HEALTH SYSTEMS STRENGTHENING ACCELERATOR

LEVERAGING IMMUNIZATION CAMPAIGNS TO STRENGTHEN ROUTINE IMMUNIZATION AND HEALTH SYSTEMS

A Systematic Review of Literature

March 2021 | Benjamin Picillo, Leah Ewald, and Grace Chee

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HEALTH SYSTEMS STRENGTHENING ACCELERATOR

The Health Systems Strengthening Accelerator (Accelerator) is a global initiative funded by the United States Agency for International Development (USAID), with co-funding from the Bill & Melinda Gates Foundation. Its goal is to partner with countries to build resilient high-performing health systems that respond to persistent and emerging health challenges that disproportionately impact vulnerable populations. The Accelerator contributes to USAID's strategy for achieving improved health equity, quality, and resource optimization, by helping countries apply a whole-of-systems lens to intractable health systems issues, connecting local innovation and global knowledge, strengthening local ownership and processes, and building the institutional architecture needed to ensure lasting change.

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ACRONYM LIST

AEFI	Adverse event following immunization
AFP	Acute flaccid paralysis
AFRO	WHO African Region
bOPV	Bivalent oral poliovirus vaccine
CHD	Child health day
C-LQAS	Clustered lot quality assurance sampling
COVID-19	Coronavirus
DHS	Demographic and Health Survey
DRC	Democratic Republic of Congo
DTP	Diphtheria, tetanus, and pertussis
EPI	Expanded Program on Immunization
EMRO	WHO Eastern Mediterranean Region
EURO	WHO European Region
EVD	Ebola virus disease
GPEI	Global Polio Eradication Initiative
GSM	Global System for Mobile Communications
HPV	Human papilloma virus
HSIS	Health Systems and Immunization Strengthening
HSS	Health Systems Strengthening
IA2030	Immunization Agenda 2030
ICER	Incremental cost-effectiveness ratio
IPC	Infection prevention control
IPV	Inactivated poliovirus vaccine
LMIC	Low- and middle-income country
LQAS	Lot-quality assurance sampling
MCV	Measles-containing vaccine
MICS	Multi-Indicator Cluster Survey
PAHO	Pan American Health Organization
PHC	Primary health care
PIRI	Periodic intensification of routine immunization
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RED/REC	Reaching Every District/Reaching Every Child
RI	Routine immunization
SAGE	Strategic Advisory Group of Experts
SARS	Severe acute respiratory syndrome
SBCC	Social behavior change communication
SEARO	WHO South-East Asia Region
SIA	Supplementary immunization activity
SMNet	Social Mobilization Network (India)
SMS	Short message service
tOPV	Trivalent oral poliovirus vaccine
UNICEF	United Nations Children Fund
USAID	United States Agency for International Development
VPD	Vaccine preventable disease
WHO	World Health Organization
WPRO	WHO Western Pacific Region

EXECUTIVE SUMMARY

Introduction

There is a continued need to explore how decision-making on the appropriate and strategic use of campaigns and routine immunization (RI)[1] systems — vis-à-vis their relative effectiveness — can be more productive and effective at increasing and maintaining immunization coverage. It is essential to identify opportunities to:

- Improve policies that affect country decisions regarding national campaigns versus other strategies for closing immunity gaps.
- Strengthen campaign effectiveness at the country level.

Strengthen coordination between campaigns and RI systems to create a complementary approach to identifying and reaching the unvaccinated to reduce dependence on campaign-based delivery and strengthen country RI systems.

Objectives

While the role that campaigns have played in increasing immunization coverage, increasing population immunity, and achieving eradication globally is well-documented, there is a need to systematically identify and synthesize the evidence on how campaigns can be deployed more effectively and/or efficiently, and how campaigns could contribute to longer-term RI strengthening. The objective of this systematic literature review was to identify, analyze, and synthesize evidence related to the research questions of interest and to summarize key learnings and identify gaps in evidence that would support practical approaches for more holistic country-level planning among RI, campaigns, and other immunization service delivery modalities to achieve immunization goals.

Methods

The authors employed multiple search strategies — including electronic peer-reviewed database searches and gray literature reviews — to find a broad range of resources that would contribute to the research areas of interest. The review used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as a guiding framework for the search. The authors conducted further qualitative analysis of all included resources to provide more detailed data responding to the research themes of interest. This analysis synthesized common findings across major themes and highlighted particularly compelling examples of innovative practices to characterize the evidence base while identifying possible gaps within the data.

Results

A total of 2,560 unique records were identified from peer-reviewed and gray literature sources; 185 were eligible for full-text review, of which 134 were included in a full-text thematic analysis. The most prevalent area explored through the literature was documentation of practical experiences with different campaign-based delivery modalities, including documenting promising practices or challenges in implementation (N=29, 13.6%). The most discussed modalities were catch-up campaigns and PIRIs. Approximately 10% (N=20) of the included literature documented efforts of campaigns to strengthen functions of the health system. Literature that documented efforts to either provide inputs or strengthen processes related to any health system function were coded to this theme. A substantial section of the literature also discussed challenges in reaching underimmunized or zero-dose children and broader topics related to reducing inequities in immunization coverage through campaign-based delivery modalities (N=19, 8.9%).

[1] For this paper, routine immunization includes fixed-site vaccination, routine outreach, and mobile outreach.

The included literature demonstrated a substantial body of work on improving coverage estimation either during campaigns or in the post-campaign period (N=17, 8.0%). The use of digital technologies and geospatial methodological techniques to improve coverage estimation or targeting of populations were also well-documented. Other relatively prevalent themes explored in the literature were the use of community engagement or social mobilization strategies to improve campaign effectiveness (N=24, 11.3%), disruptions to health system and/or RI as a result of campaigns (N=16, 7.5%), supply-side incentives to health workers and their influence on campaign implementation (N=11, 5.2%), specific discussion of the role of planning and/or Reaching Every District/Reaching Every Child (RED/REC) before or after campaigns (N=10, 4.7%), and the cost-effectiveness of campaigns, though these articles predominantly assessed the cost-effectiveness of national nonselective campaigns against alternatives (N=9, 4.2%).

