

SUPPLEMENTAL STRATEGIES TO REACH ZERO-DOSE CHILDREN

JULY 2022

Scoping Review

SUMMARY REPORT TO GAVI, ON BEHALF OF THE ZAMBIA
EVALUATION & RESEARCH OF 0-DOSE (ZERO-D) PROJECT



SCOPING REVIEW SUMMARY REPORT

SUPPLEMENTAL IMMUNIZATION STRATEGIES TO REACH ZERO-DOSE CHILDREN

BACKGROUND

Nationwide, non-selective measles campaigns are resource-intensive strategies that aim to vaccinate children regardless of prior vaccination or disease status—as a result, many children receive duplicate doses of MCV. New approaches are being explored to better reach high priority populations and improve efficiency by focusing on reaching unvaccinated, "zero-dose" children.

Supplemental delivery strategies tailored to identify and fill immunity gaps could present efficient, effective ways to reach zero-dose children. There is a critical need to strengthen the confidence of decision makers to weigh alternatives to non-selective, nationwide SIAs and identify supplemental delivery strategies to reach measles zero-dose children. Understanding the success, extent, and scope of these strategies where they have been implemented is instrumental in developing more efficient, effective vaccination strategies to fill immunity gaps and reduce measles disease burden.

APPROACH

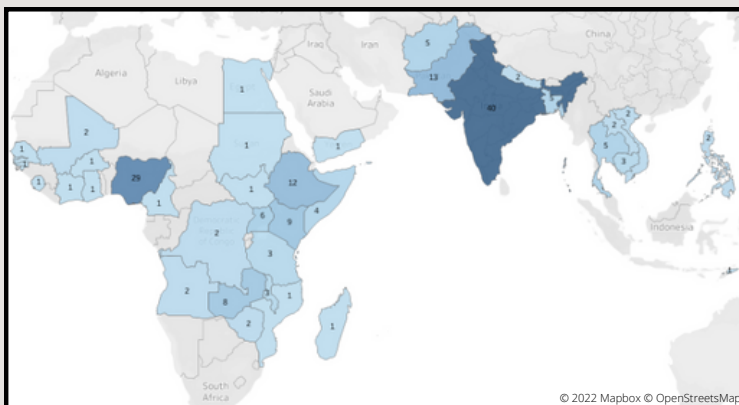
We conducted a scoping review of supplemental strategies used to reach zero-dose children, which will inform future data collection and program and policy decisions amongst decision makers to understand what is needed for countries to consider alternate strategies to supplement or replace nationwide non-selective SIAs. We limited our review to literature describing interventions for measles-rubella vaccination, polio vaccination, and those addressing the expanded program on immunization (EPI) as a whole; interventions that focused on the "reach" component of the Identify-Reach-Measure-Monitor-Advocacy (IRMMA) framework; and interventions in low-income or lower-middle-income countries.

We identified 9,450 titles through our search strategy. We conducted title/abstract screening of 8,239 articles, full text screening of 2,451 articles, and data extraction for 256 articles. A total of 190 articles were included in our final analytic set, and are described in the full report and menu of supplemental strategies to reach zero-dose children.

RESEARCH QUESTIONS

What supplemental strategies have been used to reach children who are zero-dose (unvaccinated) and under-vaccinated (receiving less than the full immunization schedule) in low- and middle-income countries?

How were these supplemental strategies tailored to their populations of interest?



GEOGRAPHIC DISTRIBUTION OF INCLUDED STUDIES

The most common countries referenced among the 190 included studies were India (43), Nigeria (30), and Pakistan (11)—countries that had both high numbers of zero-dose children and circulating poliovirus during the period included in our review.

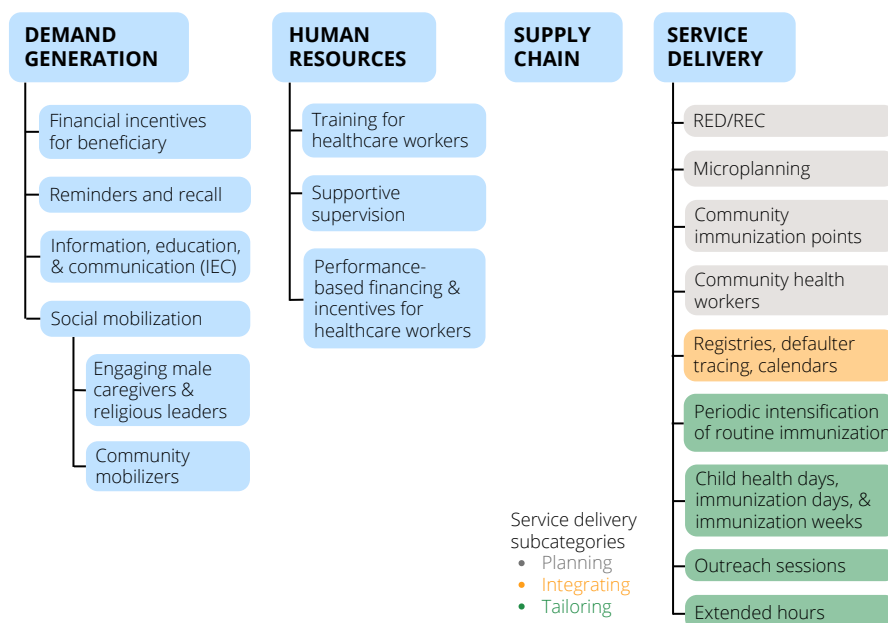
SCOPING REVIEW SUMMARY REPORT

SUPPLEMENTAL IMMUNIZATION STRATEGIES TO REACH ZERO-DOSE CHILDREN

FINDINGS

Based on the IRMMA framework, we classified supplemental strategies into four categories—demand generation, human resources, supply chain, and service delivery. Within service delivery strategies, we applied sub-categories for planning, integrating, or tailoring. Many strategies described in the included studies are enhancements to the routine immunization program that aim to improve coverage; in some settings, these strategies are already standard components of the routine immunization program, offering lessons to other settings on how to integrate new strategies into ongoing program activities.

Selecting which supplemental strategies to implement—and how effective different strategies are in improving immunization coverage—is heavily context-specific.



DEMAND GENERATION



- *Reminders and recall systems* and *community mobilizers* have been used in many different countries and settings, and seem to be positively impacting vaccination coverage where they are implemented.

SERVICE DELIVERY



- Tailoring through *community immunization points* at schools and transit points, *outreach sessions*, and *extended hours* could expand more opportunities for reaching un- and under-vaccinated children.
- Supporting and amplifying *RED/REC* and *microplanning* could help bridge implementation barriers and facilitate targeted, tailored strategies through enhanced planning.

CROSS-CUTTING



- Strategic *funding* could help expand and enhance service delivery and demand generation and help stem the need for vaccination campaigns.
- *Integrating* multiple components, and *tailoring* to the appropriate local context, offers an opportunity to maximize reach and impact.
- *Evaluating* which strategies are most effective in which contexts and understanding how decision makers, health workers, and caregivers perceive these interventions are key areas needing further research.

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INTRODUCTION

Many countries use nationwide non-selective supplementary immunization activities (SIAs) as the primary strategy to close measles and rubella immunity gaps. The World Health Organization (WHO) measles vaccine position paper recommends that countries conduct periodic SIAs until routine immunization coverage with two doses of measles-containing vaccine is >90% for three consecutive years [1]. However, SIAs are resource-intensive, nationwide campaigns that provide vaccines to children within a specified age range regardless of prior vaccination or disease status [2]. Often a large proportion of children reached by these campaigns have previously received at least one or two doses of MCV [3].

New approaches are being sought to improve reach to the highest priority populations for vaccination and/or improve the use of resources employed during vaccination programs. These supplemental strategies do not aim to vaccinate all eligible children nationwide, but instead focus on vaccinating measles zero-dose children. For the purposes of this review, we define zero-dose children as those who have never received a single dose of any vaccine.

In countries with high performing vaccination programs, supplemental delivery strategies tailored to identify and fill immunity gaps could be a more efficient and effective way to reach zero-dose children [4]. Additionally, policy makers need to be comfortable and confident in choosing to shift from non-selective, nationwide SIAs to other supplemental delivery strategies to reach measles zero-dose children. Understanding the success, extent, and scope of these strategies is instrumental in developing more efficient and effective vaccination programs to fill immunity gaps. However, the evidence base for countries to draw upon when operationalizing funding policies is currently lacking.

OBJECTIVES

In consideration of this, we conducted a scoping review of supplemental strategies used to reach zero-dose children, which will inform future data collection and program and policy decisions amongst decision makers to understand what is needed for countries to move away from nationwide non-selective SIAs.

Our aims were two-fold: to assess what supplemental strategies have been used to reach zero-dose/unvaccinated or under-vaccinated children in low- and middle-income countries (LMIC), and to understand how these strategies were used and tailored to populations of interest.

This scoping review aims to address the following questions:

- 1** What supplemental strategies have been used to reach children who are zero-dose (unvaccinated) and under-vaccinated (receiving less than the full immunization schedule) in low- and middle-income countries?
- 2** How were these supplemental strategies tailored to their populations of interest?

METHODS + APPROACH

We conducted a scoping review to explore enhanced and supplemental strategies being used in countries as alternatives to nation-wide, non-selective SIAs. We first identified relevant literature for review, then conducted title and abstract screening, full-text screening, data extraction, and evidence synthesis.

LITERATURE SEARCH. We searched PubMed, World Wide Science, and Scopus. We also conducted targeted gray literature searches through WHO regional databases, WHO IRIS, and JSI. Our search terms were related to child immunization in LMIC.

INCLUSION AND EXCLUSION CRITERIA. We included papers that identified or characterized un/under-vaccinated children and described tailored strategies to reach them. Key information in this report was abstracted from the final set of papers, with validation of 10% of included papers. We refined our exclusion criteria to limit the scope of this review and focus on interventions most relevant for measles vaccination strategies. We limited our review to literature describing interventions for measles-rubella vaccination, polio vaccination, and those addressing the expanded program on immunization (EPI) as a whole; interventions that focused on the “reach” component of the Identify-Reach-Measure-Monitor-Advocacy (IRMMA) framework; and interventions in low-income or lower-middle-income countries.

About the IRMMA Framework

The IRMMA framework for zero-dose children has the following core components to support sustainable, tailored interventions:

Identify — who, where, why, and how many zero dose children exist

Reach — flexible, integrated approaches to address supply and demand side barriers

Monitor and Measure — real-time monitoring and outcome measurement

Advocacy — using evidence to make a case for political attention and resources

Learn more through [Gavi's Zero Dose Funding Guidelines](#).

METHODS + APPROACH

DATA EXTRACTION. Data were extracted from the final list of studies per the data extraction template (Annex 3), which was iteratively refined based on key references and consultation with experts, and as new categories emerged. Data extraction was completed by one reviewer, and 10% of data extraction was validated by a study team member. We iteratively coded, classified, and analyzed extracted data; preliminary groupings were established in consultation with expert reviewers and project leadership.

Navigating concurrent, complementary scoping reviews

Over the course of this review, we learned of a concurrent review led by the WHO on measles and rubella campaign customization [5]. This review explores both non-selective nationwide vaccination campaigns and tailored and targeted vaccination campaigns. To prevent duplication and complement the WHO review by Bhatnagar and colleagues, thus broadening the range of supplemental strategies that can be used to vaccinate children, we excluded literature and materials that exclusively describe vaccination campaigns. We included national immunization days, child health days, and other campaign-like activities that were excluded from the WHO-led review.

SUMMARY OF FINDINGS

LITERATURE REVIEW RESULTS

We identified a total of 9,450 titles through our search strategy. After excluding duplicates, we screened the titles and abstracts of 8,239 studies based on our established inclusion and exclusion criteria (Annex 1). We screened the full text of 2,451 articles and extracted data from 256 of these (Figure 1).

