. However, achieving this requires addressing persistent challenges in LMICs, including limited infrastructure, workforce shortages, logistical challenges, financial barriers, and sociocultural factors affecting vaccine acceptance [7–9]. Vaccine delay and administering vaccines after the recommended age pose additional threats through prolonged susceptibility and increased outbreak risk [10]. Common reasons include parental concerns about immune system overload, scheduling difficulties, insufficient professional advice, and lack of understanding about timely vaccination benefits [11,12].

The WHO Health System Framework provides a structured approach through six building blocks: Service Delivery, Health Workforce, Health Information Systems, Access to Vaccines, Financing, and Leadership and Governance [13]. This framework offers a valuable perspective for examining vaccination coverage interventions and identifying system-strengthening strategies. However, limited evidence exists regarding health system approaches aligned with this framework in LMICs. This review synthesises evidence by systematically mapping interventions designed to enhance vaccine uptake among children under 2 years in LMICs, focusing on strategies aligned with the WHO framework to inform immunisation policies, strengthen vaccination systems and promote sustainable, equitable services.

Review questions

1. What are the characteristics of health system strengthening interventions aligned with the WHO Health System Framework that aim to enhance vaccine uptake among children under two years of age in LMICs?
2. How have these interventions/strategies been used to strengthen routine immunisation systems, and what are their capabilities in improving equitable vaccine coverage in early childhood?
3. How have barriers and facilitators shaped the implementation of interventions targeting the WHO Health System Building Blocks to improve vaccine uptake among children under two years of age in LMICs?

Methods

The protocol followed the Joanna Briggs Institute and PRISMA-ScR guidelines [14] and was registered on the Open Science Framework (osf.io/M3WUK) [15]. Studies were included if they focused on children under 2 years of age in LMICs (World Bank definition), evaluated interventions to improve vaccine uptake, and mapped to WHO Health System components. Only English-language publications until January 2025 were included.

From date of inception, six databases were searched: Medline, APA PsycINFO, Embase (via Ovid), PubMed, Cochrane Library, and Google Scholar. These databases were selected to provide comprehensive coverage of biomedical literature (Medline, PubMed, Embase), psychological and behavioural research relevant to vaccine acceptance (APA PsycINFO), and systematic reviews (Cochrane Library). For grey literature, we followed the guidelines of Haddaway *et al.* [16] and searched the first 300 results via Google Scholar, as evidence suggests that relevance ranking diminishes substantially beyond this threshold and additional screening yields minimal relevant results while significantly increasing workload. The search terms combined children, vaccines, immunisation (adapted from Jain *et al.* [17]), and LMICs keywords from Cochrane EPOC [18] (Supplementary File 1: Search Strategy). Records were managed using Rayyan.ai [19]. Two researchers (MH and SI) independently screened all titles and abstracts, and any disagreements were resolved by consensus and/or by consulting a third reviewer (BAK). Full texts were retrieved for studies that were considered eligible or had insufficient information in the abstract. The full texts were screened again using the same process to determine which studies should be included in the review.

Interventions were classified according to the six WHO Health System Building Blocks using a pre-defined classification framework based on WHO definitions [13]. Studies frequently addressed multiple building blocks simultaneously; therefore, each intervention was mapped to all relevant blocks, rather than a single primary category. Two reviewers (MH and BAK) independently classified each intervention, and discrepancies were resolved through discussion and consensus. When consensus was not reached, a third reviewer (SI) was consulted. To minimise misclassification, the reviewers used explicit criteria derived from the WHO framework: Service Delivery encompassed interventions targeting accessibility, availability, or quality of immunisation services; Health Workforce included training, supervision, or deployment strategies; Health Information Systems covered data collection, monitoring, or feedback mechanisms; Access to Essential Medicines addressed vaccine availability, supply chain, or cold chain issues; Financing included cost reduction, incentives, or funding mechanisms; and Leadership and Governance encompassed policy development, coordination, or accountability structures.

Data extraction captured study details, intervention characteristics, WHO building blocks addressed, outcomes, and barriers/facilitators using standardised Microsoft Excel forms. Narrative synthesis followed the SWiM guidelines [20] and was performed by authors MH and BAK. Studies were categorised by WHO framework building blocks. Outcomes were synthesised to identify effectiveness patterns, and barriers and facilitators were thematically analysed.

Results

The search identified 2897 records; after removing 297 duplicates, 2600 titles/abstracts were screened for eligibility. Following a full-text review of 126 articles, 53 studies met the inclusion criteria (Figure 1: PRISMA flow Diagram; Supplementary File 1: Characteristics of the included studies). The included studies spanned 35 years from 1989 to 2024, with a notable increase in publications after 2010, reflecting the growing interest in health-system approaches to improve vaccination coverage Most studies originated from lower-middle-income (54.7%) and low-income (41.5%) countries. Regarding the study setting, the majority (81.1%) were conducted in community-based settings, with the remainder in hospital (17.0%) or combined community and hospital (1.9%) settings. The study designs included non-experimental (43.4%), mixed methods (17.0%), and experimental (17.0%) designs (Table 1). Mean intervention duration was 39.3 months (SD = 62.1; median = 11; range = 0.5-228).

WHO building block distribution

Health Information Systems were the most frequently targeted (83.0%), followed by Leadership & Governance (79.2%) and Service Delivery (60.4%). The health Workforce was the least addressed (35.8%). Most studies addressed four (26.4%) or three (24.5%) blocks, while only 3.8% addressed a single block and 11.3% incorporated all six blocks. No study addressed all blocks uniformly (Figs. 2-5).