Conclusions

An in-depth review of the included resources demonstrated that there is a large evidence base on the ways in which campaigns have become more effective at reaching their target populations, as well as the general risks and opportunities that immunization campaigns pose to LMICs' health systems. Published literature on how countries choose among multiple campaign modalities for a specific vaccine (i.e., deciding between a national non-selective SIA versus a geographically targeted SIA) — including cost-effectiveness data — is limited. The short-term and longer-term risks that immunization campaigns pose to RI systems and the health system as a whole have been documented both qualitatively and quantitatively in some contexts. This review also highlighted that campaigns tend to provide a substantial number of health system inputs, such as cold-chain equipment or microplanning capacity strengthening; however, efforts to improve campaign effectiveness or leverage campaign-generated resources (e.g., data, health worker capacity development) for RI strengthening have focused less on strengthening systems performance drives — policies, regulations, organizational structures, and/or behaviors — that could contribute to larger impacts on immunization systems writ large. This review also suggests that polio SIAs have been successful in reaching hard-to-reach and hard-to-vaccinate communities, though other SIAs (e.g., measles) have had more mixed success in increasing coverage among hard-to-reach communities. Data on these communities generated from SIAs has been used in RI planning in some contexts, but there have been many missed opportunities to strengthen these linkages, including not using this data in surveillance systems to identify emerging immunity gaps, to develop more robust pro-equity RI planning.

Accordingly, there are opportunities to 1) improve policies that affect country decisions regarding the use of national campaigns versus other strategies for closing immunity gaps, and 2) strengthen coordination between campaigns and RI systems to create a complementary approach to identifying and reaching the unvaccinated to reduce dependence on campaign-based delivery and strengthen RI systems. Based on this analysis, there are multiple evidence gaps that if explored could provide important information for immunization and health system managers in LMICs to strengthen the linkage between immunization campaigns and RI systems.

INTRODUCTION

Campaign-based delivery approaches provide essential health services and commodities to children in low- and middle-income countries (LMIC) whose health systems cannot regularly reach target populations [1]. Accordingly, a major strategy to increase immunization coverage and create herd immunity has been the use of mass immunization campaigns to introduce new vaccines and to increase coverage of a range of antigens. Immunization campaigns or supplementary immunization activities (SIA) — coupled with delivery through routine immunization (RI) systems — have been a major component of polio and measles elimination efforts. Other vaccines — such as cholera, Japanese encephalitis, human papilloma virus (HPV), typhoid, and yellow fever — are often introduced through campaign modalities though are also provided through RI. For most vaccines, campaign and RI delivery modalities are used in combination depending on the specific programmatic objectives and contexts.

Despite SIAs' ability to reach large numbers of individuals, the global average of one-dose of measles containing vaccine (MCV1) coverage has remained approximately 85% for more than a decade [2]. Global second-dose (MCV2) coverage has increased to 69% as of 2018 but remains below the threshold required to stop transmission [3]. Achieving the necessary immunity levels to interrupt transmission requires consistently high MCV coverage through RI and SIA approaches coupled with strong routine tracking and surveillance to identify immunity gaps [4]. For polio, support for SIAs through the Global Polio Eradication Initiative (GPEI) has been a major contributor to polio eradication efforts. Only two countries — Afghanistan and Pakistan — still have wild poliovirus transmission as of 2020 [5]. Given the large GPEI investments in immunization system infrastructure for polio eradication, there are opportunities and concerns around how to leverage and sustainably fund these assets for countries' immunization systems once polio is eradicated[5,6].

Despite historical increases in global immunization coverage, substantial coverage inequities exist both across regions and within countries. For example,

of the 19.4 million children less than one-year of age that did not receive three doses of diphtheria, tetanus, and pertussis (DTP3), 41% live in fragile or polio-endemic settings [7]. MCV1 coverage in the World Health Organization's (WHO) African Region (AFRO) region has stagnated at around 71-74% over the last decade, compared to 85% globally [2]. Regional disparities for MCV2 are more substantial, with 26% and 80% MCV2 coverage in AFRO and in WHO's South-East Asia Region (SEARO), respectively, as of 2018 [3]. Significant inequities in coverage by socioeconomic status and geography (including subnational disparities) have been documented through the use of disaggregated data through population-based surveys, such as the Demographic and Health Survey (DHS) or Multi-Indicator Cluster Survey (MICS) [7]. Given these challenges, there has been a renewed focus on creating a shared vision for reaching underimmunized and zero-dose children — estimated at 7 million and 13 million children per year, respectively [6] — in the WHO's Immunization Agenda 2030 (IA2030) and Gavi, the Vaccine Alliance's strategy for 2021-2025, Gavi 5.0 [6–8], which will serve as shared vision for guiding the United States Agency for International Development (USAID)'s investments in immunization [9].

While SIAs and RI services both seek to reduce these coverage inequities, identifying and implementing appropriate service delivery approaches for hard-to-reach (those facing supply-side barriers to receiving immunization services, such as physical accessibility or

discrimination by healthcare providers) and hard-to-vaccinate (those facing demand-side barriers, such as lack of awareness of service availability, or those that distrust the health system) remains a persistent challenge [10]. A key component of increasing equitable access is to identify an optimal set of service delivery modalities—including well-planned and targeted campaigns as needed—to reach under-immunized and zero-dose children while maintaining population-level coverage and strengthening primary health care (PHC) delivery [8,9].

Finding the correct balance of immunization service modalities to address these challenges is an ongoing question, particularly as strong RI systems are needed during inter-campaign periods to maintain coverage [11]. Campaigns may present opportunities for strengthening RI systems, and potentially other aspects of PHC delivery [11–13]. Yet, over-reliance on SIAs as a delivery modality has led to trade-offs in country-led strengthening of RI systems and, in many instances, has not achieved coverage targets for key populations [14]. Preparations for campaigns also require significant resources and effort, often diverting attention and resources from routine service delivery [15,16]. Increased frequency of campaigns can also create fatigue among health workers, which can affect campaign quality [15]. Over the long run, reliance on campaigns to close immunity gaps that result from weak RI systems may not be sustainable [11,13].

The novel coronavirus (COVID-19) pandemic has also significantly disrupted the provision of RI and immunization campaigns in many LMICs, potentially threatening previous gains in immunization coverage and transmission of vaccine-preventable disease (VPD) in fragile and non-fragile settings [9,17]. WHO originally recommended temporary suspension of immunization campaigns in March 2020 [18], which resulted in the cancellation of more than 30 planned measles SIAs in 2020 [17]. However, given varying COVID-19 epidemiological profiles across different contexts, WHO has since created a unified framework for assessing the risk of safely carrying out immunization campaigns during the pandemic that assesses the risk of VPD outbreaks against the risk of COVID-19 and the ability of the health system to safely conduct a campaign with high-quality infection and prevention control (IPC) measures [19]. Nevertheless, a survey of 82 countries in May 2020 revealed that RI activities at both fixed-post sites and through outreaches were 85% lower in May 2020 compared to January and February 2020. 73% of countries also reported a perceived decrease in demand [20]. Recent cost-benefit modeling also suggests that the benefits of maintaining RI services — assuming appropriate service adaptations and IPC measures — outweigh the potential extended mortality impacts from COVID-19 across Africa [21]. These challenges underscore the need to identify practical strategies that can mitigate the expansion of immunity gaps otherwise addressed through SIAs and RI services in non-pandemic circumstances.