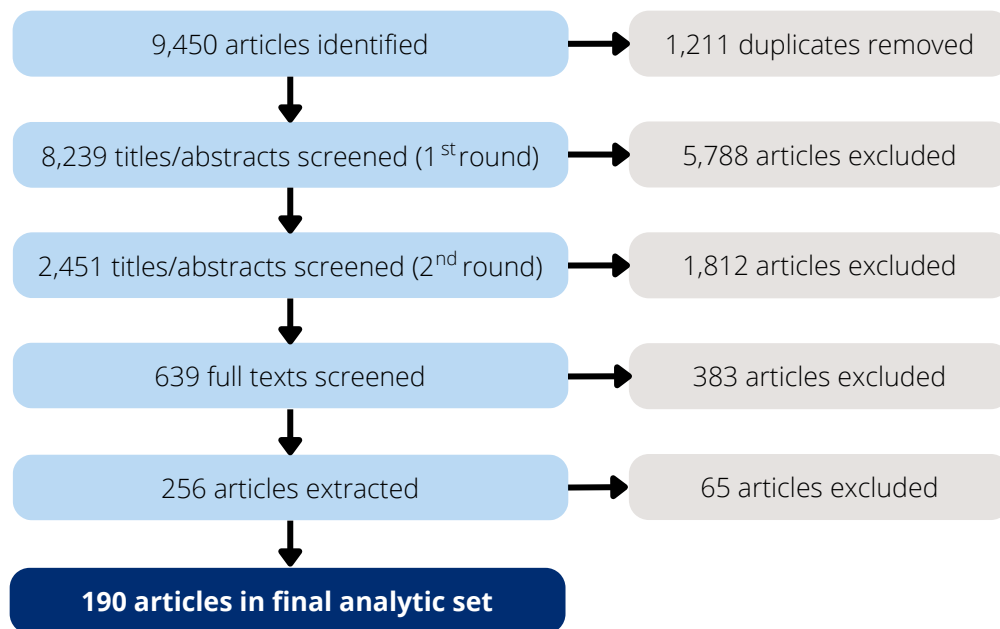


FIGURE 1. CONSORT flow diagram

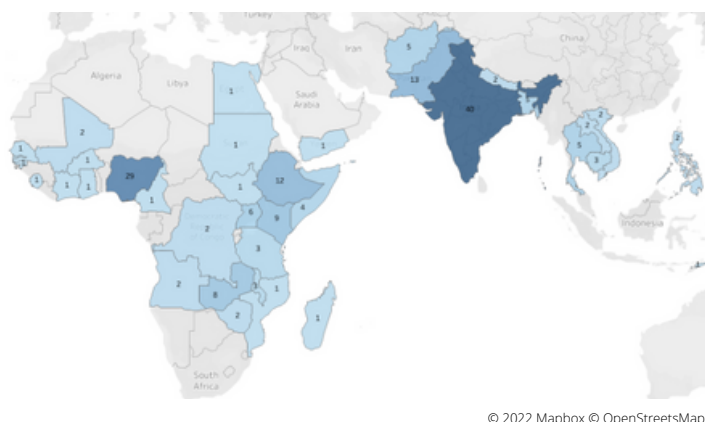
NATURE, SIZE, AND SCOPE OF INCLUDED LITERATURE

We categorized the publications included in our analytic sample by region, intervention implementation level, target population, funder, factors addressed, economic considerations, and tailoring approach. Publications were double counted when they addressed multiple factors, so the total number of articles in each table does not necessarily equal 190, the size of our analytic sample. Percent of articles is also provided for each subcategory; however, the total percent will sum to over 100 when double counted as described previously.

SUMMARY OF FINDINGS

Articles by geography

We extracted information on the WHO region in which interventions were implemented, aligning where possible and appropriate with WHO regions. The most common countries referenced were India (43), Nigeria (30), and Pakistan (11), countries that had both high numbers of zero-dose children and circulating poliovirus during the period included in our review.



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FIGURE 2. Articles by geographic region

TABLE 1. Number of included articles by geographic region

Geographic scope	Number of articles	Percent of articles
WHO Africa Region (AFRO)	86	45%
WHO South-East Asia Region (SEARO)	55	29%
WHO Eastern Mediterranean Region (EMRO)	23	12%
WHO Western Pacific Region (WPRO)	8	4%
LMIC (broadly)	9	5%
Global	11	6%
No geographic area/region indicated	2	1%

SUMMARY OF FINDINGS

Articles by intervention level

Intervention level indicates the setting or administrative level in which implementation was concentrated. After originally extracting these data from included studies using the administrative level only, we subsequently recoded to provide additional detail for both administrative/government setting and other settings, as shown in Table 2.

TABLE 2. Number of included articles by intervention level

Intervention level	Number of articles	Percent of articles
Regional/multi-national	6	3%
National	22	12%
Province/state	26	14%
District	51	27%
Sub-district	17	9%
Village or community	14	7%
Health facility	11	6%
School	2	1%
Border	3	2%
Other (humanitarian, individual, transit, congregation, etc.)	5	3%
Multiple or varied	24	13%
No level indicated	9	5%

Articles by population

In Table 3 we describe the target population of intervention among the included articles. Many studies (n=64) targeted multiple populations, including 20 that focused on children and caregivers. Included in the “other” category are migrants, nomadic populations, urban slum populations, and security-inaccessible areas.

SUMMARY OF FINDINGS

TABLE 3. Number of included articles by population

Target population	Number of articles	Percent of articles
Children	76	40%
Women	30	16%
Caregivers	19	10%
Children and caregivers	20	11%
Healthcare workers	23	12%
General population	12	6%
Populations in a specific geographic area	8	4%
Other	24	13%
No population listed	11	6%

Articles by funder

The funders described in Table 4 provided financial support for the study or intervention. Many studies (n=71) did not list a funder and 69 indicated multiple funders. For those that did report a funder, we categorized the listed entities as bilateral, philanthropic, international non-governmental organization (INGO), government, civil society organization (CSO), or other.

TABLE 4. Number of included articles by funder

Funder type	Number of articles	Percent of articles
Bilateral agency/organization	41	22%
Philanthropic	36	19%
International NGO	33	17%
Government	17	9%
CSO	3	2%
Other	24	13%
No funder listed	71	37%

SUMMARY OF FINDINGS

Articles by IRMMA factors addressed

We additionally categorized each study intervention by the factors it addresses, drawn from the IRMMA framework and related resources (Table 5). Interventions classified as “other” included integration of services, logistics support, planning, service provision, and micro-costing. In 127 articles, interventions were described as addressing multiple factors. Delivery and demand were the most common factors addressed, signaling a potential focus and interest on interventions addressing these factors.

TABLE 5. Number of included articles by IRMMA factor addressed

IRMMA factors	Number of articles	Percent of articles
Delivery of services	132	69%
Demand generation	123	65%
Human resources	68	36%
Identifying children	57	30%
Monitoring and evaluation	31	16%
Supply chain	25	13%
Other	9	5%
None listed	5	3%

Articles by economic considerations described

Table 6 describes the economic or cost-related considerations of the interventions captured in these publications. These considerations often centered around cost effectiveness, unanticipated costs, necessary costs, or cost-savings. We categorized these considerations as supply-side costs: human resources, intervention costs, supply chain and other supply side costs. Demand-side costs included: incentives for participants and other demand side costs. The most described cost was related to human resources, indicating additional considerations related to training, salaries, and incentives for healthcare workers.

SUMMARY OF FINDINGS

TABLE 6. Number of included articles by economic considerations addressed

Economic considerations	Number of articles	Percent of articles
Supply side	43	23%
Human resources	19	10%
Intervention costs	8	4%
Supply chain	3	2%
Other supply-side costs	13	7%
Demand side	12	6%
Incentives	9	5%
Other demand-side costs	3	2%
Overall costs	16	8%
Funding gaps	7	4%
Cost-effectiveness	8	4%
Multiple	1	0.5%
No costs listed (n/a)	120	63%

Articles by tailoring approach

Table 7 categorizes articles by tailoring approach, which describes how an intervention is targeted when implemented in different settings. Traditionally, MCV is administered to all eligible children in the target age group during SIAs, irrespective of their previous measles vaccination status or other characteristics. The review by Bhatnagar et al. [5] identified different mechanisms by which campaigns and other interventions could be customized so they focused on better reaching unvaccinated populations. We used the same categorization of tailoring approaches to classify the interventions identified.

SUMMARY OF FINDINGS

Tailoring approaches include program characteristics (e.g. health system infrastructure, vaccination coverage, history of SIAs, etc.); population (e.g. socially or economically disadvantaged populations, mobile populations, etc.); geography (e.g. outbreak location, hard-to-reach populations, disaster/conflict areas, etc.); epidemiology (e.g. based on measles surveillance, susceptible age groups, etc.); previous vaccination status (e.g. using home-based records or verbal recall, etc.); other; and none. Articles often had multiple tailoring approaches, most commonly tailoring by program characteristics.

TABLE 7. Number of included articles by tailoring approach

Tailoring approach	Number of articles	Percent of articles
Program characteristics	101	53%
Population	86	45%
Geography	75	39%
Epidemiology	40	21%
Previous vaccination status	34	18%
Other	15	8%
None listed	15	8%

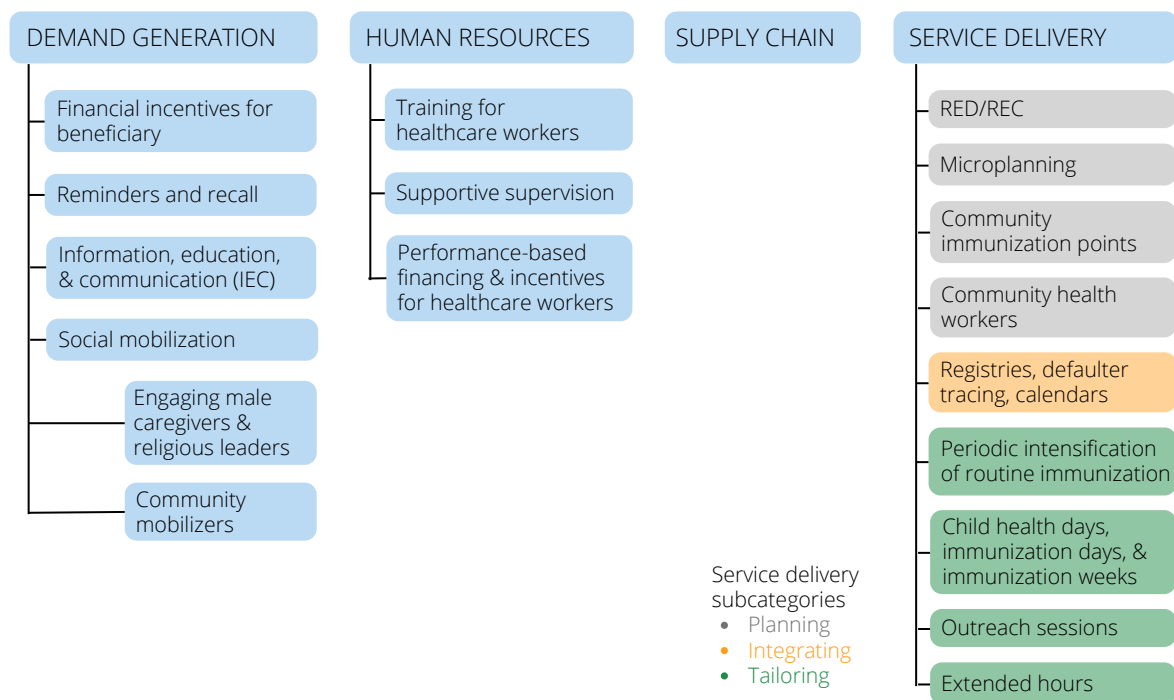
Supplemental strategies identified in the literature

In Annex 4, we list all supplemental strategies identified in this review. We briefly describe the classification of each intervention, where it was implemented, what outcomes were measured to track success, and any contextual considerations for that strategy. Interventions are organized based on the IRMMA framework topic mapping for zero-dose children [6]: demand, human resources, supply chain, service delivery. We did not identify interventions in monitoring and assessment or governance.

SUPPLEMENTAL STRATEGIES

We describe here the interventions identified through the scoping review, organizing each by its relevant IRMMA framework categorization (Figure 3). Importantly, several interventions frequently appear together in the literature—for example, RED/REC and microplanning—as they are often part of a comprehensive strategy to identify and reach zero-dose children. Where possible, we identify those links in each respective section; however, we aim to avoid duplicate information in our summaries below so not all articles are indicated in multiple sections where such crossover occurs in the study's interventions.

FIGURE 3. Mapping of supplemental strategies



SUPPLEMENTAL STRATEGIES

DEMAND GENERATION

Demand-side interventions included financial incentives for beneficiaries; reminders and recall for caregivers when vaccinations are due; and information, education and communication interventions to provide information to caregivers. Of the 46 articles identified, more than half included reminders and recall systems. Providing information and education to caregivers was the intervention that seemed successful in all contexts.

Financial incentives for beneficiary

A variety of financial incentives have been used in LMICs to improve vaccine uptake including conditional and unconditional cash transfers, microcredit, and voucher programs in the 10 studies included in our analysis. Bassani et al. [7] provided a systematic review and meta-analysis that found little or no evidence of a beneficial impact of financial incentives on vaccination coverage. This review found a small, but non-significant, improvement in vaccination coverage due to cash transfers. Additionally, a review by Cruz et al. [8] found that cash transfers mostly improved immunization rates and vaccination coverage for children under five, though such transfers alone may not improve health inequities in immunization.

Many of the 10 individual studies in our review that included a financial incentive component indicated some increase in vaccination coverage, though this varied by antigen and region. The majority of our included studies focused on cash transfers, whereas Bassani et al. [7] explored incentives more broadly, including microcredit, voucher schemes, and user fee removal. For measles vaccination, studies were mixed in terms of improvements in coverage from conditional cash transfers, though not all studies provided cash transfers up to the age of measles vaccination (i.e., only provided cash for earlier childhood vaccines). Most studies were from India; there were also studies in Nigeria, Kenya, and the Philippines.

Reminders and recall

We found several studies that included reminders and recalls for caregivers when vaccinations were due as an intervention. In most cases, reminders were coupled with another intervention component on the supply-side including registry of children due for vaccinations, defaulter tracking, and training for healthcare workers. In five studies, reminders were coupled with financial incentives to encourage caregivers to receive the vaccinations.

SUPPLEMENTAL STRATEGIES

There was a mix of SMS and voice messaging as reminders. Additionally, some studies found an opportunity to not only send tailored reminders about vaccines due, but also provide educational messaging on immunization and child health.

Most studies in our analysis found reminder systems to be effective at improving vaccination rates, as was also found by the two systematic reviews included [9,10]. The geographic breadth appears to be widespread in terms of countries that have successfully implemented reminders. Reminders were tailored at a variety of levels, but many were at subnational levels (villages, health facilities, and city zones). Innovation included mhealth technology that linked an electronic registry with reminders and an application for HCWs to list and track children as well as reminding parents of vaccines due.