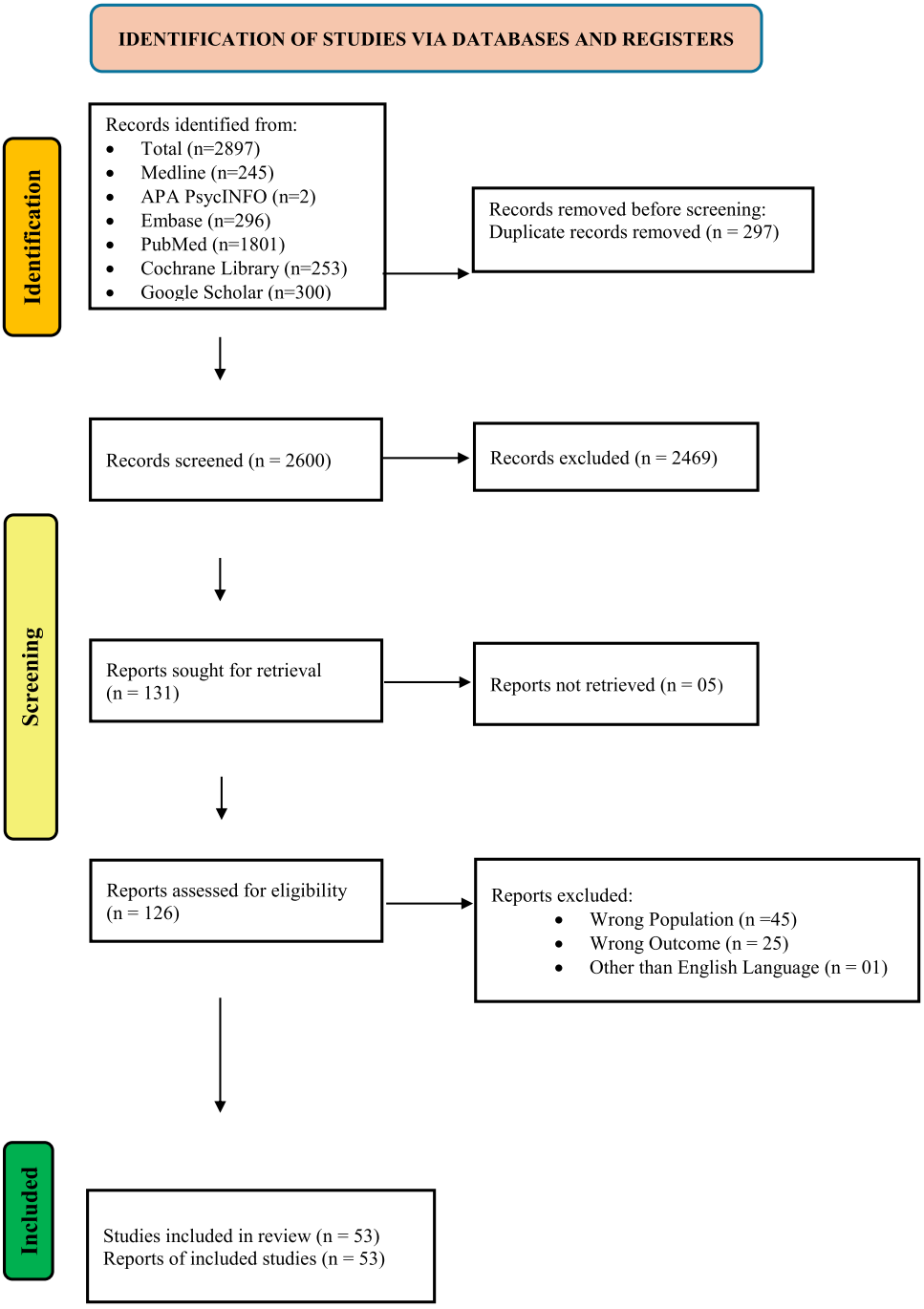

Figure 1. PRISMA flow diagram.

Key implementation strategies

Data-related strategies were the most consistently applied, including data monitoring (88.7%), coverage tracking (86.8%), and data-driven decision-making (86.8%). Service delivery improvements focused on accessibility/availability (67.9%) and quality (41.5%). Governance interventions emphasised policy improvements (60%) and structured mechanisms (36%). Health workforce strategies included capacity building (34%) and personnel deployment (26%). Access-related efforts addressed logistical challenges (57%), vaccine availability (30%), and supply chain enhancement (17%). Financial interventions were the least represented: reducing costs (23%), removing barriers (23%), and improving affordability (17%).

Effective intervention approaches

Service delivery

Integration with other health services improves coverage and efficiency [21,22]. SMS and manual reminder systems enhance vaccine timeliness and reduce dropout rates [23,24]. Community engagement involving religious leaders, local influencers, and community health workers increases trust and uptake [25,26]. Outreach services addressed geographical barriers through mobile

Table 1
Study characteristics by income group.

Characteristic		Overall N = 53	Low income N = 22	Lower–Middle N = 29	Upper–Middle N = 2	p-value
WHO building Blocks Targeted by Income Group						
1	Service delivery	32 (60.4%)	14 (63.6%)	17 (58.6%)	1 (50.0%)	0.9
2	Health workforce	19 (35.8%)	7 (31.8%)	11 (37.9%)	1 (50.0%)	0.9
3	Health information systems	44 (83.0%)	18 (81.8%)	24 (82.8%)	2 (100.0%)	>0.9
4	Access to essential medicines	36 (67.9%)	17 (77.3%)	17 (58.6%)	2 (100.0%)	0.3
5	Health financing	20 (37.7%)	8 (36.4%)	11 (37.9%)	1 (50.0%)	>0.9
6	Leadership & governance	42 (79.2%)	18 (81.8%)	23 (79.3%)	1 (50.0%)	0.6
Study Design and Setting Characteristics by Income Group						
1	Experimental	9 (17.0%)	4 (18.2%)	5 (17.2%)	0 (0.0%)	0.3
2	Mixed-methods	9 (17.0%)	3 (13.6%)	6 (20.7%)	0 (0.0%)	
3	Non-experimental	23 (43.4%)	12 (54.5%)	9 (31.0%)	2 (100.0%)	
4	Qualitative	6 (11.3%)	3 (13.6%)	3 (10.3%)	0 (0.0%)	
5	Review/secondary analysis	6 (11.3%)	0 (0.0%)	6 (20.7%)	0 (0.0%)	
Study Setting Characteristics						
1	Community	43 (81.1%)	17 (77.3%)	24 (82.8%)	2 (100.0%)	0.8
2	Community & hospital	1 (1.9%)	1 (4.5%)	0 (0.0%)	0 (0.0%)	
3	Hospital	9 (17.0%)	4 (18.2%)	5 (17.2%)	0 (0.0%)	
Urban/Rural Area						
1	Rural	15 (28.3%)	6 (27.3%)	8 (27.6%)	1 (50.0%)	0.5
2	Rural & urban	24 (45.3%)	9 (40.9%)	15 (51.7%)	0 (0.0%)	
3	Urban	14 (26.4%)	7 (31.8%)	6 (20.7%)	1 (50.0%)	
Vaccine Type and Intervention Materials by Income Group						
1	DPT/OPV	8 (15.1%)	5 (22.7%)	3 (10.3%)	0 (0.0%)	0.02
2	Hepatitis B/Tetanus	2 (3.8%)	0 (0.0%)	1 (3.4%)	1 (50.0%)	
3	Measles	2 (3.8%)	0 (0.0%)	1 (3.4%)	1 (50.0%)	
4	Multiple vaccines	17 (32.1%)	5 (22.7%)	12 (41.4%)	0 (0.0%)	
5	Routine childhood immunizations	24 (45.3%)	12 (54.5%)	12 (41.4%)	0 (0.0%)	
Material Type Used						
1	Data & research tools	23 (43.4%)	7 (31.8%)	16 (55.2%)	0 (0.0%)	0.065
2	Digital tools	6 (11.3%)	2 (9.1%)	4 (13.8%)	0 (0.0%)	
3	Media & communication	4 (7.5%)	1 (4.5%)	2 (6.9%)	1 (50.0%)	
4	Not specified	1 (1.9%)	0 (0.0%)	1 (3.4%)	0 (0.0%)	
5	Physical tools	6 (11.3%)	4 (18.2%)	1 (3.4%)	1 (50.0%)	
6	Printed/educational materials	13 (24.5%)	8 (36.4%)	5 (17.2%)	0 (0.0%)	
7	Duration (months)	Mean	Median	Standard deviation	Minimum–Maximum	
		39.3	11	62.1	0.5-228	