In taking stock of the benefits, challenges, and trade-offs that immunization campaigns pose to RI and health systems writ large, there is a continued to need to explore how decision-making on the appropriate and strategic use of campaigns and RI systems — vis-à-vis their relative effectiveness — can be more productive and effective at increasing and/or maintaining immunization coverage, particularly in the context of the COVID-19 pandemic. Therefore, it is important to identify opportunities to 1) improve policies that affect country decisions regarding the use of national campaigns versus other strategies for closing immunity gaps, 2) strengthen campaign effectiveness at the country level, and 3) strengthen coordination between campaigns and RI systems to create a complementary approach to identifying and reaching the unvaccinated in order to reduce dependence on campaign-based delivery and strengthen country RI systems.

Research Questions and Objectives

While the role that campaigns have played in increasing immunization coverage and population immunity globally is well-documented, there is a need to systematically identify and synthesize the evidence on how resources generated from campaigns (e.g., data, social mobilization platforms, microplanning) can be leveraged more effectively and/or efficiently to contribute to longer-term RI strengthening.

While past studies have explored these issues for specific diseases (primarily polio and measles) [13,15,16,22,23], an expanded systematic analysis across multiple disease areas and campaign approaches with an expanded set of research questions represents a novel contribution to the evidence base.

Accordingly, the authors of this review identified the following related questions of interest:

- **Why do countries** choose campaigns as a service delivery modality, in relation to donor incentives, political incentives, performance/quality of routine services, etc.?
- **What strategies** have been implemented to improve campaign effectiveness?
- **What opportunities** and/or risks have campaigns presented to the broader health system (e.g., diverting resources, opportunities for integration, community trust building, first contact with health system)?
- **What has been** the practical experience in utilizing resources and assets from campaigns to strengthen RI systems (e.g., use of data, increased political commitment, public awareness)?
- **How have countries** responded to carrying out immunization campaigns during times of epidemic/pandemic?

The objective of this systematic literature review was to identify, analyze, and synthesize evidence related to the research questions of interest and to summarize key learnings and identify gaps in evidence that would support practical approaches for more holistic country-level planning among RI, campaigns, and other immunization service delivery modalities to achieve immunization goals.

Operational Definition of Immunization Campaigns

Definitions of what constitute "immunization campaigns" vary. Throughout this report, the authors use immunization campaigns and SIAs interchangeably, but employ the WHO 2016 definition of SIAs: "an effective strategy for delivering vaccination to children otherwise missed by routine services or to older susceptible individuals who are not among the age groups targeted by the Expanded Programme on Immunization (EPI) services" [24]. As appropriate, the authors also have employed the following definitions of more specific campaign modalities:

- **Catch-up SIAs** rapidly increase coverage for a specific age group, usually without consideration of past vaccination status; catch-up campaigns can be non-selective or targeted to a specific geographic region [4].
- **Follow-up SIAs** prioritize identifying and vaccinating children born since the last cohort of children immunized through a previous catch-up SIA and without consideration of past vaccination status [4].
- **Mop-up activities** identify and vaccinate children without consideration of past vaccination status within a specific area with known susceptibility and that were previously missed by another SIA [25].
- **Periodic intensification of routine immunization (PIRI)** uses campaign-style approaches to increase coverage of vaccines typically delivered through RI in contexts with low RI coverage. PIRIs can take on multiple modalities, such as immunization days/weeks or child health days (CHDs), but typically deliver immunization and health promotion (in the form of information, education, and communication) with or without the integration of other services (e.g., malaria diagnostics or nutritional status screening), and are most commonly conducted at non-fixed posts [26].

METHODOLOGY

Search Strategy and Information Sources

The authors employed multiple search strategies — including electronic peer-reviewed database searches and gray literature reviews — to find a broad range of resources that would contribute to the research areas of interest. The review used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as a guiding framework for the search. Based on the research questions, the authors elaborated key themes that were then used to shape search terms for the respective reviews. These terms were grouped into two main areas: 1) service delivery modalities to capture the range of campaign and campaign-like approaches to delivering immunization services, and 2) terms that captured key outputs or outcomes of interest on how campaign-based delivery modalities have influenced RI or broader health system strengthening (HSS). The review only considered resources that were immunization-specific but was agnostic of specific vaccines or antigens. As the research question on the continuation of immunization campaigns during times of epidemics was included after the initial review of articles began, the authors employed a more direct search strategy to find peer-reviewed and gray literature on this specific topic.

Peer-Reviewed Literature

The authors conducted a title search in PubMed and Web of Science using the search terms,

including the Boolean operators, described in

Table 1. The search was limited to articles published in 2010 or later. For PubMed, the search was limited to records on human subjects. Both database searches were completed in March 2020.

Gray literature

The gray literature review searched multiple publicly available databases, including the World Bank Open Knowledge Repository, the United Nations Children Fund (UNICEF) research and reports database, and the Gavi and WHO websites; websites of implementing partners with significant experience in immunization were also searched. This portion of the search employed a simplified set of search terms given the likelihood that resources within these databases were more likely to address the key outputs and outcomes of interest. For all except the Gavi website, the authors used the following terms:

TABLE 1 **Peer-reviewed Literature Database Search Terms**

DOMAIN	TERMS
Base	(Immunization OR vaccination)
Service-delivery modality	AND (campaign OR supplementary immunization activit* OR periodic intensification of routine immunization OR integrat* OR routine)
Outputs/outcomes	AND (health system* OR effective* OR coverage OR performance OR quality OR politic* OR strateg* OR risk OR incentive OR cost OR resource* OR funding OR elimination)

(immunization OR vaccination OR immunisation) AND (campaign OR supplementary immunization activity OR SIA). For the Gavi website, the search team used the term immunisation campaign.

Other sources were also identified through consultations with a range of implementing partners that have or are currently working within the immunization space.

RI in pandemic settings literature

Given the narrow scope of this section of the literature search, the authors searched PubMed, and used a simplified Google search to identify possible articles and resources. The search terms included: (ebola OR zika OR sars OR measles OR polio) AND (outbreak) AND (routine immunization OR impact on routine immunization).