Information, education, and communication (IEC)

Information, education, and communication interventions focused on generating resources to educate communities about immunization. While some interventions used traditional peer-to-peer approaches or groups to provide information, half of these interventions used mhealth platforms to disseminate information. There were also several “edutainment”—or educational entertainment—interventions that provided content in an engaging manner.

Reminders & recall in Ethiopia and Bangladesh

A randomized controlled trial in northwest Ethiopia [11] showed that 82.6% of children whose caregivers received SMS reminders were fully immunized at 12 months, compared to 70.9% of children in the control arm. Timeliness was also found to significantly increase for children receiving the intervention. Because this used an automated messaging system, such an approach could be scaled up to other parts of the country.

In Bangladesh [12], a smartphone application was developed to connect healthcare workers and caregivers. The application allowed HCWs to create a registry of pregnant women. Pregnant women could then notify HCWs of births. The application would then remind mothers and HCWs of vaccination. The system also allowed supervisors to track progress and plan vaccination sessions. Full vaccination in the rural intervention area increased from 58.9% to 76.8%, and in urban areas increased from 40.7% to 57.1%.

SUPPLEMENTAL STRATEGIES

Spotlight on IEC: India and the Gambia

In the Gambia [16], given concerns about vaccine confidence and lack of knowledge, a multimedia educational tool “the vaccine speaking book” was developed to provide prerecorded information about vaccines. The book was provided in local languages and taken home by caregivers to share with others. The book increased caregiver knowledge, with median knowledge scores doubling at 1-month follow up visits and tripling at 3-month follow up visits; however, the highest score, 19, was still 20 points below the maximum score of 39. Given the success of this book in increasing caregiver knowledge, speaking books have been developed on several other topics.

In Pune, India [17], an intervention was implemented to improve immunization coverage among under-five children living with a school student through child-to-child and child-to-parent information, education, and communication strategy. The intervention included training sessions, posters, cartoon stories, and take-home leaflets about vaccination. Mother’s knowledge, vaccine card retention and vaccination coverage all improved in areas where this intervention was implemented.

SOCIAL MOBILIZATION

Although social mobilization is also part of demand generation, we list it separately as interventions less targeted at female caregivers and rather at the engagement of other key stakeholders involved in immunization decision-making. This includes mass media and village committees in the general category, male caregivers and religious leaders, and community mobilizers to promote vaccination. There were 51 articles identified that included social mobilization interventions, all of which seem to work in all contexts. Social mobilization is considered a key aspect of immunization programs.

Social mobilization

Social mobilization included a variety of different initiatives including mass media promotion, community meetings, and establishment of village development committees. It also included

SUPPLEMENTAL STRATEGIES

training and sensitization for various community members including journalists, teachers, village leaders, community-based organizations, government officials, and other stakeholders. Social mobilization efforts often included the use of community mobilizers.

Social mobilization in Nigeria

In Nigeria [15], a participatory action research approach was taken in several states. Community members, implementing stakeholders and government officials identified problems influencing immunization coverage and came up with solutions that were then implemented at the ward level. A committee was established to monitor implementation of the interventions identified. These included advocacy visits to the local king and religious leaders, home visits and community mobilization to promote vaccination, and the renovation of the health facility and two more health workers being hired. This bottom-up approach of listening to the community's needs and co-creating ways to address barriers to vaccination and improved complete vaccination by card from 61% to 91%.

Engaging male caregivers and religious leaders

Social mobilization efforts included articles that engaged male caregivers and recruited religious leaders to promote vaccination. In areas where male caregivers or heads of household have significant influence on vaccination decisions, this intervention can be particularly successful. Similarly, in areas where religious leaders are influential and trusted sources of information, they can use their platform to promote vaccination in their communities. Engagement of religious leaders was often done as one piece of social mobilization activities and often included other community mobilizers as well.

Pakistan's Community Service Model

In Pakistan [14], the Community Service Model provided educational sessions to household heads and fathers of children less than one year old. This highly successful intervention resulted in 89% of children being fully immunized, compared to 14% in a control group.

SUPPLEMENTAL STRATEGIES

Community mobilizers

Community mobilizers were described in several of the identified papers. They ranged in their responsibilities, from defaulter tracking and creating registries of children to be vaccinated to providing educational messages to raise awareness about immunization. They were also sometimes involved in surveillance activities, particularly for acute flaccid paralysis (AFP).

Some studies also described community mobilizer's involvement in promoting programs beyond immunization, including growth monitoring and nutrition as well as water, sanitation, and hygiene. In half of the studies, community mobilizers were one component of a broader social mobilization strategy that included other interventions. A few studies described providing community mobilizers with financial remuneration or phone time, but mostly costs were related to training.

All studies described community mobilizers as a successful strategy for increasing demand for vaccination. Most of these studies implemented community mobilizers at state, district, or sub-district level, which included facilities, urban slums and religious congregations. Most studies were from India and Nigeria, and most were established for polio vaccination, such as through the CORE group polio project.

Volunteer Community Mobilizers in Nigeria

Community mobilizers in Nigeria were part of a broader community engagement strategy to improve acceptance of oral polio vaccine. This included town announcers, religious leaders, and village development committees to provide awareness and messaging about immunization. It also included providing vaccination in the community through mobile health teams and child health camps, which provided a wider range of child health services.

An evaluation from Duru et al. [13] found that Volunteer Community Mobilizers (VCMs) conducted home visits to review routine immunization status and referred more than 300,000 children to health centers for routine immunizations in high-risk areas over a three-year period.

SUPPLEMENTAL STRATEGIES

HUMAN RESOURCES

Human resource interventions included healthcare worker training, supportive supervision, and financial incentives for healthcare workers. Of the 40 articles identified, more than half included training; supportive supervision seemed successful in all contexts.

Training for healthcare workers

Training for healthcare workers included a variety of programs: peer mentoring, coaching, collaborative learning, refresher sessions, and manager training. Training topics were diverse, focusing broadly on routine immunization services, valid/invalid doses, side effects and adverse events, facility management, interpersonal communication, and promotion of vaccines. Some programs designed trainings with healthcare workers and community members, while others implemented existing trainings, like the curriculum created by the WHO. Training success was often measured by knowledge improvements, vaccination coverage, and service quality. Most programs were conducted at the province/state level or lower (district, village, and community levels), but generally targeted regions with poor routine immunization performance, low vaccination coverage, and poor provider knowledge.

Spotlight on training in Ethiopia

In Ethiopia [18], continuous quality improvement intervention was implemented at health facilities, districts, and zonal levels to improve immunization services. A baseline report indicated shortage of skilled workforce, and therefore EPI managers and coordinators underwent the WHO 10-day immunization training for mid-level managers. In addition, providers received the 5-day WHO Immunization in Practice training focused on immunization services and communications. In follow-up to the training, EPI consultants provided quarterly onsite technical support, and supervisors reviewed the quality improvement checklists to monitor the plans developed during training. As a result, the gap in vaccination coverage narrowed: when comparing coverage from baseline to month 12 of the intervention, pentavalent coverage increased from 63.6 to 79.3%, measles coverage increased from 62.5 to 72.8%, BCG coverage increased from 62.4 to 73.5%, and PCV coverage increased from 65.3 to 81.0%

SUPPLEMENTAL STRATEGIES

Supportive supervision

Among the papers reviewed, only one intervention focused solely on supportive supervision. Other interventions included supportive supervision as a component, but they did not measure the impact of supportive supervision specifically. Supportive supervision was provided to vaccination teams in volatile regions, primary health centers, and EPI and health facility staff. In the paper focused solely on supportive supervision, the support concentrated on monitoring EPI performance, correcting issues, identifying gaps/barriers of action plans, and follow up on action plans. Outcomes for all interventions utilizing supportive supervision as a component were changes in immunization coverage, data quality, knowledge, attitudes, and practices.

Supportive supervision in Côte d'Ivoire

In Côte d'Ivoire [19], one paper assessed the impact of technical support among the 10 health districts with the largest number of children not vaccinated against measles. The supervision aimed to improve the vaccine program performance in each district by monitoring EPI performance, correcting issues, identifying gaps/barriers of action plans, and developing and following up on action plans.

Additionally, monthly data collection, workshops, and assessments were completed, and results were provided to EPI coordinators in each district. The support had a positive effect: MCV coverage increased in eight out of 10 districts and in all but one district, coverage increased to above 80%.

SUPPLEMENTAL STRATEGIES

Performance-based financing and incentives for healthcare workers

Performance-based financing (PBF) and incentives for healthcare workers primarily targeted providers and community health workers, like ASHAs in India. Utilizing vouchers and direct payments, performance was measured through services performed, including vaccination, consultations, planning services, and examinations. The effect of performance-based financing was measured through vaccination coverage, quality of care, drug availability at intervention facilities, staff attitude, staff morale, and staff punctuality.

For the most relevant outcome of vaccination coverage, results were generally mixed across papers, with an almost equal split among interventions seeing improved coverage and interventions seeing no impact or only small improvements. Authors speculated that unsuccessful schemes were challenged by possible demand-side barriers, vaccine stock outs, and other health financing reforms that may have crowded out the effects of the PBF scheme. PBF schemes were also impacted by existing quality of care and administrative difficulties in calculating and providing vouchers.

Financial incentives in Nigeria

In Nigeria [20], a study compared performance-based financing to decentralized facility financing (fixed monetary incentive not linked to quantity of services) for health facilities. Researchers concluded that performance-based financing was more effective than decentralized facility financing, increasing vaccination coverage for vaccines that do not require sequential uptake (BCG, measles, full vaccination); gains for sequential vaccines (OPV, pentavalent) were not significant. The study's authors hypothesized that the limited magnitude of increases in full vaccination coverage was largely due to demand-side rather than supply-side barriers.

SUPPLEMENTAL STRATEGIES

SUPPLY CHAIN

Interventions focused on supply chains included implementation of new vial policies, improved cold chain equipment availability, and changes in vaccine distribution. Vial-related interventions include reducing doses per vial (for example, moving from 10-dose vials to 5-dose vials) and institution of an open vial policy. In general, healthcare workers preferred lower dose vials, which also resulted in increased vaccination coverage and reduced wastage. Reduced wastage was also seen after the introduction of an open vial policy.

Improved cold chain equipment, specifically increased fridge availability, also demonstrated increased vaccination coverage but led to funding challenges and increased delivery costs. Finally, introduction of direct-to-facility vaccine distribution reduced stock-outs and preliminary data suggest this distribution method also improved vaccination coverage. We did not include typical supply chain improvements or expansions for new vaccine introductions.

SERVICE DELIVERY

Service delivery had the highest number of articles and interventions found in this scoping review. Within service delivery, interventions were classified as “planning” interventions when the focus was on identifying children and tied to vaccinating them, “integrating” when tied to another government department (education, transportation), and “tailoring” when traditional

Reducing MCV vial sizes in Zambia

In a study in Zambia [21], authors concluded that switching from the conventional 10-dose measles containing vaccine vials to the 5-dose vials had positive effects on coverage and wastage. Qualitative research also showed that healthcare workers preferred 5-dose vials and did not want to return to 10-dose vials, saying that 5-dose vials improved their ability to vaccinate more children and created less vaccine wastage. Additionally, authors measured the impact of switching vials on MCV coverage; MCV2 coverage increased 3.5 percentage points due to the intervention.

SUPPLEMENTAL STRATEGIES

immunization was adapted to reach un- or under-vaccinated children. Planning interventions included RED/REC, microplanning, community immunization points, and community health workers to vaccinate children. Integrating included using immunization registries, defaulter tracing and calendars to plan immunization sessions. Tailoring were innovations such as PIRIs, child health days/weeks, outreach sessions and extended clinic hours.

Reaching Every District (RED)/Reaching Every Child (REC)

The RED/REC approach—a community-based strategy developed by the WHO Regional Office for Africa that aims to identify and reach every unimmunized child in every district—was discussed in 13 included articles. Most focused on the program’s implementation individually or as an integrated component of a broader strategy to improve immunization and child health service coverage in countries in Africa, South Asia, or South-East Asia.

RED/REC has generally been hailed as an effective strategy that can be tailored to meet local needs, with many reporting sustained gains in immunization coverage and improvements to data quality and community health worker engagement; other studies, though, have reported persistent coverage gaps despite RED and other immunization initiatives and called for renewed and strengthened RED/REC planning and resource mobilization. While the RED program has been used in countries since 2002, it is well-suited to tailoring its approach and targeting high-need areas.

RED/REC in Malawi and Kenya

In Malawi and Kenya [22], the RED approach was reviewed and tailored through a series of adaptation workshops to refine target areas, develop new microplans, and secure buy-in. Workshop participants included national immunization program officials, health workers from each district, village and community leaders, and implementation partners, facilitating input from key stakeholders involved in all levels of the program. This co-creation approach ensured that the adapted guide was informed by and suited for the settings where it was most needed, and that there would be broad support from in-country program implementers and communities.

SUPPLEMENTAL STRATEGIES

Microplanning

Nine papers discussed microplanning, frequently in the context of REC/REC implementation. Microplanning allowed for targeted, tailored preparations, especially in support of reaching remote, isolated, marginalized, or conflict areas. Included articles highlighted the importance of both a robust initial microplanning process and recurrent, iterative microplanning exercises to adapt to evolving program needs and context. While immunization coverage gains were not specifically attributed to microplanning, the exercise formed a critical component of EPI planning and implementation focused on geographic areas and communities with relatively low vaccination coverage .