vaccination teams, substantially raising full immunisation coverage [27,28]. Educational interventions targeting caregivers have been shown to improve knowledge and awareness [29,30].

Health workforce

Continuous quality improvement interventions, including training, supportive supervision, and performance monitoring, enhance immunisation capacity [27]. Training on microplanning, data monitoring, and decentralised management has proven effective [31]. Community health worker deployment in underserved areas significantly improves outreach [26,32].

Health information systems

Data collection and defaulter tracking systems improve coverage monitoring [33]. Household mapping guided health worker assignments and outreach effectiveness [26]. Even basic paper registers for dropout recording have been proven functional [22].

Access and supply chain

Informed push models reduce stockouts and improve cold chain management [34]. Innovative delivery devices addressing cold chain challenges showed promise [28]. Ensuring that outreach teams-maintained vaccine stocks prevented delivery interruptions [22].

Financing

Standardised vaccination fees, free services, and incentives (food/medicine vouchers) addressed economic barriers and improved timely vaccination [22,35].

Leadership and governance

Decentralisation, microplanning, and performance-based agreements improved resource utilisation and accountability [31]. Interagency coordinating committees enhance program coordination and information sharing [36].

Multicomponent interventions

Comprehensive approaches that simultaneously address multiple building blocks have demonstrated superior effectiveness. Examples include The Bamako Initiative, which revitalises primary healthcare through integrated service delivery, workforce development, financing, and governance reforms [37], and community-based approaches that combine mobilisation, CHW training, household mapping, and service provision [26].

Barriers and facilitators

Implementation barriers included geographic challenges limiting rural access [38], limited caregiver knowledge requiring targeted education [29], insufficient healthcare worker capacity and poor service quality [27], financial constraints affecting implementers and recipients [39], weak health system infrastructure, including cold chain deficiencies [34], and technical/logistical issues in monitoring systems [27,31].

Vaccine uptake barriers included distance to facilities and transportation difficulties [32,38], knowledge gaps and misconceptions about vaccine safety [29,30], cultural beliefs and social norms influencing acceptance [40], poor service quality and healthcare