Eligibility Criteria

The peer-reviewed and gray literature searches employed a similar set of inclusion and exclusion criteria. Articles were included if they met all of the following conditions:

- Were available in English
- Related to service delivery modality decision-making, campaign effectiveness, campaign implementation processes, interactions between campaigns and RI, and the risks/opportunities of campaigns for RI or the larger health system
- Discussed immunization campaigns that are not responses to outbreaks/emergencies
- Included low-income or middle-income countries

The team excluded articles that:

- Lacked focus on immunization campaigns
- Only focused on immunization campaigns in response to outbreaks/emergencies
- Did not relate to service delivery modality decision-making, campaign effectiveness, campaign implementation processes, interactions between campaigns and RI, and the risks/opportunities of campaigns for RI or the larger health system
- Focused solely on costing
- Were protocol articles
- Included high-income countries only

Data Collection and Study Selection

Peer-reviewed literature

Outputs from the database searches were exported into a citation manager (EndNote) and then uploaded to EPPI-Reviewer Web (Version 4.11.4.0). After screening for duplicates, two reviewers conducted an initial title and abstract review of a subset of records to ensure that the reviewers were calibrated in their application of the eligibility criteria. The reviewers then completed independent reviews of the title/abstracts. Following the title/abstract review, one reviewer completed the full-text review using the same eligibility criteria. Next, one reviewer conducted an inductive thematic coding of the included articles; the initial set of themes codified in the search terms were used as a starting point, but additional themes were codified as the review progressed.

Gray literature

One reviewer completed the review of database/website search results using the same eligibility criteria. The reviewer relied on titles, abstracts, executive summaries, introductions, and/or body of the text to determine eligibility. Following determination of eligibility, the reviewer entered data in an Excel sheet, including a synthesis of key findings from each resource. Following the completion of the inductive thematic coding of the peer-reviewed literature, a reviewer applied the same coding structure created under the peer-reviewed literature coding, allowing for the creation of additional codes should they be needed.

RI in pandemic settings literature

One reviewer collected and analyzed the search results. Given the different thematic nature of this area of inquiry, key findings were synthesized independent of the thematic coding structure used for the peer-reviewed and gray literature.

Analysis and Synthesis of Results

For each included article/resource from the peer-reviewed and gray literature, the reviewer extracted the following information from each article: vaccines, country/countries, and major themes based on the thematic coding structure. The authors then summarized the findings using simple descriptive statistics.

The authors then conducted further qualitative analysis of all resources to provide more detailed data responding to the research questions of interest. This analysis synthesized common findings across major theme and highlighted particularly compelling examples of innovative practices to characterize the evidence base while identifying possible gaps within the data.

RESULTS

Study Selection

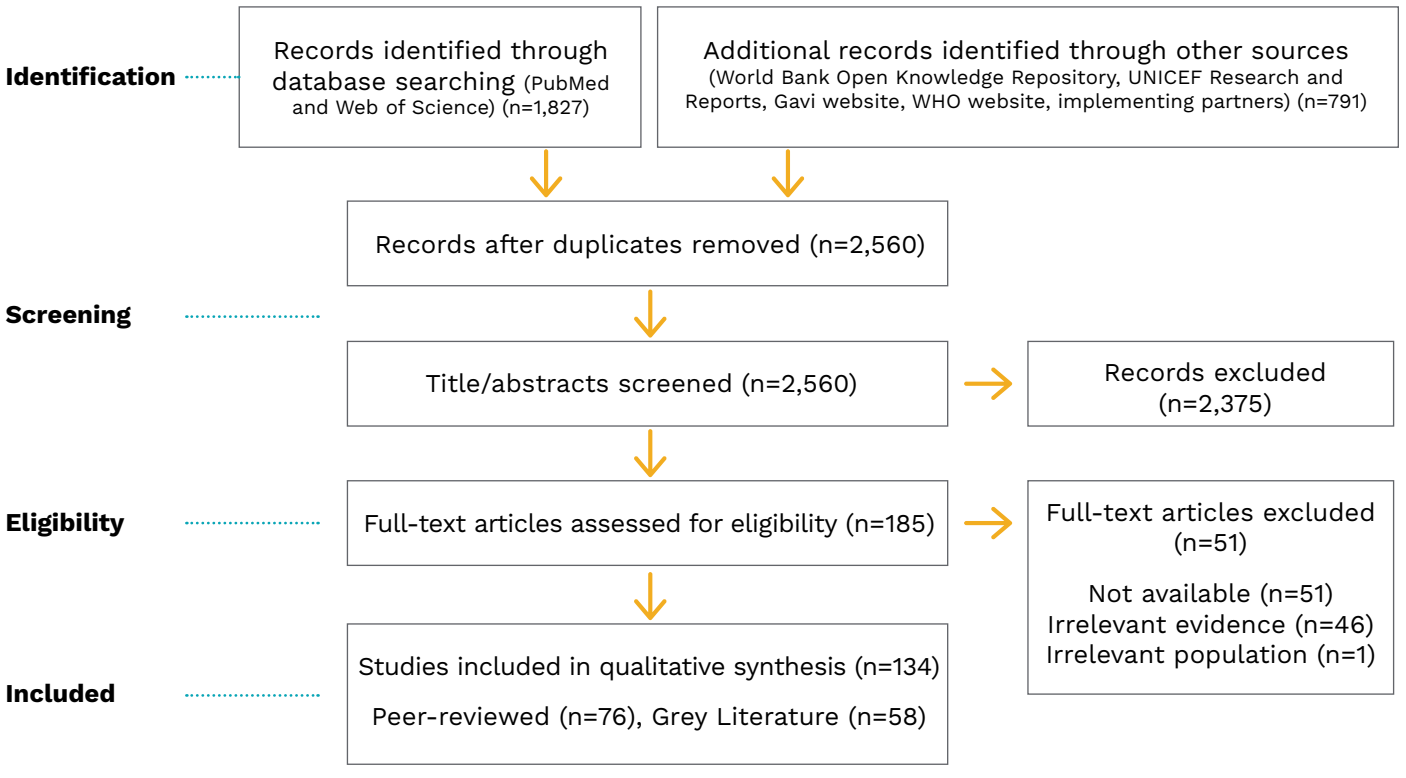
A total of 2,560 unique records were identified from peer-reviewed and gray literature sources. Of this total, 185 were eligible for full-text review. Of those eligible for full-text review, one was excluded due to an irrelevant target population for the campaign, four were excluded due to lack of availability, and 51 were excluded as they did not meet the eligibility criteria of containing findings relevant to the research questions of interest. 134 full-text articles were included in the qualitative thematic analysis; 76 (57%) were from peer-reviewed sources and 58 (43%) were from gray literature sources (Figure 1).

For the directed literature search on the implications of maintaining RI services or conducting campaigns in the context of an epidemic or pandemic, the reviewer identified and included 10 articles; these articles are not included in totals summarized in Figure 1 as they did not follow the same review process.