Registries, defaulter tracing, and calendars

Fourteen papers described the use of immunization registries, defaulter tracing, or calendars to strengthen strategies to identify and reach under- and unimmunized children, particularly focusing on efforts to rapidly identify and follow up with missed vaccinations. Most also discussed community mobilizers or reminders, highlighting the importance of integrating these planning and follow-up approaches with community outreach and demand generation.

Microplanning in India

Microplans were central to two programs in India—Intensified Mission Indradhanush (IMI) and Muskaan Ek Abhiyan—that aimed to identify vaccination coverage gaps and reach under- and un-immunized children through improved coordination, increased engagement of community health workers and other service providers, and build political will. In both IMI [23] and Muskaan Ek Abhiyan [24], microplanning approaches were adapted to focus on local resource mobilization, such as training and supervision of Auxiliary Nurse Midwives (ANMs), Accredited Social Health Activists (ASHAs), and Anganwadi workers (AWWs).

The IMI microplanning process also included microcosting exercises to detail incremental costs of supplies and resources. In Muskaan Ek Abhiyan, the proportion of fully immunized children increased, the presence of AWWs and ASHAs increased, and the functioning of cold chain equipment also increased as a result of the campaign.

SUPPLEMENTAL STRATEGIES

Of note, registry or tracing tools were often digital, requiring software or app access and familiarity; several papers identified this learning curve and the associated costs of software/app development as potential barriers to effective implementation.

Generally, most settings employing these strategies saw an improvement in immunization coverage and timeliness among intervention groups, though the specific boost provided by the registries and tracing approaches often could not be separated from other interventions. Defaulter tracing—engaging health workers (or technologies) to follow up with children who have missed appointments or doses (“defaulters”)—was also beneficial, and some highlighted registry apps incorporated color coding and other mechanisms to facilitate this process. However, there are substantial technology and human resources costs that could be necessary to effectively develop and implement these types of planning strategies.

Phone-based defaulter tracing in Kenya

A pilot program in Kenya [25] took advantage of high phone ownership to establish phone-based defaulter tracing in 12 health clinics with high drop-out rates, following up with caregivers or neighbors of children two weeks after a missed dose. Tracers used call durations to estimate the cost of each follow-up and approximate the cost of the program at scale. While some sites relied on nurses for tracing activities, those who engaged CHWs for this phone-based defaulter tracing were more effective. Of note, this study found that more than one-third of defaulters (based on the clinic records) were not true defaulters; rather, they had been vaccinated at other sites; this highlights the value of electronic, integrated registries with defaulter tracing. Overall, the tracing approach helped to address data gaps and improved retention and uptake in the target community.

Community health workers

South Asian countries featured prominently among the 25 included papers focusing on community health workers (CHWs). In many settings, CHWs were engaged to provide integrated health services, frequently linked with maternal and newborn care.

SUPPLEMENTAL STRATEGIES

Engaging at these time points allows CHWs to provide care and education on a range of topics, including nutrition and immunization. Capacity strengthening remains an important component of and challenge to effective CHW programs to build and maintain community trust and ensure quality service delivery.

Some settings establish specific criteria for CHWs, such as India's ASHA network which includes sex, age, literacy, and residency requirements. Effect of CHWs varied by setting and priority interventions; several included studies highlighted statistically significant but not meaningful changes to full immunization status, uptake of health services, and other measures in communities with CHW involvement. Almost all included papers emphasized the need to support continued capacity development, training, and retention strategies for CHWs, and the need to strengthen political and programmatic support to ensure continuity and stability of CHW networks.

Community immunization points

Special immunization points were set up to reach children in the community in places where they frequent. These included schools, as well as transit points and border posts for mobile populations. In conflict and emergency settings, this included the use of permanent polio teams and engagement of security personnel to provide vaccination in areas that were difficult to access. The ability to quickly mobilize resources when there is an opportunity is key to the success in conflict settings.

Catch-up vaccination in Thailand

In Thailand [26], a school with a high migrant population implemented a catch-up vaccination initiative. Schools created a register at the start of the year based on immunization status. Schools were then visited once per month, so zero dose children could receive them all by the end of the year. This project demonstrated that hard-to-reach children can be captured in school settings with most children receiving all offered vaccinations when available. Of note, coverage of single-dose vaccines exceeded 90% for each; however, coverage declined for subsequent doses of multi-dose vaccines.

SUPPLEMENTAL STRATEGIES

Periodic Intensification of Routine Immunization (PIRI)

All of the papers that described PIRIs were in India describing the Mission Indradhanush program in districts that have low vaccination coverage and high dropout rates. The program included door-to-door identification of children missing vaccination, development of district-level microplans to decide vaccination sites, social mobilization by community health workers, and immunization sessions done for 7 consecutive days per month. Auxiliary nurse-midwives came from their periphery health facilities to deliver vaccines and other health services. There was a focus on sessions reaching urban slums, nomadic populations and other under-served areas. This intervention was quite successful at increasing the number of fully immunized children, and found in Uttar Pradesh, 80% of children at the sessions were zero dose [27].

Child health days, immunization days, and immunization weeks

Most child health days, national and sub-national immunization days, and immunization weeks provided other services in addition to immunization, such as growth monitoring, vitamin A supplementation, oral rehydration therapy, malaria prevention and treatment. Services were provided at several different venues including house-to-house, health facilities, school-based delivery, and community outreach posts. Examples of outreach post sites were included in the community immunization points section.

In some countries, child health days and immunization weeks are routinely done to catch-up children who have missed routine immunization, such as Sierra Leone that conducts biannual child health days. However, in others they are more targeted at areas with poor immunization coverage, hard-to-reach populations, interruptions in the routine immunization system, or experiencing recent outbreaks. Subnational immunization days specifically targeted provinces or districts based on the above. These were most often done for polio vaccination. In conflict-affected settings (Yemen, Somalia), these interventions were crucial to delivering services to children, as the routine system had often been disrupted for extended periods.

SUPPLEMENTAL STRATEGIES

Uganda's child health days

In Uganda [28], child health days were expanded to be family health days—the package of interventions was expanded to improve health for pregnant, lactating, and non-lactating women, as well as men. They used churches and mosques as community entry points and outreach sites. Rollout started in poor-performing districts of Uganda and was scaled up nationwide. The services were provided for a month in each district on prayer days of Friday, Saturday, and Sunday and at community outreach post sites identified by community members for hard-to-reach or mobile populations. Of the total MCV coverage in 2012 and 2013, the authors estimate that family health days contributed 20% and 24%, respectively; they helped to reduce the number of unvaccinated children in the population and supported sub-regions and districts in reaching target coverage levels for MCV and DTP3.

Outreach sessions

Outreach sessions were conducted to reach under and unvaccinated children. Planning for outreach sessions included using quantitative and qualitative data to determine which communities are underserved and have the highest number of zero-dose children, for optimal targeting of sessions in those areas. In some interventions, outreach sessions were conducted via mobile clinics or teams that would change their location to reach remote communities during different seasons.

Fixed posts and outreach sessions in Uganda

In Uganda [29], routine immunization services are delivered through both fixed posts and outreach sessions. These sessions are planned, regular and periodic single-day visits by health facility staff to populations located more than 5-15 km from the facility. These outreaches are often integrated with other vital interventions, such as vitamin A supplementation, deworming tablets, and insecticide-treated nets. An evaluation found that while one district reported 32% of children using outreach services, another found 87% of children used them. Convenient timing of sessions and community mobilization beforehand were key to use of the outreach sessions.

SUPPLEMENTAL STRATEGIES

Extended hours

Extended hours for vaccination sessions were targeted at urban areas, including urban slums, to increase the opportunities for vaccination for caregivers to bring their children.

Extended and modified hours in Bangladesh's urban slums

At sub-district levels in Bangladesh [30], interventions were developed in collaboration with stakeholders and tried in different areas. In urban slum areas of Dhaka, an EPI intervention package was implemented that included extended hours, training for healthcare workers, a screening tool to reduce missed opportunities for vaccination and community support groups for social mobilization. Normally, EPI services are provided from 10:00am-2:00pm, but this was extended to 5:00pm to enable working mothers to bring their children for vaccination.

In another area, the EPI session schedule was modified because it was very difficult to conduct sessions in extreme hard-to-reach villages. EPI sessions were held every other month for two consecutive days rather than monthly for one day, decreasing the travel time for providers and allowing sessions to run later. Both interventions substantially increased vaccination coverage in the areas where they were implemented. The package of interventions in Dhaka estimated that it cost \$20.95 per valid fully immunized child.

DISCUSSION

Our aim in this scoping review was to capture and describe the breadth of strategies that could serve as alternatives to national, non-selective SIAs for measles-containing vaccine and other EPI components. There is certainly a critical role for national, non-selective SIAs in specific settings and contexts. However, as global immunization evolves, there is a need to equip global partners and countries to consider alternatives that diverge from the traditional nationwide, non-selective campaign—an inherently resource-intensive and at times redundant approach—to maximize impact while minimizing resource demands.

These alternative strategies can include tailored campaigns (for example, geographically focused campaigns) or enhancements to the routine program (for example, national immunization days or default tracing strategies), all falling between national, non-selective SIAs at one end of the continuum and the routine EPI at the other. While broadening our classification of interventions beyond just SIA or routine allows for greater flexibility and ingenuity to meet country and community needs, and hopefully serves to better target the use of scarce resources, there is a risk that these approaches serve only to extend the time between national campaigns rather than eliminating the need for them entirely.

We focused on “routine enhancements”—approaches that build upon the traditional EPI structures and activities but do not specifically involve campaigns or campaign-like efforts—but we recognize that this definition carries some ambiguity. What may be a routine enhancement in one setting is a core component of the routine program in others. For example, India’s Universal Immunization Programme hinges on a broad, multi-level CHW network; however, CHWs may not be part of the standard program in other settings and would thus be counted as an enhancement to the routine program. Context plays a key role in how we describe enhancements to routine immunization and how these enhancements are operationalized.

DISCUSSION

Strategies used in fragile or conflict settings

We recognize that strategies to reach children in conflict-affected or fragile settings are innately tailored, targeted supplemental strategies and could provide valuable learnings for routine immunization programs. However, the context in which those strategies are developed and implemented varies greatly from that of non-conflict settings and would need thorough synthesis and interpretation before being of use in translational efforts. While this is a critical research gap with potential learnings for a range of settings and contexts, our review prioritizes learnings to inform alternative approaches in Zambia and similar countries that are not presently facing substantial conflict or fragility concerns. Thus, for this scoping review, we excluded literature that focused on fragile or conflict-affected settings (such as refugee populations, humanitarian emergencies, etc.). Some articles described efforts by the EPI program to reach communities or districts in isolated or conflict areas through the routine program, leveraging supplemental strategies like RED/REC or child health days; in this case, we have aimed to capture relevant learnings that could inform strategies to reach remote communities in non-conflict settings. We agree that there is a need to identify and assess strategies used to effectively reach zero dose children in these complex settings, many of which maybe applicable in non-fragile/conflict settings as well.

EFFECTIVENESS OF SUPPLEMENTAL STRATEGIES

The range of strategies captured in this review highlights the breadth of possibilities for countries aiming to shift from broad, non-selective campaigns to more targeted—arguably, more sustainable—approaches integrated into the routine EPI. In focusing on these routine enhancements, we are challenged to capture intervention-specific impact and quantify the effect of these approaches on immunization coverage, timeliness, and trust. Few studies were able to disentangle the effects of a specific approach on target outcomes or capture individual data showing the effect on those exposed to the intervention. Many relied on DHS or other national or subnational surveys to associate interventions with changes in population-level coverage, which falls short of describing local effects in the communities experiencing higher levels of under- or unvaccinated children. Further research—particularly implementation research and qualitative research—would be of value to better describe the effectiveness of these interventions and how they are viewed and accessed by their target populations.

DISCUSSION

Many strategies leverage multiple components to improve reach and impact

We noted that many studies, particularly those centered on service delivery interventions, described programs or strategies that incorporated multiple components rather than a single intervention or approach. For example, several studies that described the RED/REC approach also incorporated microplanning, as well as supply chain enhancements, social mobilization, and human resource training to varying degrees. India's ASHA workers were highlighted in studies exploring microplanning, performance-based financing, and community health workers, demonstrating the ASHA program incorporates and is relied upon to implement a range of interventions to better meet the needs of the community. Blending multiple supplemental strategies into a comprehensive, integrated approach to identify and reach zero dose or under-vaccinated children appears to be vital to expanding reach and improving effectiveness and impact of supplemental strategies, helping to alleviate the need for national, non-selective campaigns.

SUPPLEMENTAL STRATEGY COSTS AND RESOURCE NEEDS

While acknowledging the resource-intensive nature of national, non-selective SIAs and the need to explore alternatives, few studies presented concrete estimates or projections of the economic costs of these routine enhancement programs, nor the return on investment. One example was the Bangladesh intervention package that included extended hours, training, a missed opportunities screening tool, and community mobilization. The strategy estimated that it cost \$20.95 per fully immunized child [30]. However, it is unclear how this compares to the cost of providing vaccines via a campaign format. Understanding the cost implications of supplemental strategies as compared to campaigns will be helpful in planning for implementation.