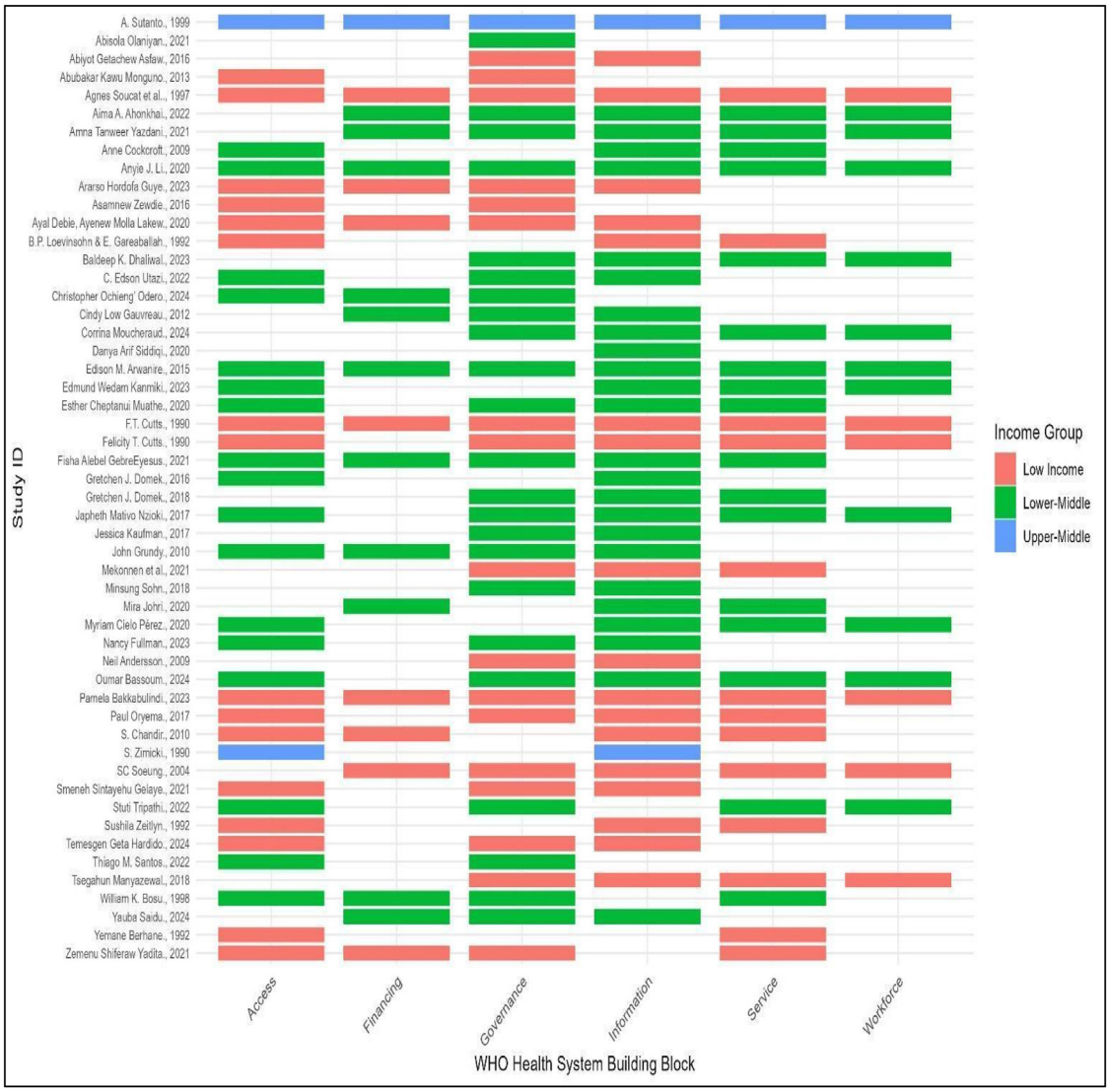

Figure 2. WHO health system's six building blocks by country income groups.

system distrust [22,24], and financial constraints preventing service access [35,39].

Key facilitators included community involvement and participation [26,41], educational interventions enhancing caregiver knowledge [29,30], healthcare worker capacity enhancement and service quality improvements [27,31], mobile services and outreach activities [22,28], financial incentives and cost-reduction strategies [22,35], improved infrastructure, supply chains, and coordination [31,34], and technological innovations, such as mobile reminders [23,28].

Discussion

This scoping review synthesised evidence from 53 studies across multiple LMICs, revealing significant insights into health system strengthening interventions for increasing childhood vaccination coverage. Service delivery interventions predominated (71.69% of studies), followed by information systems (75.5%) and governance (77.4%), suggesting that researchers and implementers focus primarily on direct service provision rather than on upstream determinants such as financing and governance structures.

The geographical concentration in sub-Saharan Africa, particularly Ethiopia, reflects the global burden of under-immunisation and the urgent need for evidence-based interventions. The predominance of community-based interventions (81.1%) underscores the recognition that effective vaccination strategies must extend beyond traditional health facilities to reach vulnerable populations. Most importantly, multicomponent interventions that simultaneously address multiple WHO building blocks have demonstrated superior effectiveness compared to single-component approaches, aligning with health systems thinking that emphasises interconnected components [22,37].

These findings align with the growing literature emphasising the importance of health system approaches. Previous reviews have identified community engagement, health worker training, and integrated service delivery as key components [17]. The prominence of reminder systems aligns with high-income country evidence demonstrating their effectiveness in improving vaccination timeliness [23,24]. Geographic barriers are well documented in the broader LMIC literature, with distance, transportation costs, and challenging terrain significantly impeding uptake [27,30]. The outreach strategies and mobile vaccination teams documented in this review provide practical solutions, building on decades of evidence supporting community-based delivery models.

Knowledge and information barriers reflect the broader health literacy challenges documented globally. Educational intervention

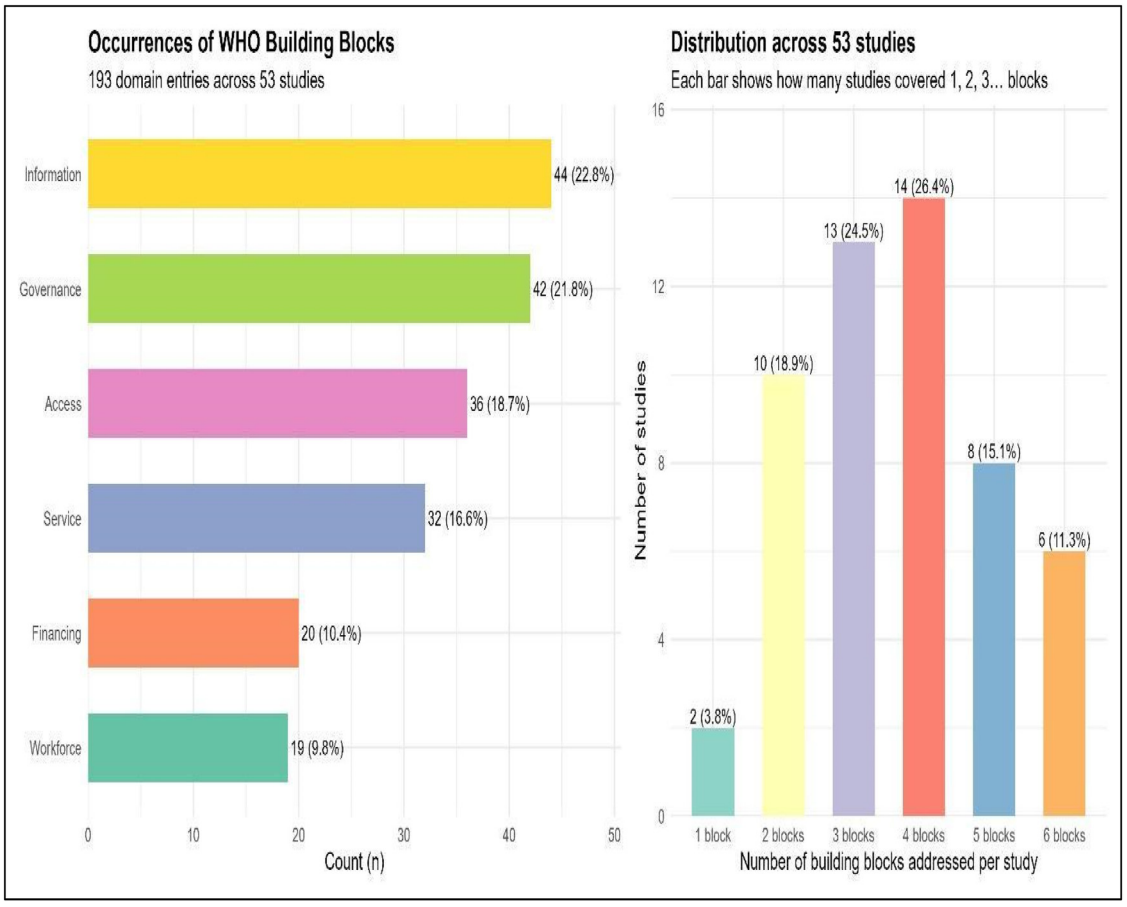

Figure 3. Occurrences of WHO building blocks and distribution across studies.