Study Characteristics

Of the 134 included peer-reviewed articles and gray literature resources, the predominant vaccine discussed was MCV (N=60, 40.0%), followed by resources that addressed multiple antigens or broad issues related to the intersection of campaigns and RI (N=41, 27.3%), and then polio (N=32, 21.3%). The included evidence discussed other vaccines that can be delivered via campaign-base delivery modalities with less frequency (Table 2).

FIGURE 1 **PRISMA Flowchart for Peer-Reviewed and Gray Literature Review**



Across geography (coded against WHO country groupings), the majority of resources included evidence from the AFRO region (N=44, 32.8%), with Nigeria being the most represented country. Resources that addressed multiple countries (e.g., cross-country analyses or case studies representing multiple countries) were second most common (N=36, 26.9%). Within evidence from SEARO and the Western Pacific Region (WPRO), the most frequently represented countries were India and Indonesia. Within the Eastern Mediterranean Region (EMRO), all of the seven included resources documented evidence from Pakistan. Among the gray literature, a significant portion of resources included policy or strategy documents — predominantly from Gavi and WHO — that provided information on various aspects of implementing campaigns or the intersection between campaign implementation and RI strengthening. Overall, these resources represented 18.7% (N=25) of total resources (Table 2).

For the targeted search on campaigns during epidemics, all of the included 10 resources were related to measles and polio SIAs in the context of the Ebola virus disease (EVD) outbreak of 2014-15 in West Africa or of measles outbreaks. There were no records found or included on immunization strategies during Zika, severe acute respiration syndrome (SARS), or polio outbreaks.

TABLE 2 Characteristics of included full-text peer-reviewed and gray literature

Vaccine*	Peer-Reviewed, N (%)	Gray, N (%)	Total, N (%)
Cholera	3 (3.5%)	-	3 (2.0%)
HPV	1 (1.2%)	-	1 (0.7%)
Japanese Encephalitis	1 (1.2%)	-	1 (0.7%)
Measles or MCV	47 (54.7%)	13 (20.3%)	60 (40.0%)
Meningitis A	1 (1.2%)	-	1 (0.7%)
Multiple antigens or RI/EPI	9 (10.5%)	32 (50.0%)	41 (27.3%)
Polio	19 (22.1%)	13 (20.3%)	32 (21.3%)
Rubella	2 (2.3%)	6 (9.4%)	8 (5.8%)
Typhoid	1 (1.2%)	-	1 (0.7%)
Yellow Fever	2 (2.3%)	-	2 (1.3%)
Geography**			
AFRO	34 (44.7%)	10 (17.2%)	44 (32.8%)
EMRO	5 (6.6%)	2 (3.4%)	7 (5.2%)
EURO	1 (1.3%)	-	1 (0.7%)
PAHO	3 (3.9%)	-	3 (2.1%)
SEARO	10 (13.2%)	3 (5.2%)	13 (10.0%)
WPRO	3 (3.9%)	2 (3.4%)	5 (3.7%)
Multi-country	20 (26.3%)	16 (27.6%)	36 (26.9%)
Not country specific†	-	25 (43.2%)	25 (18.6%)

PAHO = Region of Pan American Health Organization; EURO = WHO European Region
* Records could be coded as containing evidence pertaining to multiple antigens
** Based on WHO regional groupings
† For gray-literature records (e.g., policy or strategy document) that were not specific to a given geography

Thematic Analysis

Based on the inductive thematic coding structure, Table 3 displays the frequencies of major themes of interest. Resources could be coded to multiple codes. The most prevalent area explored through the literature was documentation of practical experiences with different campaign-based delivery modalities (e.g., catch-up SIAs, follow-up SIAs, PIRIs, etc.), including documenting promising practices or challenges in implementation (N=29, 13.6%). The most discussed modalities were catch-up campaigns and PIRIs. Approximately 10% (N=20) of the included literature documented efforts of campaigns to strengthen functions of the health system. Literature that documented efforts to either provide inputs or strengthen processes related to any health system function were coded to this theme. A substantial section of the literature also discussed challenges in reaching underimmunized or zero-dose children and broader topics related to reducing inequities in immunization coverage through campaign-based delivery modalities (N=19, 8.9%). The included literature demonstrated a substantial body of work on improving coverage estimation either

TABLE 3 **Frequency of themes in qualitatively analyzed peer-reviewed & gray literature**

Theme	Peer-Reviewed, N (%)	Gray, N (%)	Total, N (%)
Behavior-change communication	4 (2.6%)	-	4 (1.9%)
Community engagement/social mobilization	16 (10.3%)	8 (13.8%)	24 (11.3%)
Cost-effectiveness	9 (5.8%)	-	9 (4.2%)
Coverage – General estimation	15 (9.7%)	2 (3.4%)	17 (8.0%)
Coverage – Use of digital technology	3 (1.9%)	1 (1.8%)	4 (1.9%)
Coverage - Geospatial methods	6 (3.9%)	-	6 (2.8%)
Delivery modalities*	12 (7.7%)	17 (29.3%)	29 (13.6%)
HSS through campaigns**	17 (11.0%)	3 (5.2%)	20 (9.4%)
Incentives – Demand-side	2 (1.3%)	-	2 (0.9%)
Incentives – Supply-side	11 (7.1%)	-	11 (5.2%)
Private sector	1 (0.6%)	-	1 (0.5%)
Planning & RED/REC	10 (6.5%)	-	10 (4.7%)
RI strengthening from campaigns†	11 (7.1%)	3 (5.2%)	14 (6.6%)
RI disruption	16 (10.3%)	-	16 (7.5%)
Surveillance	3 (1.9%)	-	3 (1.4%)
Underimmunized/zero-dose/equity	17 (11.0%)	2 (3.4%)	19 (8.9%)
Urban populations	2 (1.3%)	-	2 (0.9%)
Other (policy, strategy document)	-	22 (37.9%)	22 (10.3%)

* Describes practical experiences on implementation of campaign-base delivery modalities, including possible discussions of how campaigns were particularly effective or could have been more effective, or discussing relative merits of different modalities (e.g., PIRI or Child Health DAY)

** Describes concerted effort of campaign to contribute to broader HSS, including providing inputs into health system functions or working to strengthen broader health system capacities or processes

† Describes specific concerted effort to use assets or resources from campaigns to strengthen RI Service delivery

during campaigns or in the post-campaign period (N=17, 8.0%). The use of digital technologies and geospatial methodological techniques to improve coverage estimation or targeting of populations were also well-documented. Other relatively prevalent themes explored in the literature were the use of community engagement or social mobilization strategies to improve campaign effectiveness (N=24, 11.3%), disruptions to health system and/or RI as a result of campaigns (N=16, 7.5%), supply-side incentives to health workers and their influence on campaign implementation (N=11, 5.2%), specific discussion of the role of planning and/or Reaching Every District/Reaching Every Child (RED/REC) before or after campaigns (N=10, 4.7%), and the cost-effectiveness of campaigns, though these articles predominantly assessed the cost-effectiveness of national nonselective campaigns against alternatives (N=9, 4.2%). There was sparse evidence on the role of the private sector in campaigns and/or campaign-related RI strengthening, or discussion of strengthening immunization campaigns within urban settings.