Some papers did discuss incremental costs or other resource needs (i.e., number of worker-hours per month needed for defaulter tracing) but these costs are heavily influenced by local context and the ability to mobilize existing networks or partners. An ideal next step would involve quantifying the costs of each class of SIA alternative described here in order to map investment needed, returns, other resource needs, and alignment with existing routine structures (allowing for dual use of resources, rather than reallocation as campaigns demand).

DISCUSSION

LINKAGES TO VACCINATION CAMPAIGNS

While the term “vaccination campaign” is often used interchangeably with “supplementary immunization activity” (SIA), many of the strategies presented above are actually SIAs but not campaigns. We considered vaccination campaigns to be those that administer vaccines, such as polio and measles vaccines, to all children in the target age group irrespective of their previous vaccination status.

Some papers described how to use the campaign platform as an opportunity to enhance routine immunization services [31,32]. There were also several interventions that were similar to campaign-style initiatives. For example, child health days, national immunization days, immunization weeks, and PIRIs are all short-term resource intensive initiatives that provide additional opportunities to catch-up children who may have missed routine vaccination. While they may include additional outreach or even house-to-house vaccination, the main distinction from campaigns is that they do not blanket vaccinate anyone in the target age group. While some are done nationally, many were found to have been tailored to reach specific populations. These types of tailored approaches may be a viable alternatives to nationwide non-selective campaigns.

LIMITATIONS OF THIS REVIEW

While this scoping review aimed to describe the range of strategies used to improve immunization access and acceptance—specifically strategies to reach zero-dose children through routine program enhancements or other alternatives to nationwide, non-selective vaccination campaigns—we acknowledge several important limitations of this approach.

First, we recognize that our findings are likely influenced by publication bias towards positive outcomes. While we identified several studies that reported neutral or non-significant results, there was little published literature with negative findings.

DISCUSSION

Second, our review identified few detailed reports of a measurable impact of each intervention type across studies. This was primarily due to a lack of appropriate comparison groups across studies. Where possible, we included descriptions of study results but—recognizing that there are concurrent reviews that are more quantitatively assessing the effectiveness and impact of supplemental strategies—we generally focused on summarizing the approaches and highlighting select examples with more generalizable contexts or specific outcome measures. We also note that most studies reported only short-term outcomes or impact but lacked assessments of a long-term impact on immunization coverage or measures of sustainability of these approaches.

Finally, as described above, we iteratively adjusted our scoping review approach as we learned of complementary reviews underway and related work by WHO [5]. We believe adapting our approach to avoid redundant efforts helped ensure the resulting report and catalog of supplemental strategies addresses key gaps in the knowledge base and is better suited for use by partners at the global, regional, national, and sub-national levels. We acknowledge that such an approach is less methodologically rigorous and strays from formal scoping review procedures; however, given our focus on supporting planning and implementation of alternatives to nationwide, non-selective measles vaccination campaigns in Zambia and other countries, we felt that this adjusted approach was more appropriate for our project and study aims.

Supplemental strategies identified in the literature

In Annex 4, we list all supplemental strategies identified in this review. We briefly describe the classification of each intervention, where it was implemented, what outcomes were measured to track success, and any contextual considerations for that strategy. Interventions are organized based on the IRMMA framework topic mapping for zero-dose children [6]: demand, human resources, supply chain, service delivery. We did not identify interventions in monitoring and assessment or governance.

CONCLUSION

Several strategies described in this report have been implemented in multiple countries, yet some demonstrate greater potential to replace nationwide non-selective campaigns.

Among demand generation interventions, **reminders and recall systems** and **community mobilizers** have been used in many different countries and with apparent positive impact on vaccination coverage. For service delivery, tailoring through **community immunization points** at schools and transit points, **outreach sessions**, and **extended vaccination session hours** could provide more opportunities for reaching un- and under-vaccinated children. Funding to expand these service delivery options could improve routine immunization delivery systems and help stem the need for future vaccination campaigns. Additional support for and amplification of **RED/REC** and **microplanning** could help bridge implementation barriers and facilitate targeted, tailored strategies through enhanced planning. **Integrating multiple components**, and tailoring to the appropriate local context, offers an opportunity to maximize reach and impact

It is important to note that the strategy a country chooses to invest in will be context-specific. Additional evaluation of which strategies are most effective in which contexts is needed. Tailoring strategies will help target un- and under-vaccinated children. Furthermore, understanding how decision makers, healthcare workers, and caregivers will receive these interventions is important to understand their potential impact. By improving access to and uptake of vaccination through these supplemental strategies, countries may be able to lessen the need for national, non-selective vaccination campaigns.

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ANNEXURE

ANNEX 1

SEARCH STRATEGY AND TERMS

Search methodology

To identify relevant published literature—aiming to cast a wide net in order to capture all relevant interventions—we searched PubMed, World Wide Science and Scopus, as well as targeted searches of gray literature through WHO regional databases, WHO IRIS, and JSI re. Search terms were related to child immunization in low- and middle-income countries and were developed by immunization and MR vaccination experts at JHSPH, in consultation with a reference informationist. WHO search terms were based on those developed for the previous databases, but adapted to be more general. JSI papers were handpicked by scrolling through to identify relevant reports. While we intended to also include literature from the USAID development experience clearinghouse, the system was unavailable at the time of our search and review and was thus excluded.

While this was not a systematic review, we used Covidence to manage this review, including screening and extraction. In both the title/abstract and full-text screening phases, articles were screened by two independent reviewers; conflicts were resolved by committee. Key information described below was abstracted from the final set of papers, with validation of 10% of included papers.

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PubMed search terms

(zero-dose[tiab] OR zerodose[tiab] OR unvaccinate*[tiab] OR under-vaccinate*[tiab] OR unimmunize*[tiab] OR unimmunise*[tiab] OR under-immunize*[tiab] OR under-immunise*[tiab] OR immunization* [tiab] OR immunization* [tiab] OR non-vaccination[tiab])

AND

("Child"[mh] OR "Infant"[mh] OR "Infant, Newborn"[mh] OR "Adolescent"[mh] OR "Child, Preschool"[mh] OR "child"[tiab] OR "infant"[tiab] OR "adolescent"[tiab] OR "children"[tiab] OR "infants"[tiab] OR "adolescents"[tiab] OR "pediatric patient"[tiab] OR "pediatric patients"[tiab] OR "adolescence"[tiab] OR "youth"[tiab] OR "youths"[tiab] OR "juvenile"[tiab] OR "childhood"[tiab] OR "teenager"[tiab] OR "teenagers"[tiab] OR "teen"[tiab] OR "teens"[tiab] OR "preschool child"[tiab] OR "neonate"[tiab] OR "newborn"[tiab] OR "baby"[tiab] OR "babies"[tiab] OR "pediatric"[tiab] OR "pediatrics"[tiab] OR "paediatric"[tiab] OR "paediatrics"[tiab] OR "toddler"[tiab] OR "toddlers"[tiab])

AND

("afghanistan"[MeSH Terms] OR "albania"[MeSH Terms] OR "algeria"[MeSH Terms] OR "american samoa"[MeSH Terms] OR "angola"[MeSH Terms] OR "antigua and barbuda"[MeSH Terms] OR "argentina"[MeSH Terms] OR "armenia"[MeSH Terms] OR "aruba"[MeSH Terms] OR "azerbaijan"[MeSH Terms] OR "bahrain"[MeSH Terms] OR "bangladesh"[MeSH Terms] OR "barbados"[MeSH Terms] OR "republic of belarus"[MeSH Terms] OR "belize"[MeSH Terms] OR "benin"[MeSH Terms] OR "bhutan"[MeSH Terms] OR "bolivia"[MeSH Terms] OR "bosnia and herzegovina"[MeSH Terms] OR "botswana"[MeSH Terms] OR "brazil"[MeSH Terms] OR "bulgaria"[MeSH Terms] OR "burkina faso"[MeSH Terms] OR "burundi"[MeSH Terms] OR "cabo verde"[MeSH Terms] OR "cambodia"[MeSH Terms] OR "cameroon"[MeSH Terms] OR "central african republic"[MeSH Terms] OR "chad"[MeSH Terms] OR "chile"[MeSH Terms] OR "china"[MeSH Terms] OR "colombia"[MeSH Terms] OR "comoros"[MeSH Terms] OR "democratic republic of the congo"[MeSH Terms] OR "congo"[MeSH Terms] OR "costa rica"[MeSH Terms] OR "cote d ivoire"[MeSH Terms] OR "croatia"[MeSH Terms] OR "cuba"[MeSH Terms] OR "cyprus"[MeSH Terms] OR "czech republic"[MeSH Terms] OR "djibouti"[MeSH Terms] OR "dominica"[MeSH Terms] OR "dominican republic"[MeSH Terms] OR "ecuador"[MeSH Terms] OR "egypt"[MeSH Terms] OR "el salvador"[MeSH Terms] OR "equatorial guinea"[MeSH Terms] OR "eritrea"[MeSH Terms] OR "estonia"[MeSH Terms] OR "eswatini"[MeSH Terms] OR "ethiopia"[MeSH Terms] OR "fiji"[MeSH Terms] OR "gabon"[MeSH Terms] OR "gambia"[MeSH Terms] OR "georgia republic"[MeSH Terms] OR "ghana"[MeSH Terms] OR "gibraltar"[MeSH Terms] OR "greece"[MeSH Terms] OR "grenada"[MeSH Terms] OR "guam"[MeSH Terms] OR "guatemala"[MeSH Terms] OR "guinea"[MeSH Terms] OR "guinea bissau"[MeSH Terms] OR "guyana"[MeSH Terms] OR "haiti"[MeSH Terms] OR "honduras"[MeSH Terms] OR "hungary"[MeSH Terms] OR "india"[MeSH Terms] OR "indonesia"[MeSH Terms] OR "iran"[MeSH Terms] OR "iraq"[MeSH Terms] OR "jamaica"[MeSH Terms] OR "jordan"[MeSH Terms] OR "kazakhstan"[MeSH Terms] OR "kenya"[MeSH Terms] OR "democratic people's republic of korea"[MeSH Terms] OR "republic of korea"[MeSH Terms] OR "kosovo"[MeSH Terms] OR "kyrgyzstan"[MeSH Terms] OR "laos"[MeSH Terms] OR "latvia"[MeSH Terms] OR "lebanon"[MeSH Terms] OR "lesotho"[MeSH Terms] OR "liberia"[MeSH Terms] OR "libya"[MeSH Terms] OR "lithuania"[MeSH Terms] OR "macau"[MeSH Terms] OR "republic of north macedonia"[MeSH Terms] OR "madagascar"[MeSH Terms] OR "malawi"[MeSH Terms] OR "malaysia"[MeSH Terms] OR "indian ocean islands"[MeSH Terms] OR "mali"[MeSH Terms] OR "malta"[MeSH Terms] OR "micronesia"[MeSH Terms] OR