success aligns with social and behavioural change communication theories emphasising knowledge, attitudes, and social norms for sustained behavioural change [29]. Community leaders and trusted influencers roles support extensive research on innovation diffusion and social network theories. Economic barriers are consistent with extensive literature documenting the disproportionate impact of healthcare costs on poor households. The effectiveness of financial incentives and fee removal strategies supports the broader universal health coverage movement and elimination of financial barriers [35,37].

Evidence from high-burden countries demonstrates the practical impact of integrated approaches. In Ethiopia, the Reaching Every District using Quality Improvement (RED-QI) approach significantly improved vaccination coverage, with tetanus seroprotection increasing from 59.6% to 79.1% in intervention districts, alongside improvements in vaccination timeliness and fewer missed opportunities [42]. Between 2000 and 2019, Ethiopia's basic vaccination coverage progressed from 14.3% to 44.1% through health extension worker programmes and expanded primary healthcare services [43]. Similarly, Nigeria's implementation of the Global Polio Eradication Initiative contributed to a threefold increase in DPT3 coverage (from 21% to 66%) between 1989 and 2014, while geographic information system tracking of vaccination teams enabled identification and vaccination of previously missed settlements in northern states [44]. In Pakistan, the Lady Health Worker programme, encompassing over 100,000 community health workers, demonstrated that areas with active LHW coverage showed significantly better health indicators, with a randomised controlled trial showing that targeted pictorial educational messages delivered by community health workers improved DPT-3/Hepatitis B completion rates by 39% [45,46]. These national-level successes underscore the importance of context-specific, community-based approaches combined with systematic strengthening of the health workforce.

Implications and recommendations

Healthcare services should prioritise multicomponent interventions that simultaneously address multiple aspects of vaccination delivery systems. Facilities should establish robust reminder systems using both traditional (appointment cards) and innovative (SMS) approaches adapted to local contexts [23,24]. Comprehensive healthcare worker training programs should extend beyond technical skills to include communication, counselling, and community engagement competencies [27]. The integration of vaccination with other maternal-child health services should be systematised rather than isolated [22,38].

Communities should be engaged as active partners, rather than passive recipients. Evidence demonstrates that community mobilisation strategies are most effective when they involve local leaders, utilise existing social structures, and address community-specific barriers [25,26]. Community health worker programs should be strengthened and expanded, with ongoing training, supervision, and support to ensure quality and sustainability [26,32]. Communities should be supported in developing local vaccination barrier solutions, particularly regarding geographic access and social norms [37].

Policymakers should prioritise comprehensive immunisation policies that address all six WHO building blocks rather than individual components. Fragmented approaches are less effective than integrated strategies that simultaneously address service delivery,