Following the broad thematic review, the authors conducted an in-depth full-text analysis of major thematic areas. The following describes major findings, including specific country experiences.

A. Guidelines and country-decision making on campaign implementation

This review found little peer-reviewed information examining country decision-making processes around mass immunization campaigns. However, some considerations may be gleaned from WHO and Gavi guidance on the topic, which likely weighs heavily in countries' decisions given the organizations' roles in supporting immunization programs and campaigns technically and financially. This review also found some evidence on the cost-effectiveness of different campaign delivery strategies.

WHO guidance on use of immunization campaigns

WHO supports the use of mass non-targeted campaigns complementary to routine services to protect against the accumulation of measles susceptible individuals and outbreaks in most situations; however, WHO guidance indicates that countries can cease conducting measles SIAs if coverage is above a certain threshold, this coverage can be sustained through routine services, and subnational coverage data is available and trustworthy. However, the exact milestones that countries should meet before ceasing campaigns has varied in the guidance. The WHO 2016 SIA field guide states that, for measles, "Countries unable to achieve high and homogenous vaccination coverage through RI services should regularly conduct SIAs to rapidly reduce the pool of susceptible children, and must aim to vaccinate all eligible children. WHO recommends that SIAs should be continued until countries are able to reach and sustain 95% coverage with two doses through RI programmes" [24]. A WHO 2017 position paper states that, "Countries conducting regular campaigns to achieve high population immunity should consider cessation of campaigns only when >90–95% vaccination coverage has been achieved at the national level for both MCV1 and MCV2, as determined by accurate coverage data for a period of at least 3 consecutive years" [27].

Before ceasing campaigns, a national committee should review historical coverage data at national and district level, degree of coverage heterogeneity between districts, the population immunity profile, the predicted rate of the accumulation of susceptible individuals without campaigns, the detailed epidemiology of measles, and the measles surveillance system. If adequate data is not available, or if the data suggests that the population immunity would drop below herd immunity, it recommends that SIAs continue [27]. In a report following a 2018 meeting of the WHO Strategic Advisory Group of Experts (SAGE), the threshold indicated for considering ceasing campaigns was lower, with the report stating, "Countries with medium disease incidence and periodic outbreaks, inadequate immunity in some populations and moderate programme capacity (e.g., MCV1 coverage of 85–90% and MCV2 coverage of 80–90%) can conduct targeted campaigns according to the epidemiological profile of the subnational areas concerned if high-quality data are available for accurate subnational analysis" [28]. The guidance offers a few alternatives to national SIAs in specific situations.

If a national SIA is not possible due to low program capacity, if there is substantial heterogeneity in the immunity profiles of the country, or if there are small, localized outbreaks occurring, countries may opt for a subnational SIA targeting a smaller geographic area. Very large countries may opt for a phased SIA, while limiting the number of phases as much as possible [24,27].

WHO's caution about measles SIA cessation stems from measles being the most infectious of vaccine preventable diseases and therefore requiring very high coverage across all subpopulations to reach herd immunity (between 89-94%, depending on the setting) [27,29]. They, therefore, recommend that countries monitor the accumulation of susceptible individuals over time and conduct an SIA when the number approaches the size of one birth cohort, usually every 2-5 years [24]. Their concerns about low measles coverage are also mixed in with concerns about low rubella coverage, since rubella is usually delivered in combination with measles. Sustained low rubella vaccination coverage among infants and young children may theoretically lead to a "paradoxical effect" whereby the age distribution of exposure to rubella shifts in such a manner that more women are exposed to the virus during their reproductive years, thereby leading to an increase in congenital rubella syndrome [24].

Additionally, WHO guidance indicates that a combined delivery strategy that involves campaigns alongside RI is cost-effective compared to an RI-only strategy in contexts where RI alone leads only to moderate coverage levels [27]. This assertion is based on evidence from Latin America and the Caribbean showing that achieving high immunization coverage through RI and campaigns achieves cost savings compared to achieving moderate coverage through RI alone [30], from the United States and Canada showing that two doses of measles vaccines is cost-effective whether delivered through routine services or campaigns [31], and from Zambia showing that in a setting where routine coverage is low, delivery of a second dose through campaigns is cost-effective compared to routine administration of a single dose [32].[2]

WHO's guidance is clear that all SIAs should be used in tandem with and to strengthen RI systems. SIAs and RI should flow in a cycle, with information about target populations, health facility session plans, catchment areas, risk factors for non-vaccination and cold chain capacity feeding from the routine system, to the SIA system, and back again. Countries are instructed to develop 3-5 objectives around training, logistics, vaccine safety surveillance, advocacy, social mobilization, communication, supervision, monitoring and evaluation, or surveillance for strengthening RI through the SIA and appoint focal points to carry out these activities [24]. Additionally, the WHO recommends that children's immunization cards and clinic vaccination registers should allow accurate recording of supplementary (MCV0), routine (MCV1 and MCV2), and campaign doses [27].

WHO's guidance on polio aligns with that of GPEI, to which it is party. GPEI's Polio Endgame Strategy 2019-2023 aims to achieve eradication by fighting a battle on several fronts. In polio endemic countries (currently Afghanistan and Pakistan), preventative and outbreak-response SIAs are used to control the spread of wild poliovirus and circulating vaccine-derived poliovirus. Challenges faced in these countries include gaps in SIA quality (especially adequate microplanning), difficulty reaching mobile and hard-to-reach populations, and vaccine refusal stemming from mistrust of government, lack of confidence in vaccine safety, or campaign fatigue. In response, the Strategy recommends countries strengthen their data-driven action plans and accountability frameworks; incorporate alternative vaccination strategies such as subnational immunization days, expanded age groups, or the use of fractional dose inactivated poliovirus vaccine (IPV) in hard-hit areas; prioritize national and subnational dashboard feedback loops; use innovative strategies to track populations and vaccinators such as geospatial information system (GIS) or mobile phone apps; strengthen community engagement; and address other development and health needs of communities targeted by SIAs to build trust [33].