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"palau"[MeSH Terms] OR "mauritania"[MeSH Terms] OR "mauritius"[MeSH Terms] OR "mexico"[MeSH Terms] OR "moldova"[MeSH Terms] OR "mongolia"[MeSH Terms] OR "montenegro"[MeSH Terms] OR "morocco"[MeSH Terms] OR "mozambique"[MeSH Terms] OR "myanmar"[MeSH Terms] OR "namibia"[MeSH Terms] OR "nepal"[MeSH Terms] OR "netherlands antilles"[MeSH Terms] OR "nicaragua"[MeSH Terms] OR "niger"[MeSH Terms] OR "nigeria"[MeSH Terms] OR "oman"[MeSH Terms] OR "pakistan"[MeSH Terms] OR "panama"[MeSH Terms] OR "papua new guinea"[MeSH Terms] OR "paraguay"[MeSH Terms] OR "peru"[MeSH Terms] OR "philippines"[MeSH Terms] OR "poland"[MeSH Terms] OR "portugal"[MeSH Terms] OR "puerto rico"[MeSH Terms] OR "romania"[MeSH Terms] OR "russia"[MeSH Terms] OR "rwanda"[MeSH Terms] OR "samoa"[MeSH Terms] OR "sao tome and principe"[MeSH Terms] OR "saudi arabia"[MeSH Terms] OR "senegal"[MeSH Terms] OR "serbia"[MeSH Terms] OR "seychelles"[MeSH Terms] OR "sierra leone"[MeSH Terms] OR "slovakia"[MeSH Terms] OR "slovenia"[MeSH Terms] OR "melanesia"[MeSH Terms] OR "somalia"[MeSH Terms] OR "south africa"[MeSH Terms] OR "south sudan"[MeSH Terms] OR "sri lanka"[MeSH Terms] OR "saint kitts and nevis"[MeSH Terms] OR "saint lucia"[MeSH Terms] OR "saint vincent and the grenadines"[MeSH Terms] OR "sudan"[MeSH Terms] OR "suriname"[MeSH Terms] OR "syria"[MeSH Terms] OR "tajikistan"[MeSH Terms] OR "tanzania"[MeSH Terms] OR "thailand"[MeSH Terms] OR "timor leste"[MeSH Terms] OR "togo"[MeSH Terms] OR "tonga"[MeSH Terms] OR "trinidad and tobago"[MeSH Terms] OR "tunisia"[MeSH Terms] OR "turkey"[MeSH Terms] OR "turkmenistan"[MeSH Terms] OR "uganda"[MeSH Terms] OR "ukraine"[MeSH Terms] OR "uruguay"[MeSH Terms] OR "uzbekistan"[MeSH Terms] OR "vanuatu"[MeSH Terms] OR "venezuela"[MeSH Terms] OR "vietnam"[MeSH Terms] OR "middle east"[MeSH Terms] OR "yemen"[MeSH Terms] OR "yugoslavia"[MeSH Terms] OR "zambia"[MeSH Terms] OR "zimbabwe"[MeSH Terms] OR "africa south of the sahara"[MeSH Terms] OR "africa, central"[MeSH Terms] OR "africa, northern"[MeSH Terms] OR "africa, southern"[MeSH Terms] OR "africa, eastern"[MeSH Terms] OR "africa, western"[MeSH Terms] OR "west indies"[MeSH Terms] OR "indian ocean islands"[MeSH Terms] OR "caribbean region"[MeSH Terms] OR "central america"[MeSH Terms] OR "latin america"[MeSH Terms] OR "south america"[MeSH Terms] OR "asia, central"[MeSH Terms] OR "asia, northern"[MeSH Terms] OR "asia, southeastern"[MeSH Terms] OR "asia, western"[MeSH Terms] OR "europe, eastern"[MeSH Terms] OR "developing countries"[MeSH Terms] OR "afghanistan"[Text Word] OR "albania"[Text Word] OR "algeria"[Text Word] OR "american samoa"[Text Word] OR "angola"[Text Word] OR "antigua"[Text Word] OR "barbuda"[Text Word] OR "argentina"[Text Word] OR "armenia"[Text Word] OR "armenian"[Text Word] OR "aruba"[Text Word] OR "azerbaijan"[Text Word] OR "bahrain"[Text Word] OR "bangladesh"[Text Word] OR "barbados"[Text Word] OR "belarus"[Text Word] OR "byelarus"[Text Word] OR "belorussia"[Text Word] OR "byelorussian"[Text Word] OR "belize"[Text Word] OR "british honduras"[Text Word] OR "benin"[Text Word] OR "dahomey"[Text Word] OR "bhutan"[Text Word] OR "bolivia"[Text Word] OR "bosnia"[Text Word] OR "herzegovina"[Text Word] OR "botswana"[Text Word] OR "bechuanaland"[Text Word] OR "brazil"[Text Word] OR "brasil"[Text Word] OR "bulgaria"[Text Word] OR "burkina faso"[Text Word] OR "burkina fasso"[Text Word] OR "upper volta"[Text Word] OR "burundi"[Text Word] OR "urundi"[Text Word] OR "cabo verde"[Text Word] OR "cape verde"[Text Word] OR "cambodia"[Text Word] OR "kampuchea"[Text Word] OR "khmer republic"[Text Word] OR "cameroon"[Text Word] OR "cameron"[Text Word] OR "cameroun"[Text Word] OR "central african republic"[Text Word] OR "ubangi shari"[Text Word] OR "chad"[Text Word] OR "chile"[Text Word] OR "china"[Text Word] OR "colombia"[Text Word] OR "comoros"[Text Word] OR "comoro islands"[Text Word] OR "mayotte"[Text Word] OR "congo"[Text Word] OR "zaire"[Text Word] OR "costa rica"[Text Word] OR "cote d ivoire"[Text Word] OR "cote d ivoire"[Text Word] OR "ivory coast"[Text Word] OR "croatia"[Text Word] OR "cuba"[Text Word] OR "cyprus"[Text Word] OR "czech republic"[Text Word] OR "czechoslovakia"[Text Word] OR "djibouti"[Text Word] OR "french somaliland"[Text Word] OR "dominica"[Text Word] OR

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"dominican republic"[Text Word] OR "ecuador"[Text Word] OR "egypt"[Text Word] OR "united arab republic"[Text Word] OR "el salvador"[Text Word] OR "equatorial guinea"[Text Word] OR "spanish guinea"[Text Word] OR "eritrea"[Text Word] OR "estonia"[Text Word] OR "eswatini"[Text Word] OR "swaziland"[Text Word] OR "ethiopia"[Text Word] OR "fiji"[Text Word] OR "gabon"[Text Word] OR "gabonese republic"[Text Word] OR "gambia"[Text Word] OR "georgia"[Text Word] OR "georgian"[Text Word] OR "ghana"[Text Word] OR "gold coast"[Text Word] OR "gibraltar"[Text Word] OR "greece"[Text Word] OR "grenada"[Text Word] OR "guam"[Text Word] OR "guatemala"[Text Word] OR "guinea"[Text Word] OR "guyana"[Text Word] OR "guiana"[Text Word] OR "haiti"[Text Word] OR "hispaniola"[Text Word] OR "honduras"[Text Word] OR "hungary"[Text Word] OR "india"[Text Word] OR "indonesia"[Text Word] OR "timor"[Text Word] OR "iran"[Text Word] OR "iraq"[Text Word] OR "isle of man"[Text Word] OR "jamaica"[Text Word] OR "jordan"[Text Word] OR "kazakhstan"[Text Word] OR "kazakh"[Text Word] OR "kenya"[Text Word] OR "korea"[Text Word] OR "kosovo"[Text Word] OR "kyrgyzstan"[Text Word] OR "kirghizia"[Text Word] OR "kirgizstan"[Text Word] OR "kyrgyz republic"[Text Word] OR "kirghiz"[Text Word] OR "laos"[Text Word] OR "lao pdr"[Text Word] OR "lao people s democratic republic"[Text Word] OR "latvia"[Text Word] OR "lebanon"[Text Word] OR "lesotho"[Text Word] OR "basutoland"[Text Word] OR "liberia"[Text Word] OR "libya"[Text Word] OR "libyan arab jamahiriya"[Text Word] OR "lithuania"[Text Word] OR "macau"[Text Word] OR "macao"[Text Word] OR "macedonia"[Text Word] OR "madagascar"[Text Word] OR "malagasy republic"[Text Word] OR "malawi"[Text Word] OR "nyasaland"[Text Word] OR "malaysia"[Text Word] OR "maldives"[Text Word] OR "indian ocean"[Text Word] OR "mali"[Text Word] OR "malta"[Text Word] OR "micronesia"[Text Word] OR "kiribati"[Text Word] OR "marshall islands"[Text Word] OR "nauru"[Text Word] OR "northern mariana islands"[Text Word] OR "palau"[Text Word] OR "tuvalu"[Text Word] OR "mauritania"[Text Word] OR "mauritius"[Text Word] OR "mexico"[Text Word] OR "moldova"[Text Word] OR "moldovian"[Text Word] OR "mongolia"[Text Word] OR "montenegro"[Text Word] OR "morocco"[Text Word] OR "ifni"[Text Word] OR "mozambique"[Text Word] OR "portuguese east africa"[Text Word] OR "myanmar"[Text Word] OR "burma"[Text Word] OR "namibia"[Text Word] OR "nepal"[Text Word] OR "netherlands antilles"[Text Word] OR "nicaragua"[Text Word] OR "niger"[Text Word] OR "nigeria"[Text Word] OR "oman"[Text Word] OR "muscat"[Text Word] OR "pakistan"[Text Word] OR "panama"[Text Word] OR "papua new guinea"[Text Word] OR "paraguay"[Text Word] OR "peru"[Text Word] OR "philippines"[Text Word] OR "philipines"[Text Word] OR "phillipines"[Text Word] OR "poland"[Text Word] OR "polish people s republic"[Text Word] OR "portugal"[Text Word] OR "portuguese republic"[Text Word] OR "puerto rico"[Text Word] OR "romania"[Text Word] OR "russia"[Text Word] OR "russian federation"[Text Word] OR "ussr"[Text Word] OR "soviet union"[Text Word] OR "union of soviet socialist republics"[Text Word] OR "rwanda"[Text Word] OR "ruanda"[Text Word] OR "samoa"[Text Word] OR "pacific islands"[Text Word] OR "polynesia"[Text Word] OR "samoan islands"[Text Word] OR "sao tome and principe"[Text Word] OR "saudi arabia"[Text Word] OR "senegal"[Text Word] OR "serbia"[Text Word] OR "seychelles"[Text Word] OR "sierra leone"[Text Word] OR "slovakia"[Text Word] OR "slovak republic"[Text Word] OR "slovenia"[Text Word] OR "melanesia"[Text Word] OR "solomon island"[Text Word] OR "solomon islands"[Text Word] OR "norfolk island"[Text Word] OR "somalia"[Text Word] OR "south africa"[Text Word] OR "south sudan"[Text Word] OR "sri lanka"[Text Word] OR "ceylon"[Text Word] OR "saint kitts and nevis"[Text Word] OR "st kitts and nevis"[Text Word] OR "saint lucia"[Text Word] OR "st lucia"[Text Word] OR "saint vincent"[Text Word] OR "st vincent"[Text Word] OR "grenadines"[Text Word] OR "sudan"[Text Word] OR "suriname"[Text Word] OR "surinam"[Text Word] OR "syria"[Text Word] OR "syrian arab republic"[Text Word] OR "tajikistan"[Text Word] OR "tadjikistan"[Text Word] OR "tadzhikistan"[Text Word] OR "tadzhik"[Text Word] OR "tanzania"[Text Word] OR "tanganyika"[Text Word] OR "thailand"[Text Word]

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OR "siam"[Text Word] OR "timor leste"[Text Word] OR "east timor"[Text Word] OR "togo"[Text Word] OR "togolese republic"[Text Word] OR "tonga"[Text Word] OR "trinidad"[Text Word] OR "tobago"[Text Word] OR "tunisia"[Text Word] OR "turkey"[Text Word] OR "turkmenistan"[Text Word] OR "turkmen"[Text Word] OR "uganda"[Text Word] OR "ukraine"[Text Word] OR "uruguay"[Text Word] OR "uzbekistan"[Text Word] OR "uzbek"[Text Word] OR "vanuatu"[Text Word] OR "new hebrides"[Text Word] OR "venezuela"[Text Word] OR "vietnam"[Text Word] OR "viet nam"[Text Word] OR "middle east"[Text Word] OR "west bank"[Text Word] OR "gaza"[Text Word] OR "palestine"[Text Word] OR "yemen"[Text Word] OR "yugoslavia"[Text Word] OR "zambia"[Text Word] OR "zimbabwe"[Text Word] OR "northern rhodesia"[Text Word] OR "global south"[Text Word] OR "africa south of the sahara"[Text Word] OR "sub saharan africa"[Text Word] OR "subsaharan africa"[Text Word] OR "central africa"[Text Word] OR "north africa"[Text Word] OR "northern africa"[Text Word] OR "magreb"[Text Word] OR "maghrib"[Text Word] OR "sahara"[Text Word] OR "southern africa"[Text Word] OR "east africa"[Text Word] OR "eastern africa"[Text Word] OR "west africa"[Text Word] OR "western africa"[Text Word] OR "west indies"[Text Word] OR "indian ocean islands"[Text Word] OR "caribbean"[Text Word] OR "central america"[Text Word] OR "latin america"[Text Word] OR "south america"[Text Word] OR "central asia"[Text Word] OR "north asia"[Text Word] OR "northern asia"[Text Word] OR "southeastern asia"[Text Word] OR "south eastern asia"[Text Word] OR "southeast asia"[Text Word] OR "south east asia"[Text Word] OR "western asia"[Text Word] OR "east europe"[Text Word] OR "eastern europe"[Text Word] OR "developing country"[Text Word] OR "developing countries"[Text Word] OR "developing nation"[Text Word] OR "developing nations"[Text Word] OR "developing population"[Text Word] OR "developing populations"[Text Word] OR "developing world"[Text Word] OR "less developed country"[Text Word] OR "less developed countries"[Text Word] OR "less developed nation"[Text Word] OR "less developed nations"[Text Word] OR "less developed world"[Text Word] OR "lesser developed countries"[Text Word] OR "lesser developed nations"[Text Word] OR "under developed country"[Text Word] OR "under developed countries"[Text Word] OR "under developed nations"[Text Word] OR "under developed world"[Text Word] OR "underdeveloped country"[Text Word] OR "underdeveloped countries"[Text Word] OR "underdeveloped nation"[Text Word] OR "underdeveloped nations"[Text Word] OR "underdeveloped population"[Text Word] OR "underdeveloped populations"[Text Word] OR "underdeveloped world"[Text Word] OR "middle income country"[Text Word] OR "middle income countries"[Text Word] OR "middle income nation"[Text Word] OR "middle income nations"[Text Word] OR "middle income population"[Text Word] OR "middle income populations"[Text Word] OR "low income country"[Text Word] OR "low income countries"[Text Word] OR "low income nation"[Text Word] OR "low income nations"[Text Word] OR "low income population"[Text Word] OR "low income populations"[Text Word] OR "lower income country"[Text Word] OR "lower income countries"[Text Word] OR "lower income nations"[Text Word] OR "lower income population"[Text Word] OR "lower income populations"[Text Word] OR "underserved countries"[Text Word] OR "underserved nations"[Text Word] OR "underserved population"[Text Word] OR "underserved populations"[Text Word] OR "under served population"[Text Word] OR "under served populations"[Text Word] OR "deprived countries"[Text Word] OR "deprived population"[Text Word] OR "deprived populations"[Text Word] OR "poor country"[Text Word] OR "poor countries"[Text Word] OR "poor nation"[Text Word] OR "poor nations"[Text Word] OR "poor population"[Text Word] OR "poor populations"[Text Word] OR "poor world"[Text Word] OR "poorer countries"[Text Word] OR "poorer nations"[Text Word] OR "poorer population"[Text Word] OR "poorer populations"[Text Word] OR "developing economy"[Text Word] OR "developing economies"[Text Word] OR "less developed economy"[Text Word] OR "less developed economies"[Text Word] OR "underdeveloped economies"[Text Word] OR "middle income economy"[Text Word] OR "middle income economies"[Text Word] OR "low income economy"[Text Word] OR "low income economies"[Text Word] OR