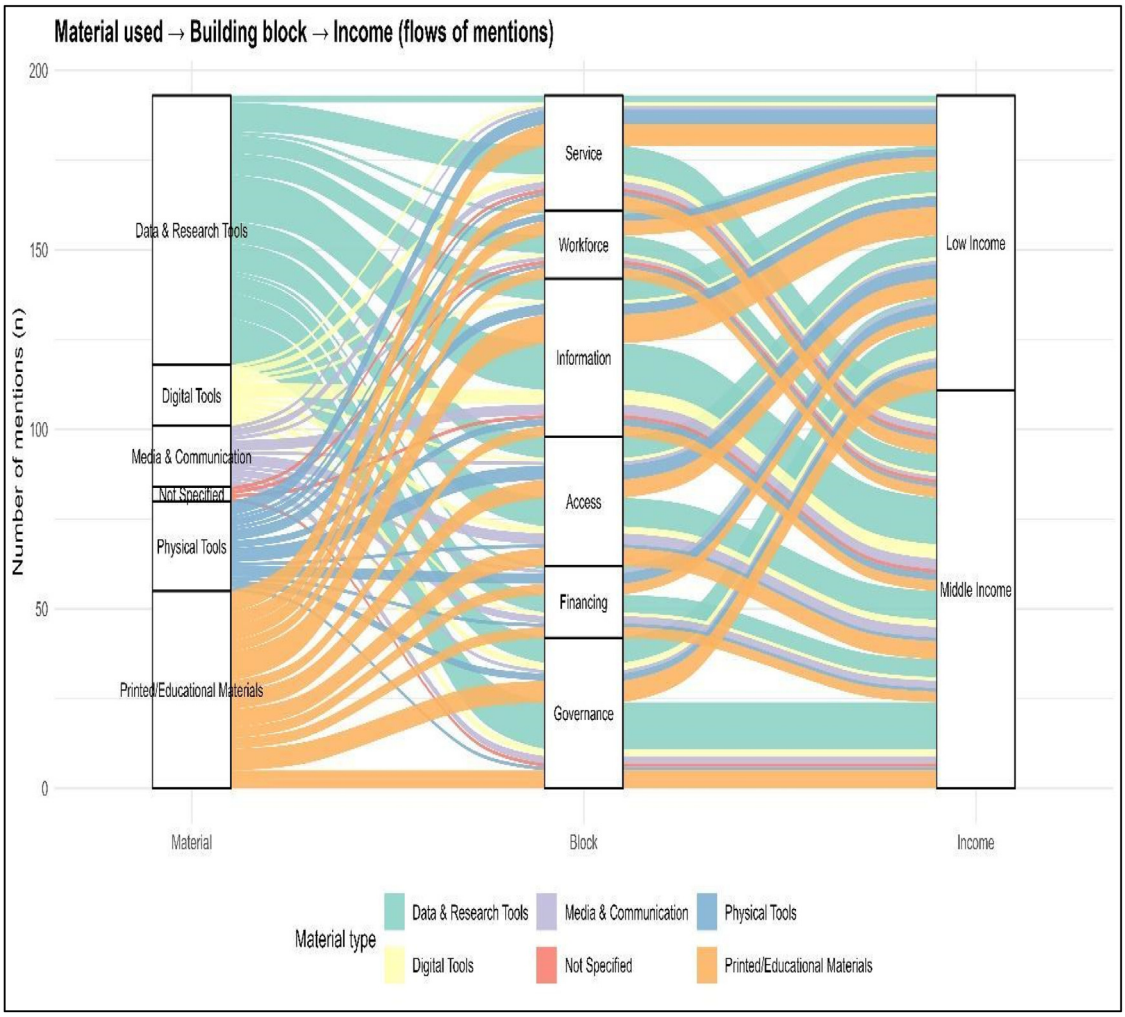

Figure 4. Sankey diagram illustrating the distribution of intervention materials (left) through WHO health system building blocks (centre) to country income classifications (right). Flow of intervention materials through WHO building blocks to country income classifications.

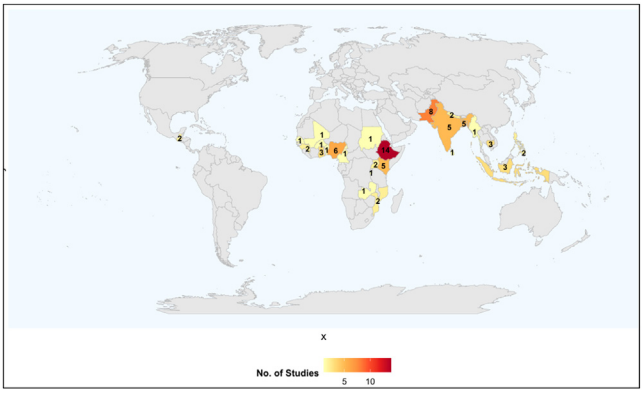

Figure 5. Map depicts the distribution of included studies. Numbers depict the number of studies per country.
The boundaries and designation shown on this map are software-generated and do not imply any positioning or expression of opinion by the authors or they are in situations regarding the legal status of any country, territory, city, or area, or the delimitation of its frontiers and boundaries.

workforce, information systems, access, financing, and governance. National programs should be designed and funded as comprehensive health system-strengthening initiatives. Governments should establish sustainable financing mechanisms that address both supply- and demand-side barriers [35,39]. National health information systems should support evidence-based decision-making by investing in infrastructure and regular feedback mechanisms [31].

Governance structures should ensure multisectoral coordination. Interagency coordinating committees provide models for multi-stakeholder coordination that are adaptable to different contexts [36]. Regulatory frameworks should support innovative delivery approaches, including digital technologies and alternative service delivery models [23,28]. Research priorities should focus on comprehensive multicomponent interventions and examine the cost-effectiveness of different health system strengthening approaches, particularly in underrepresented regions such as Latin America and parts of Asia.

These findings have important implications for global efforts to achieve universal vaccination coverage and Sustainable Development Goals. Evidence demonstrates that achieving high coverage in LMICs requires comprehensive health system strengthening rather than narrow disease-specific interventions. This suggests the need for greater integration and coordination among programs targeting different health outcomes. The emphasis on community-based approaches has implications for healthcare workforce planning, requiring significant community health worker program expansion. The success of technological innovations (mobile health interventions, innovative delivery devices, and digital tracking)

suggests that technology can address traditional barriers, although solutions must be contextually appropriate and implemented within comprehensive strengthening efforts.

Conclusion

This review identified diverse health system strengthening interventions that enhance vaccine uptake among children under 2 years of age in LMICs. Service delivery interventions were the most common, with reminder systems, community-based approaches, outreach services, and health education being prominent strategies. Multicomponent interventions addressing multiple WHO building blocks simultaneously showed the most substantial improvements. Significant barriers include geographic access challenges, knowledge gaps, service quality issues, economic constraints, and health system weaknesses. Facilitators included community engagement, education, service quality improvements, accessibility enhancements, financial support, health system strengthening, and technological innovations. Context-specific integrated approaches that simultaneously address multiple health system components are essential. Strengthening workforce capacity, integrated systems, and addressing financing barriers remain vital for achieving global immunisation goals. Future research should focus on developing and evaluating comprehensive interventions, particularly in regions with persistent immunisation challenges.

Limitations

This scoping review has several limitations that should be considered when interpreting its findings. First, the review was restricted to English-language publications, which may have excluded relevant studies published in other languages, particularly from francophone African and Spanish-speaking Latin American countries, where significant immunisation research exists. Second, as a scoping review following the PRISMA-ScR guidelines, we did not conduct a formal quality assessment of the included studies, which is consistent with the scoping review methodology but limits our ability to assess the strength of evidence. Third, the predominance of studies from sub-Saharan Africa, particularly Ethiopia, may limit the generalisability of findings to other LMIC regions such as Latin America and parts of Asia, where fewer studies were identified. Finally, the classification of interventions under the WHO building blocks involved subjective judgment, as many interventions addressed multiple components simultaneously. Although two reviewers independently classified the data with consensus resolution, some degree of misclassification may have occurred.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This scoping review was not funded by any source.

Ethics statement

Ethical approval was not required for this scoping review.

Acknowledgements

This review forms the basis for a qualitative study in Khyber Pakhtunkhwa, Pakistan, engaging EPI stakeholders and community members to explore childhood immunisation barriers and facilitators, and integrating evidence with local insights to develop practical, context-specific strategies.

Author contributions

Muhammad Hakim: Conceptualisation, Title and abstract screening, full text review, descriptive analysis, Manuscript writing.

Saima Afaq: Supervision, manuscript writing and manuscript revision.

Bilal Ahmad Khan: Title and abstract screening, full text review, narrative synthesis, manuscript writing.

Sara Imtiaz: Title and abstract screening, full text review, manuscript writing.

Farhad Ali: Supervision, Descriptive analysis.

Zia ul Haq: Supervision, Manuscript revision.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijid.2026.108376.

References

[1] World Health Organization Vaccines and immunization. 2024 [accessed 5 April 2025]. Available: https://www.who.int/health-topics/vaccines-and-immunization.