[2] All three of these studies were not identified through the search as they were published prior to 2010 but have been cited based on their inclusion within WHO guidance documents.

On the second front, non-endemic countries using bivalent oral polio vaccine (bOPV) are at risk of vaccine-derived polio outbreaks if their coverage is low and their sanitation systems are weak because children who receive bOPV can spread the virus to others through open defecation or poor hand hygiene. The Strategy recommends these countries conduct pre-emptive SIAs to bolster immunity, along with rapid outbreak-response SIAs. The third and final front is similar but stems from the decision in April-May 2016 to globally switch from trivalent OPV (tOPV) to bOPV following the eradication of wild poliovirus type 2. At the time, countries intended to bolster their immunity during the switch by providing IPV, but a global IPV stock out prevented the timely introduction of IPV in most countries, and many countries have had difficulty achieving high coverage since then due to gaps in their immunization programs. As a result, there were 12 vaccine-derived polio type 2 outbreaks between April 2016 and February 2019. Countries respond to outbreaks with type 2 monovalent OPV, which itself has led to further vaccine-derived outbreaks in neighboring countries or regions [33].

The Strategy calls for global OPV cessation one year after wild polio eradication is certified.[3] The experience of the tOPV-bOPV switch provides ample lessons learned in gearing up for cessation, one of which is the importance of bolstering immunity immediately prior. Countries with weak health and sanitation systems are advised to begin conducting pre-cessation bOPV SIAs in the years leading up to eradication though for funding for these campaigns have been cut in recent years and the introduction of novel oral polio vaccine (nOPV) may affect the approach. In all situations, the Strategy is clear that SIAs need to be conducted in concert with RI and surveillance strengthening to decrease perpetual reliance on SIAs and protect against outbreaks; however, many of the details around financing, governance, accountability of these structures require further clarification at country levels [33].

Trends in Gavi campaign-related policies over time

Gavi's SIA support can be divided into several phases. From 2012-2015, Gavi's support to campaigns was relatively small-scale and focused on supporting countries to strengthen measles coverage as they prepared for rubella introduction, with attention to ensuring that SIAs strengthened RI. From 2015-2018, Gavi greatly expanded its support to include periodic follow-up campaigns for both measles and measles-rubella. Since the end of 2018, in recognition of stagnated coverage rates and continued under-support of RI, Gavi has been exploring a policy that would allow countries greater flexibility to select immunization strategies best tailored to their needs.

Gavi began supporting measles SIAs in 2004 by providing funding to the Measles Rubella Initiative, which in turn provided support to countries. In 2012, the Gavi Board noted that after falling to historically low levels in 2007 thanks in large part to SIAs, measles mortality had plateaued at approximately 140,000 measles-related deaths per year and that continuous donor support for cyclical SIAs was necessary to sustain high coverage. Determining that a renewed focus on RI strengthening was needed for measles control, Gavi began funding SIAs directly through their Health System and Immunization Strengthening (HSIS) Support Framework, targeting an initial six countries that were judged to be at risk of a measles outbreak prior to their introduction of the measles-rubella vaccine (guidance from WHO suggested that measles-rubella should not be introduced until countries achieved 80% routine measles coverage due to the rubella paradox). Countries were required to apply for funding through the same system that they applied for other Gavi support, with the goal of better integrating SIAs with broader Gavi health system support and allowing Gavi to support SIA planning and follow-up. At the same time, Gavi began incentivizing increases in routine measles coverage through performance-based funding [34,35].

[3] The Global Certification Commission is currently reexamining this guidance given the need to certify the absence of circulating vaccine-derived polioviruses.

In 2013, Gavi required country applications to include descriptions of how campaign activities would strengthen RI and strongly encouraged them to evaluate the implementation of routine strengthening activities [36]. It also clarified that Gavi's policy of requiring SIAs to strengthen RI applied to polio as well as measles, and called for greater partner coordination to ensure that incentives for polio SIAs did not detract attention from RI [37]. In 2015, Gavi added support for an additional measles SIA in two of the original six countries that had delayed their measles-rubella introduction in order to first address gaps in measles coverage [38].

In December 2015, Gavi's new Measles and Rubella Strategy greatly expanded Gavi support for SIAs to include periodic follow-up SIAs for measles or measles-rubella with the goals of making Gavi's campaign support comprehensive, allowing for long-term planning, and providing incentives for data use. These campaigns required co-financing to encourage country ownership and discourage overreliance on recurrent campaigns [39]. In 2017, Gavi began requiring countries to conduct post-campaign surveys [40]. By that point, Gavi had supported campaigns in 27 countries and 14 more were planned in the next year, but MCV1 coverage in Gavi countries had stagnated at 78% [41]. Gavi estimated that 17% of Gavi's impact on averted future deaths in 2016-2020 would be through campaigns as opposed to RI [42].

At the end of 2018, Gavi entered its most recent phase of SIA support. A report to the Board that year noted a number of concerns about the 2015 Strategy, including stagnated coverage across Gavi countries; pressure to achieve mortality reduction and elimination leading countries to select SIAs over RI strengthening; the diversion of resources from RI; and low-quality country applications that did not include appropriate tailoring and targeting to reach the unreached, missed opportunities to strengthen RI, and missed opportunities to use SIAs as a platform to strengthen other services [38]. The report hypothesized that setting campaign funding levels based on target population size, in combination with historic guidance on the necessity of national SIAs, created a strong incentive for countries to select national campaigns even when more targeted approaches may be more appropriate [38]. It, therefore, called for Gavi to offer more flexible strategy options to countries; strengthen its application process to ensure SIAs were tailored, were leveraged to strengthen RI and other services, and included better budgetary controls; and intensify efforts to strengthen country-level planning [38]. It also called for SAGE to strengthen its guidance around when other strategies besides national SIAs may be appropriate [38]. As a result, the HSIS Framework was amended to allow countries to request up to the full amount of operational costs to conduct a national SIA but instead apply it to a more targeted approach, such as a subnational SIA or PIRI, depending on their epidemiologic situation or profile of zero-dose children [43]. This new policy, while still being defined, will likely feed into Gavi 5.0 [8,44].

Choices among campaign-like delivery modalities

The need to identify optimal MCV delivery strategies to achieve measles elimination goals has been well-documented in higher-income settings [45,46], though there is less evidence on practical decision-making around this issue in LMICs. Meeting reports from the Technical Advisory Groups on Polio Eradication in polio-endemic countries document in-depth analysis of surveillance and case-based data, prior campaign performance, routine immunization coverage levels, access and security issues, degree of population movement, and other factors when deciding on type, timing, and location of campaign activities, with substantial support from GPEI. Country-led decision-making processes around campaigns have not been well or systematically documented [47] .