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"lower income economies"[Text Word] OR "low gdp"[Text Word] OR "low gnp"[Text Word] OR "low gross domestic"[Text Word] OR "low gross national"[Text Word] OR "lower gdp"[Text Word] OR "lower gross domestic"[Text Word] OR "lmic"[Text Word] OR "lmics"[Text Word] OR "third world"[Text Word] OR "lami country"[Text Word] OR "lami countries"[Text Word] OR "transitional country"[Text Word] OR "transitional countries"[Text Word] OR "emerging economies"[Text Word] OR "emerging nation"[Text Word] OR "emerging nations"[Text Word]

AND

Restricted to 2010 or older

Date run: 19 August 2021

Document results: 6453

Scopus search terms

TITLE-ABS-KEY (zerodose OR zero-dose OR unvaccinat* OR unimmuniz* OR unimmunis* OR under-vaccinat* OR under-immuniz* OR under-immunis* OR non-vaccinat*)

And

TITLE-ABS-KEY({child} OR {infant} OR {adolescent} OR {children} OR {infants} OR {adolescents} OR {pediatric patient} OR {pediatric patients} OR {adolescence} OR {youth} OR {youths} OR {young adult} OR {young adults} OR {juvenile} OR {childhood} OR {teenager} OR {teenagers} OR {teen} OR {teens} OR {preschool child} OR {neonate} OR {newborn} OR {baby} OR {pediatric} OR {pediatrics} OR {paediatric} OR {paediatrics} OR {toddler} OR {toddlers})

And

TITLE-ABS-KEY("Antigua and Barbuda" OR "Atlantic Islands" OR "Baltic States" OR "Commonwealth of Independent States" OR "Democratic People's Republic of Korea" OR "Democratic Republic of the Congo" OR "deprived countries" OR "deprived population" OR "deprived populations" OR "developing countries" OR "developing country" OR "developing economies" OR "developing economy" OR "developing nation" OR "developing nations" OR "developing population" OR "developing populations" OR "developing world" OR "Equatorial Guinea" OR "French Guiana" OR "Georgia Republic" OR "Independent State of Samoa" OR "Indian Ocean Islands" OR "lami countries" OR "lami country" OR "less developed countries" OR "less developed country" OR "less developed economies" OR "less developed economy" OR "less developed nation" OR "less developed nations" OR "less developed world" OR "lesser developed countries" OR "lesser developed nations" OR "low gdp" OR "low gnp" OR "low gross domestic" OR "low gross national" OR "low income countries" OR "low income country" OR "low income economies" OR "low income economy")

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OR "low income economies" OR "low income economy" OR "low income nations" OR "low income population" OR "low income populations" OR "lower gdp" OR "lower gross domestic" OR "lower income countries" OR "lower income country" OR "lower income nations" OR "lower income population" OR "lower income populations" OR "Macedonia Republic" OR "Melanesia" OR "middle income countries" OR "middle income country" OR "middle income economies" OR "middle income nation" OR "middle income nations" OR "middle income population" OR "middle income populations" OR "Pacific Islands" OR "poor countries" OR "poor country" OR "poor nation" OR "poor nations" OR "poor population" OR "poor populations" OR "poor world" OR "poorer countries" OR "poorer nations" OR "poorer population" OR "poorer populations" OR "Republic of Belarus" OR "Saint Kitts and Nevis" OR "Saint Vincent and the Grenadines" OR "South Sudan" OR "third world" OR "transitional countries" OR "transitional country" OR "Trinidad and Tobago" OR "under developed countries" OR "under developed country" OR "under developed nations" OR "under developed world" OR "under served population" OR "under served populations" OR "underdeveloped countries" OR "underdeveloped country" OR "underdeveloped economies" OR "underdeveloped nations" OR "underdeveloped population" OR "underdeveloped world" OR "underserved countries" OR "underserved nations" OR "underserved population" OR "underserved populations" OR "Afghanistan" OR "Africa" OR "Albania" OR "Algeria" OR "American Samoa" OR "Angola" OR "Argentina" OR "Armenia" OR "Asia" OR "Azerbaijan" OR "Bahrain" OR "Bangladesh" OR "Barbados" OR "Belize" OR "Benin" OR "Bhutan" OR "Bolivia" OR "Bosnia-Herzegovina" OR "Botswana" OR "Brazil" OR "Bulgaria" OR "Burkina Faso" OR "Burundi" OR "Cambodia" OR "Cameroon" OR "Cape Verde" OR "Caribbean Region" OR "Central African Republic" OR "Central America" OR "Chad" OR "Chile" OR "China" OR "Colombia" OR "Comoros" OR "Congo" OR "Costa Rica" OR "Cote d'Ivoire" OR "Croatia" OR "Cuba" OR "Cyprus" OR "Czech Republic" OR "Czechoslovakia" OR "Developing Countries" OR "Djibouti" OR "Dominica" OR "Dominican Republic" OR "East Timor" OR "Ecuador" OR "Egypt" OR "El Salvador" OR "Eritrea" OR "Estonia" OR "Eswatini" OR "Ethiopia" OR "Fiji" OR "Gabon" OR "Gambia" OR "Ghana" OR "Grenada" OR "Guam" OR "Guatemala" OR "Guinea" OR "Guinea-Bissau" OR "Guyana" OR "Haiti" OR "Honduras" OR "India" OR "Indonesia" OR "Iran" OR "Iraq" OR "Jamaica" OR "Jordan" OR "Kazakhstan" OR "Kenya" OR "Korea" OR "Kyrgyzstan" OR "Laos" OR "Latin America" OR "Latvia" OR "Lebanon" OR "Lesotho" OR "Liberia" OR "Libya" OR "Lithuania" OR "Imic" OR "Imics" OR "Madagascar" OR "Malawi" OR "Malaysia" OR "Mali" OR "Malta" OR "Mauritania" OR "Mauritius" OR "Mexico" OR "Micronesia" OR "Middle East" OR "Moldova" OR "Mongolia" OR "Montenegro" OR "Montenegro" OR "Morocco" OR "Mozambique" OR "Myanmar" OR "Namibia" OR "Nepal" OR "Netherlands Antilles" OR "New Caledonia" OR "Nicaragua" OR "Niger" OR "Nigeria" OR "Oman" OR "Pakistan" OR "Palau" OR "Panama" OR "Papua New Guinea" OR "Paraguay" OR "Peru" OR "Philippines" OR "Poland" OR "Portugal" OR "Puerto Rico" OR "Romania" OR "Russia" OR "Rwanda" OR "Saint Lucia" OR "Samoa" OR "Saudi Arabia" OR "Senegal" OR "Serbia" OR "Seychelles" OR "Sierra Leone" OR "Slovakia" OR "Slovenia" OR "Somalia" OR "South Africa" OR "South America" OR "Sri Lanka" OR "Sudan" OR "Suriname" OR "Swaziland" OR "Syria" OR "Tajikistan" OR "Tanzania" OR "Thailand" OR "Togo" OR "Tonga" OR "Tunisia" OR "Turkey" OR "Turkmenistan" OR "Uganda" OR "Ukraine" OR "Uruguay" OR "USSR" OR "Uzbekistan" OR "Vanuatu" OR "Venezuela" OR "Vietnam" OR "West Indies" OR "Yemen" OR "Yugoslavia" OR "Zambia" OR "Zimbabwe"

Date run: 23 August 2021

Document results: 2002

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World Wide Science search terms

("zero dose" OR "zero-dose" OR unvaccinat* OR unimmuniz* OR unimmunis* OR under-vaccinat* OR under-immuniz* OR under-immunis* OR non-vaccinat*) NOT "environmental"

Then filtered by:

Date: 2010-2021

Groupings: "Vaccination", "Activity", and "Study"

Date run: 23 August 2021

Document results: 646

WHO MEDICUS search terms

tw:(tw:(tw:(zero-dose)) OR (tw:(zerodose)) OR (tw:(unvaccinate*)) OR (tw:(under-vaccinate*)) OR (tw:(unimmunize*)) OR (tw:(unimmunise*)) OR (tw:(under-immunize*)) OR (tw:(under-immunise*))) AND (year_cluster:[2010 TO 2021]) AND ((tw:(infant)) OR (tw:(child*)) OR (tw:(adolescent)))) AND (year_cluster:[2010 TO 2021])

Date run: 19 August 2021

Document results: 163

WHO IRIS search terms

zerodose OR unvaccinate* OR unimmunize* OR unimmunise* OR under-vaccinate* OR under-immunise*

Date run: 19 August 2021

Document results: 92

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ANNEX 2

INCLUSION AND EXCLUSION CRITERIA

Title/abstract screening

First round

Inclusion criteria

- Papers that discuss or describe zero-dose, unvaccinated, or under-vaccinated children or adolescents and/or strategies to reach them
- Papers that describe SIAs of any form
- Papers on EPI vaccines
- Papers on vaccination in low- and middle-income settings (or with broader geographic focus including LMIC)
- Papers in English, French, Spanish, Portuguese, Italian, Russian, Ukrainian
- Papers published in 2010-2021

Exclusion criteria

- Papers that specifically focus on non-EPI vaccines (smallpox; Ebola; SARS-CoV-2, RTS,S; rabies; dengue) or vaccines in development
- Papers specific to adult vaccination or vaccination of health care workers
- Papers specific to vaccination strategies in high-income countries

Second round

Exclusion criteria

- Papers that do not have a “REACH” component of the IRMMA framework (ie only advocacy or identify)
- Papers that focus on non-traditional EPI vaccines, per the WHO table (ie varicella, Hep A)
- Papers focused only on high- or upper-middle-income countries

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Third round

Exclusion criteria

- Meeting reports
- Wrong-way integration
- Commentary/editorials
- Papers that were not specifically focused on polio, measles/measles-rubella or routine EPI as a whole

Title/abstract screening

Full text screening

Inclusion criteria

- Papers that identify and/or characterize unvaccinated/under-vaccinated individuals or communities
- Papers that describe targeted/tailored supplemental strategies to reach children who are unvaccinated or under-vaccinated

Exclusion criteria

- Modeling studies that estimate the quantity of unvaccinated/under-vaccinated children without explaining how to reach or track them (i.e. modeling from DHS or MICS)
- Papers that describe national non-selective SIAs (tag these but exclude)

ANNEXURE

ANNEX 3

DATA EXTRACTION TEMPLATE

CITATION INFORMATION	
Title	
First author	Last name and first/middle initials (e.g. Moss WJ)
Publication year	
Publication name	Journal name, website, etc.
STUDY CHARACTERISTICS	
Geographic scope of the study	Where was the study/intervention conducted? (e.g., Zambia, global, SEARO, all Gavi countries)
Which vaccines were used?	Select all vaccines used in the study/intervention
	Measles vaccine (measles, MR, etc.)
	Polio (OPV, IPV)
	DTP/pentavalent
	General/full EPI portfolio (vaccines not specified)
Other	
Who funded this study/intervention?	
What <u>are</u> the study aims?	
METHODS	
What was the approach or strategy (as described in the article)?	
What was the rationale for choosing the above strategy/approach?	What was the specific country context or other details explaining why this approach/strategy was used? (Ex. farming region; extended hours for working parents)

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Which study designs were used?	Experimental (RCT)
	Other experimental (non-RCT)
	Observational (cross-sectional, cohort, case-control)
	Systematic review
	Program evaluation
	Economic evaluation
	Qualitative study
	Case report/series, narrative review, commentary
	Other
When did the intervention start and end?	Enter start and end dates. If no dates provided, enter the study duration.
PARTICIPANTS	
What was the target population for this intervention?	Describe the intervention's target population(s)
How many participants were included?	
APPROACH/STRATEGY	
At what level was the intervention (approach/strategy) implemented?	Regional/multi-national (e.g. SEARO region)
	National (administrative level 1)
	Province/state level (administrative level 2)
	District-level (administrative level 3)
	Other
Factors addressed	Delivery
	Demand generation
	Human resources (including training)
	Supply chain
	Identifying un/under-vaccinated children
	M&E
	Other

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Tailoring approach	Epidemiology (i.e., based on measles surveillance, susceptible age groups)
	Program characteristics (i.e., health system infrastructure, vaccination coverage, history of SIAs)
	Geography (i.e., outbreak location, hard-to-reach populations, disaster/conflict areas)
	Population (i.e., <u>socially</u> or economically disadvantaged, mobile)
	Previous vaccination status (i.e., using home-based records or verbal recall)
	Other
Describe the approach/strategy that was implemented	
What partners were involved in the intervention/strategy?	List only those partners named/described in the article. Do not infer partners based on the country or program broadly.
OUTCOMES	
Summarize the authors' interpretation of the outcomes/results	
How did the authors measure success? What impact did the intervention have?	List both the measure <u>used</u> and magnitude of the outcome measured. Outcomes might include impact, outcomes, or outputs (e.g. immunization coverage, number of children reached, change <u>in</u> <u>knowledge</u> /attitudes, increased demand, etc.). Ex. 15% increase in MCV2 coverage, improved reach, etc.
What costs or other economic considerations were described?	Did the authors note funds required? Time demands? Human resource needs?
What challenges or barriers were described?	
What are the study's limitations?	
REVIEWER FEEDBACK	
Questions/concerns	
Include in final synthesis?	Yes (include)
	No (exclude)
	Need to discuss

ANNEXURE

ANNEX 4

CATALOG OF SUPPLEMENTAL STRATEGIES

For each supplemental strategy identified, we catalog the countries or geographic locations where they were used. We also pulled out what outcomes were used to describe success or measure progress of implementation. In some documents these can describe impact, but in others they may be output or outcomes of implementing these strategies. Gradients of evidence describe a synthesis of the evidence available for each strategy in terms of whether strategies “work in all contexts,” have “mixed results,” and where “additional research needed.”