[2] CDC. Fast facts on*Global immunization*; 2025. [accessed 5 July 2025]Available: *https://www.cdc.gov/global-immunization/fast-facts/index.html* .

[3] World Health Organization Immunization coverage. 2024 [accessed 5 April 2025]. Available: https://www.who.int/news-room/fact-sheets/detail/immunization-coverage.

[4] Unicef *Global childhood immunization levels stalled in 2023 leaving many without life-saving protection*; 2024. [accessed 27 August 2025]. Available: *https://www.unicef.org/press-releases/global-childhood-immunization-levels-stalled-2023-leaving-many-without-life-saving*.

[5] The value of Immunization compendium of Evidence *The Value of Vaccines: Investments in Immunization Yield High Returns by VoICE*; 2021. [accessed 1 November 2025]. Available: *https://immunizationevidence.org/the-value-of-vaccines-investments-in-immunization-yield-high-returns/*.

[6] O'Brien KL, Lemango E, Nandy R, Lindstrand A. The immunization Agenda 2030: a vision of global impact, reaching all, grounded in the realities of a changing world. *Vaccine* 2024;**42**(Suppl 1):S1–4. doi:10.1016/j.vaccine.2022.02.073.

[7] Simas C, Larson HJ. Overcoming vaccine hesitancy in low-income and middle-income regions. *Nat Rev Dis Primers* 2021;**7**:41. doi:10.1038/s41572-021-00279-w.

[8] Solís Arce JS, Warren SS, Meriggi NF, Scacco A, McMurry N, Voors M, et al. COVID-19 vaccine acceptance and hesitancy in low- and middle-income countries. *Nat Med* 2021;**27**:1385–94. doi:10.1038/s41591-021-01454-y.

[9] Guignard A, Praet N, Jusot V, Bakker M, Baril L. Introducing new vaccines in low- and middle-income countries: challenges and approaches. *Expert Rev Vaccines* 2019;**18**:119–31. doi:10.1080/14760584.2019.1574224.

[10] Choudhary TS, Reddy NS, Apte A, Sinha B, Roy S, Nair NP, et al. Delayed vaccination and its predictors among children under 2 years in India: insights from the national family health survey-4. *Vaccine* 2019;**37**:2331–9. doi:10.1016/j.vaccine.2019.03.039.

[11] Li Y, Li J, Tucker JD, Geng EH, Wu D. Pay-it-forward as a strategy to increase vaccine uptake. *BMC Glob Public Health* 2025;**3**:32. doi:10.1186/s44263-025-00151-z.

[12] Stratton K, Almario D, Mccormick MC. Institute of Medicine (US) Immunization Safety Review Committee. *Immunization safety review: hepatitis B vaccine and demyelinating neurological disorders*. Washington (DC): National Academies Press (US); 2002.

[13] World Health Organization *Monitoring the building blocks of health systems*. Geneva: WHO; 2010.

[14] Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;**169**:467–73. doi:10.7326/M18-0850.

[15] Ali F, Afaq S, Hakim M, Khan BA, Haq ZU, Imtiaz S. Strategies for enhancing vaccine uptake among children under two years age in low- and middle-income countries (LMICs): a scoping review protocol. *OSF* 2025. doi:10.17605/OSF.IO/M3WUK.

[16] Haddaway NR, Collins AM, Coughlin D, Kirk S. The role of Google Scholar in evidence reviews and its applicability to grey literature searching. *PLoS One* 2015;**10**:e0138237. doi:10.1371/journal.pone.0138237.

[17] Jain M, Shisler S, Lane C, Bagai A, Brown E, Engelbert M. Use of community engagement interventions to improve child immunisation in low-income and middle-income countries: a systematic review and meta-analysis. *BMJ Open* 2022;**12**:e061568. doi:10.1136/bmjopen-2022-061568.

[18] LMIC filters. LMIC Filters by Cochrane Effective Practice and Organisation of Care (EPOC). [accessed 1 November 2025] https://epoc.cochrane.org/lmic-filters.

[19] Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. *Syst Rev* 2016;**5**:210. doi:10.1186/s13643-016-0384-4.

[20] Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. *BMJ* 2020;**368**:l6890. doi:10.1136/bmj.l6890.

[21] Ahonkhai AA, Odusanya OO, Meurice FP, Pierce LJ, Durojaiye TO, Alufohai EF, et al. Lessons for strengthening childhood immunization in low-and middle-income countries from a successful public-private partnership in rural Nigeria. *Int Health* 2022;**14**:632–8.

[22] Cutts FT, Glik DC, Gordon A, Parker K, Diallo S, Haba F, et al. Application of multiple methods to study the immunization programme in an urban area of Guinea. *Bull World Health Organ* 1990;**68**:769–76. https://www.ncbi.nlm.nih.gov/pubmed/2073715.

[23] Mekonnen ZA, Gelaye KA, Were MC, Tilahun B. Acceptability, barriers and facilitators of mobile text message reminder system implementation in improving child vaccination: a qualitative study in northwest Ethiopia. *J Multidiscip Healthc* 2021;**14**:605–16. doi:10.2147/JMDH.S298167.

[24] Domek GJ, Contreras-Roldan IL, O'Leary ST, Bull S, Furniss A, Kempe A, et al. SMS text message reminders to improve infant vaccination coverage in Guatemala: a pilot randomized controlled trial. *Vaccine* 2016;**34**:2437–43. doi:10.1016/j.vaccine.2016.03.065.

[25] Tripathi S, Jain M, Bagai A, Rao KV. Designing appropriate, acceptable and feasible community-engagement approaches to improve routine immunisation outcomes in low-and middle-income countries: a synthesis of 3ie-supported formative evaluations. *PLoS one* 2022;**17**(10):e0275278.

[26] Nzioki JM, Ouma J, Ombaka JH, Onyango RO. Community health worker interventions are key to optimal infant immunization coverage, evidence from a pretest-posttest experiment in Mwingi, Kenya. *Pan Afr Med J* 2017;**28**:21. doi:10.11604/pamj.2017.28.21.11255.

[27] Manyazewal T, Mekonnen A, Demelew T, Mengestu S, Abdu Y, Mammo D, et al. Improving immunization capacity in Ethiopia through continuous quality improvement interventions: a prospective quasi-experimental study. *Infect Dis Poverty* 2018;**7**:119. doi:10.1186/s40249-018-0502-8.

[28] Sutanto A, Suarnawa IM, Nelson CM, Stewart T, Soewarso TI. Home delivery of heat-stable vaccines in Indonesia: outreach immunization with a prefilled, single-use injection device. *Bull World Health Organ* 1999;**77**:119–26. https://www.ncbi.nlm.nih.gov/pubmed/10083709.

[29] Zeitlyn S, Rahman AK, Nielsen BH, Gomes M, Kofoed PE, Mahalanabis D. Compliance with diphtheria, tetanus, and pertussis immunisation in Bangladesh: factors identifying high risk groups. *BMJ* 1992;**304**:606–9. doi:10.1136/bmj.304.6827.606.

[30] GebreEyesus FA, Tarekegn TT, Amlak BT, Shiferaw BZ, Emeria MS, Geleta OT, et al. Knowledge, attitude, and practices of parents about immunization of infants and its associated factors in Wadla Woreda, North East Ethiopia, 2019. *Pediatric Health Med Ther* 2021;**12**:223–38. doi:10.2147/PHMT.S295378.

[31] Soeung S, Grundy J, Biggs B, Boreland M, Cane J, Samnang C, et al. Management systems response to improving immunization coverage in developing countries: a case study from Cambodia. *Rural Remote Health* 2004;**4**:263. doi:10.22605/rrh263.

[32] Kanmiki EW, Mamun AA, Phillips JF, O'Flaherty M. Impact of a community-based primary healthcare programme on childhood diphtheria-tetanus-pertussis (DPT3) immunisation coverage in rural northern Ghana. *Res Health Serv Reg* 2023;**2**:18. doi:10.1007/s43999-023-00032-8.

[33] Bakkabulindi P, Ampeire I, Ayebale L, Mubiri P, Feletto M, Muhumuza S. Engagement of community health workers to improve immunization coverage through addressing inequities and enhancing data quality and use is a feasible and effective approach: an implementation study in Uganda. *PLoS One* 2023;**18**:e0292053. doi:10.1371/journal.pone.0292053.

[34] Bakkabulindi P, Wafula ST, Ssebagereka A, Sekibira R, Mutebi A, Ameny J, et al. Improving the last mile delivery of vaccines through an informed push model: experiences, opportunities and costs based on an implementation study in a rural district in Uganda. *PLoS Glob Public Health* 2024;**4**:e0002647. doi:10.1371/journal.pgph.0002647.

[35] Chandir S, Khan AJ, Hussain H, Usman HR, Khowaja S, Halsey NA, et al. Effect of food coupon incentives on timely completion of DTP immunization series in children from a low-income area in Karachi, Pakistan: a longitudinal intervention study. *Vaccine* 2010;**28**:3473–8. doi:10.1016/j.vaccine.2010.02.061.

[36] Grundy J. Country-level governance of global health initiatives: an evaluation of immunization coordination mechanisms in five countries of Asia. *Health Policy Plan* 2010;**25**:186–96. doi:10.1093/heapol/czp047.

[37] Soucat A, Levy-Bruhl D, de Bethune X, Gbedonou P, Lamarque J-P, Bangoura O, et al. Affordability, cost-effectiveness and efficiency of primary health care: the Bamako Initiative experience in Benin and Guinea. *Int J Health Plann Manage* 1997;**12**:S81–S108 12:1+<s81::aid-hpm467>3.3.co;2-x. doi:10.1002/(sici)1099-1751(199706).

[38] Ahonkhai AA, Odusanya OO, Meurice FP, Pierce LJ, Durojaiye TO, Alufohai EF. Lessons for strengthening childhood immunization in LMICs from a successful public-private partnership in rural Nigeria. *Int Health* 2022;**14**:632–8.

[39] Saidu Y, Ngenge BM, Nchinjoh SC, Amani A, Edwidge NN, Muteh NJ, et al. Navigating vaccine procurement and financing challenges in Cameroon: insights and recommendations from a mixed-methods study (2015-2020). *Public Health* 2024;**237**:261–9. doi:10.1016/j.puhe.2024.10.001.

[40] Cockcroft A, Andersson N, Omer K, Ansari NM, Khan A, Chaudhry UU, et al. One size does not fit all: local determinants of measles vaccination in four districts of Pakistan. *BMC Int Health Hum Rights* 2009;**9**(Suppl 1):S4. doi:10.1186/1472-698X-9-S1-S4.

[41] Tripathi S, Jain M, Bagai A, Rao KV. Designing appropriate, acceptable and feasible community-engagement approaches to improve routine immunisation outcomes in LMICs: a synthesis of 3ie-supported formative evaluations. *PLoS One* 2022;**17**:e0275278.

[42] Campbell JD, Pasetti MF, Oot L, Adam Z, Tefera M, Beyane B, et al. Linked vaccination coverage surveys plus serosurveys among Ethiopian toddlers undertaken three years apart to compare coverage and serologic evidence of protection in districts implementing the RED-QI approach. *Vaccine* 2021;**39**:5802–13. doi:10.1016/j.vaccine.2021.08.071.

[43] Nigatu T, Abraham L, Willems H, Tilaye M, Tiruneh F, Gebru F, et al. The status of immunization program and challenges in Ethiopia: a mixed method study. *SAGE Open Med* 2024;**12**:20503121241237116. doi:10.1177/20503121241237115.

[44] Touray K, Mkanda P, Tegegn SG, Nsubuga P, Erbeto TB, Banda R, et al. Tracking vaccination teams during polio campaigns in northern Nigeria by use of geographic information system technology: 2013-2015. *J Infect Dis* 2016;**213**(Suppl 3):S67–72. doi:10.1093/infdis/jiv493.

[45] Zaidi S, Shaikh SA, Sayani S, Kazi AM, Khoja A, Hussain SS. Effective role of lady health workers in immunization of children in Pakistan. *Pak J Med Sci* 2017;**33**:156–60. doi:10.12669/pjms.331.11424.

[46] Owais A, Hanif B, Siddiqui AR, Agha A, Zaidi AKM. Does improving maternal knowledge of vaccines impact infant immunization rates? A community-based randomized-controlled trial in Karachi, Pakistan. *BMC Public Health* 2011;**11**:239. doi:10.1186/1471-2458-11-239.