Strategy	Location	Outcomes measured	Gradient of evidence	References
<i>Demand generation</i>				
Financial incentives	India (5), Pakistan (1), Nigeria (1), multiple LMICs (4)	Vaccination coverage, fully immunized child	Mixed results	Chakrabarti (2021), vonHaaren (2021), Ali (2020), Raghunathan (2017), Carvalho (2014), De (2020), Kandpal (2016), Cruz (2017), Ashir (2013), Bassani (2013), Besnier (2021), Crocker-Buque (2017)
Reminders and recall	Multiple (7), India (94), Nigeria (4), Pakistan (2), Kenya (2), Ethiopia (2), Vietnam (1), Philippines (1), Burkina Faso (1), Bangladesh (1), Zimbabwe (1)	Vaccination coverage, vaccination timeliness, fully immunized child, willingness to receive messages	Mixed results; mostly positive results but a few contradictory studies	Jacobsen (2018), Watterson (2015), Nguyen (2017), Mekonnen (2019), Seth (2018), Kazi (2018), Singh (2018), Yunusa (2021), Mokaya (2017), Manakongtreecheep (2017), Garcia-Dia (2017), Johri (2020), Bangure (2015), Brown (2016), Murthy (2019), Mekonnen (2021), Schlumberger (2015), Uddin (2016), Brown (2017), Siddiqi (2020), Kim (2017), Besnier (2021), Atnafu (2017), Crocker-Buque (2017), Oladepo (2020), Eze (2015)
Information, education, & communication (IEC)	India (4), multiple (2), Pakistan (2), Thailand (2), Gambia (1)	Caregiver knowledge, vaccine card retention, vaccination coverage, vaccine timeliness, fully immunized child, caregiver perceptions	Works in all contexts	Zaidi (2020), Vaidyanathan (2019), Johri (2020), Nkereuwem (2021), Saggurti (2018), Kawkungwal (2015), Kim (2017), Goel (2012), Dway (2016), Habib (2017), Mureed (2015)

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Strategy	Location	Outcomes measured	Gradient of evidence	References
<i>Demand generation (continued)</i>				
Social mobilization	Multiple (6), Nigeria (6), India (2), Ghana (1), Ethiopia (1), Cameroon (1), Bangladesh (1), Pakistan (1), Kenya (1), Malawi (1)	Vaccination coverage, fully immunized child, reported cases for surveillance, children identified for microplans, caregiver acceptance, relationship between community and healthcare workers, vaccine card retention	Works in all contexts	Losey (2019), Warigon (2016), Nelson (2016), Freeman (2017), Hammanyero (2018), Chimpololo (2019), Siddique (2016), Uddin (2012), Demissie (2020), Ames (2015), Alhassan (2019), Curry (2014), Ado (2014), Waisbord (2010), Nzioki (2017), Jalloh (2020), Samal (2014), Warigon (2016), Habib (2017), Akwataghibe (2021), Ozawa (2018)
Male caregivers and religious leaders	Nigeria (6), India (3), Bangladesh (2), multiple (2), Pakistan (1), Afghanistan (1)	Vaccination coverage, caregiver acceptance, households resistant to vaccination, fully immunized child, zero dose child	Works in all contexts; where male caregivers and religious leaders influential in vaccine decision-making	Nwakamma (2019), Usman (2019), Fotso (2015), Warigon (2016), Ali (2015), Uddin (2010), Hayford (2014), Adamu (2019), Ado (2014), Aylward (2011), Martinez (2018), Jaliuh (2020), Saggurti (2018), Goel (2012), Nasiru (2012)
Community mobilizers	Nigeria (7), India (4), multiple (2), Ethiopia (2), Bangladesh (1), Malawi (1), Ghana (1), Pakistan (1), Zambia (1), Kenya (1), Laos (1)	Vaccination coverage, dropout rate, zero dose children, fully immunized child, caregiver acceptance, households resistant to vaccination, caregiver knowledge	Works in all contexts	Coates (2013), Weiss (2013), Deutsch (2017), Usman (2019), Nonaka (2014), Hayford (2014), Chantier (2018), Hammanyero (2018), Chimpololo (2019), Siddique (2016), Duru (2019), Igarashi (2010), Asegedew (2019), Alhassan (2019), Ado (2014), Waisbord (2010), Nzioki (2017), Arale (2019), Dougherty (2020), Warigon (2016), Habib (2017), Ongawe (2017)
<i>Human resources</i>				
Training for HCWs	Nigeria (4), India (4), Bangladesh (3), Kenya (2), Uganda (1), Ethiopia (1), Ghana (1), Laos (1), Angola (1), Nepal (1), Afghanistan (1), Pakistan (1), Timor-Leste (1), Other (1)	Knowledge scores, vaccination coverage, service quality, economic cost, training attendance, receipt of services, health service delivery indicators (not specified), RI system functioning	Mixed results; training resulted in short-term outcomes/outputs (e.g. increased knowledge) but impact on vaccination was mixed	Hossain (2021), Wallace (2017), Kosec (2015), Chelagat (2020), Bazos (2015), Uddin (2010), Hayford (2014), Manyazewal (2018), Siddique (2016), Brown (2016), Uddin (2012), Alhassan (2019), Waisbord (2010), Jain (2015), Iwu (2021), Besnier (2021), Fattorini (2019), Basheer (2021)
Supportive supervision	India (2), Nigeria (1), Pakistan (1), Ethiopia (1), Bangladesh (1), North Sudan (1), Zambia (1), Ivory Coast (1), Tanzania (1)	Vaccination coverage, data quality, KABP, health worker proficiency	Works in all contexts	Zaidi (2020), Musa (2018), Manyazewal (2018), Siddique (2016), Uddin (2016), Ryman (2011), Werner (2019), Alogan (2019), Goel (2012)

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Strategy	Location	Outcomes measured	Gradient of evidence	References
<i>Human resources (continued)</i>				
Performance-based financing and incentives for HCWs	India (4), Nigeria (2), DRC (1), Cambodia (1), Burkina Faso (1)	Vaccination coverage, quality of care, drug availability, staff attitude, staff morale, staff punctuality, user fees, healthcare costs	Mixed results	Sato (2020), Ashir (2013), Soeters (2011), Matsuoka (2014), Goel (2012), Rane (2020), Singh (2018), Kosek (2015), Kuunibe (2020)
<i>Supply chain</i>				
Supply chain	Zambia (3), Nigeria (2), Senegal (1), Vietnam (1), Guinea-Bissau (1), India (1), Ethiopia (1), Mali (1)	Wastage rates, vaccination coverage, perception of vial change, stock-outs, vaccine potency	Needs more research; pilot projects generally provided positive results, but outcomes seemed to be more related to wastage and stockouts than vaccination coverage	Krudwig (2020), Sarley (2017), Kanagat (2021), Byberg (2021), Patel (2015), Aina (2017), Zewde (2021), Halm (2012), John Snow Inc
<i>Service delivery</i>				
RED/REC	Multiple (3), Mozambique (1), Ethiopia (1), Nepal (1), Somalia (1), Sudan (1), Nigeria (1), India (1), Kenya (1), Malawi (1), Cambodia (1)	Vaccination coverage, dropout rates, fully immunized, program uptake	Works in all contexts	John Snow Inc (2021), John Snow Inc, MCSP (2018), Mackroth (2010), Khanal (2016), Kamadjeu (2011), Ryman (2011), Bolu (2018), Crocker-Buque (2017), Shikuku (2019), Tsega (2017), Soeung (2013)
Microplanning	India (2), multiple (2), Ethiopia (1), Nepal (1), Afghanistan (1), Nigeria (1), Mozambique (1)	Vaccination coverage, fully immunized, dropout rate, budget change, SIA quality, campaign reach (doses offered), freezer functioning	Works in all contexts; particularly important for reaching zero-dose children	John Snow Inc (2021), John Snow Inc, MCSP (2018), Mackroth (2010), Khanal (2016), Martinez (2018), Adamu (2019), Goel (2011), Chatterjee (2021)
Registries and defaulter tracing	Ethiopia (3), Bangladesh (2), India (2), Pakistan (2), Afghanistan (1), Burkina Faso (1), Kenya (1), Malawi (1), Nigeria (1), Tanzania (1), Timor-Leste (1), Vietnam (1), Zambia (1), variable (1)	Vaccination coverage, app acceptability, defaulter rates, costs, EPI session attendance, age-appropriate vaccination, data use in program planning, dose intervals	Needs more research in terms of operationally how would be implemented, but generally works in contexts where deployed	Nguyen (2017), Usman (2019), Zaidi (2020), Mokaya (2017), Chantler (2018) Siddique (2016), Uddin (2012), Demissie (2020), Schlumberger (2015), Uddin (2017), Werner (2019), Zaidi (2020b), Jain (2015), Atnafu (2017), Tsega (2017), Mureed (2015)

ANNEXURE

Strategy	Location	Outcomes measured	Gradient of evidence	References
<i>Service delivery (continued)</i>				
CHWs	India (8), multiple (4), Pakistan (3), Kenya (3), Uganda (2), Ethiopia (2), Bangladesh (2), Thailand (1)	Visits from CHWs, card retention, vaccination coverage, fully immunized child, number of cases	Works in all contexts	Babu (2018), Wagner (2017), Kamugisha (2018), Ganguly (2018), Freeman (2017), Stamidis (2019), Kawakatsu (2015), Uddin (2012), Demissie (2020), Hsu (2019), Curry (2014), Nzioki (2017), Hsu (2018), Zaidi (2020), Elhamidi (2017), Varghese (2014), Goel (2011), Pinna (2020), Crocker-Buque (2017), Shikuku (2019), Mupere (2020), Bhuiya (2016), Koehn (2020), Mureed (2015), Patel (2010)
Community immunization points	Nigeria (4), multiple (3), Thailand (2), Pakistan (2), Afghanistan (2), global (1), Somalia (1), India (1), Egypt (1)	Vaccination coverage, caregiver knowledge, zero dose children, fully immunized child	Works in contexts particularly to reach zero-dose children	Musa (2018), Simpson (2014), Hsu (2019), Canavati (2011), Mbaeyi (2014), Ado (2014), Arale (2019), Martinez (2018), Jsu (2018), Kaji (2016), El Sayed (2011), Crocker-Busque (2017), Orenstein (2018), Bawa (2018), Nkwogu (2018), Laxminarayan (2016), Morales (2016)
PIRIs	India (5)	Planned immunization sessions held, vaccination coverage, fully immunized child, register of children due for vaccination, caregiver knowledge	Needs more research; all papers were from India	Summan (2021), Clarke-Deeider (2021), Algotar (2019), Bhadoria (2019), Laminarayan (2016)
Child health days, immunization weeks	Multiple (9), India (5), Somalia (3), Afghanistan (2), DRC (1), Ethiopia (1), Sierra Leone (1), Uganda (1), Yemen (1)	Vaccination coverage, vaccine availability, vaccine timeliness, fully immunized child, zero-dose children, doses administered	Mixed results	Saxena (2015), Mehta (2017), Mackroth (2010), Singh (2018), Freeman (2017), Chakrabarti (2019), Palmer (2013), Sesay (2015), Ryman (2012), Kamadjeu (2011), Simpson (2014), Oliphant (2010), Mitiku (2011), Mbaeyi (2014), Waisbord (2010), Aylward (2011), Martinez (2018), El Bcheraoui (2018), Farag (2014), Mirza (2012), Mupere (2020), Bazira (2015), Mahajan (2019), Mbaeyi (2017), Morales (2016)
Outreach sessions	Nigeria (4), India (3), Uganda (2), Pakistan (2), Multiple (2), Somalia (1), Sudan (1), South Sudan (1), Yemen (1), Ethiopia (1), Laos (1), Cambodia (1), Angola (1)	Vaccination coverage, immunization balance scorecard, caregiver perception, fully immunized child, planned immunization sessions held	Works in contexts particularly to reach zero-dose children	John Snow Inc (2019), AtharAnsari (2010), Zaidi (2020), Sengupta (2017), Nsubuga (2019), Oryema (2017), Kamadjeu (2011), Mitiku (2011), Oladeji (2019), Ado (2014), Coghlan (2014), Ryman (2011), El Bcheraoui (2018), Bawa (2018), Chatterjee (2021), Warigon (2016), Habib (2017), Crocker-Buque (2017), Fattorini (2019), Bawa (2019), Merali (2014), Morales (2016)
Extended hours	Bangladesh (3), Nigeria (1), Multiple (1)	Vaccination coverage, fully immunized child, dropout rate, vaccination timeliness missed opportunities for vaccination	Needs more research; seems promising for urban areas	Uddin (2010), Hayford (2014), Adamu (2019), Uddin (2012), Crocker-Buque (2017)

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ANNEX 5

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Listed alphabetically by first author

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