A combination of delivery modalities — including nonselective catch-up campaigns and linking children to follow-up through RI platforms — were major success factors in making progress against measles elimination goals in the Americas and in Europe [25,48,49]. However, relatively few peer-reviewed articles documented implementation experiences with other campaign types and how countries decided on a mix of delivery modalities.

TABLE 4 **Findings from Cost-effectiveness Literature**

Vaccine	Geography	Intervention Comparison	Findings
Cholera [54]	Tanzania (Zanzibar)	1. Mass campaign v. status quo	Mass campaign vaccination was not cost-effective (driven by high vaccine price)
Japanese encephalitis [55]	Cambodia	1. RI at 9m v. status quo 2. RI at 9m plus campaign for 1-5y v. status quo 3. RI at 9m plus campaign for 1-10y v. status quo	All interventions were cost-effective based on country ICER* threshold with no dominant strategy Health impacts greater for campaign-inclusive interventions
Measles [56]	Uganda	1. MCV1 via RI v. MCV1 via RI plus MCV1 via SIAs	RI plus SIAs were more cost-effective than RI alone
Measles [57] **	Ethiopia	1. MCV1 via RI with financial incentive for participation in lowest two wealth quintiles v. status quo 2. MCV1 via RI plus SIAs for supplementary dose 6m-59m v. MCV1 via RI only	All interventions cost-effective with no dominant strategy RI with financial incentives was cost effective but showed smaller gains in MCV1 coverage though greater societal impacts on household income and potentially increased demand for RI in the long-term RI plus SIAs were more cost-effective than RI alone
Measles [58]	Benin	1. MCV2 via RI v. status quo 2. MCV2 via SIA v. status quo	Both strategies cost-effective, though SIA costlier SIA approach more cost-effective when prevalence of unvaccinated children was higher
Measles [59]	Democratic Republic of Congo	1. MCV1 via RI at 9m plus multiple national SIAs for MCV1/2 for 9m-5y v. only MCV1 at 9m via RI 2. MCV1 at 9m and MCV2 at 18m via RI v. only MCV1 at 9m via RI	Delivery of both doses of MCV via RI (Intervention 2) was most cost-effective
Rotavirus [60]	Somalia	1. Two doses rotavirus via SIA v. status quo 2. Two-doses rotavirus via RI v. status quo	Either strategy cost-effective based on ICER threshold RI was more cost-effective compared to SIA
Typhoid conjugate [61]	India (Kolkota) India (Delhi) Kenya (Nairobi) Vietnam (Dong Thap) Vietnam (Lwak)	1. RI for 9m v. status quo 2. RI plus campaign for 9m v. status quo 3. RI plus campaign for 9m-15y v. status quo 4. RI plus campaign for 9m-25y v. status quo 5. RI plus campaign for all ages v. status quo	Interventions 2-5 were consistently more cost-effective than intervention 1 alone across all settings Intervention 5 was cost-saving in higher incidence settings

* ICER = Incremental cost-effectiveness ratio
** Analysis used an extended cost-effectiveness methodology to examine the intervention in context of different policy instruments, including looking at household-level effects of deaths averted, financial risk protection, and government costs

Experiences in multiple countries suggest that CHDs have contributed to increased measles immunization coverage, but that opportunity costs related to CHDs can be high in contexts where measles SIAs are frequent [50]. In India, the use of immunization weeks to deliver vaccines typically provided through RI systems (akin to PIRIs) were successful in reaching hard-to-reach and zero-dose children, though there were concerns that the diversion of resources to implement these activities could lead to longer-term challenges with RI strengthening [51]. In Migori County, Kenya, a door-to-door outreach strategy for delivering RI was successful in increasing coverage among hard-to-reach populations; yet, campaign organizers felt there was a missed opportunity to link updated microplans to longer-term RI service planning following the outreach [52]. An assessment of measles SIAs' impact on RI in Nigeria noted that although no discernable impact on routine services was detected, many more parents chose to have their children vaccinated through campaigns in hard-to-reach areas of the north compared to the south, indicating that there may be efficiency gains in targeting campaigns to areas where they are in highest demand [53].

Cost-effectiveness of campaigns compared to alternative delivery modalities

The included literature provided evidence evaluating the cost-effectiveness of campaigns against other delivery modalities, as well as the cost-effectiveness of different campaign designs. Table 4 summarizes key findings from the included studies. The majority of studies attempted to estimate the cost-effectiveness of different delivery strategies against the status quo or evaluated the cost-effectiveness of introducing a new vaccine — or an additional dose — through either a campaign, the RI system, or through a combined approach.

Among the four measles-focused analyses, three found that a combined RI and SIA approach was more cost-effective than RI alone [56–58]. The other analysis comparing a combined RI and SIA approach to deliver two MCV doses against delivery of two MCV doses through RI found that the RI-only approach was more cost-effective [59]. Other studies that evaluated the introduction of new vaccines through RI or a combined RI and campaign approach for Japanese encephalitis vaccine in Cambodia [55], rotavirus vaccine in Somalia [60], and typhoid conjugate vaccine in India, Kenya, and Vietnam [61] found that combined approaches were more cost-effective. The use of a mass campaign strategy for cholera vaccine introduction in Zanzibar was found to be cost ineffective compared to no intervention [54]. There was no evidence comparing the cost-effectiveness of different forms of campaigns — such as a nonselective catch-up SIA versus a geographically targeted SIA, or a nonselective catch-up SIA versus a PIRI — to inform decision-making. Furthermore, the included articles did not discuss the ways in which this data had been used in decision-making in their respective countries.

B. Improving campaign effectiveness

Social mobilization and community engagement for campaign awareness

The importance of social mobilization and community engagement to increase awareness of campaigns and influence campaign coverage was well-documented through a number of country-specific examples. The literature documented positive and negative examples of how social mobilization, community engagement, and communication approaches prior to campaigns increased campaign awareness, though none of the included resources were able to isolate the effect of these interventions on immunization coverage. Guidance documents on social mobilization for SIAs and RI recognize the importance of feeding back data generated through SIAs for RI [62,63]; however, the analyzed evidence showed mixed results in effective use of these feedback mechanisms.

At the regional level, a review of programmatic strategies for measles elimination in the Americas concluded that tailoring social mobilization strategies and local messaging — including highlighting the value of achieving measles elimination — was influential across multiple countries during SIAs [48]. In Kenya, pre-campaign house-to-house visits, coupled with

digital innovations in pre-campaign counseling and education and short message service (SMS) reminders, were shown to increase household participation in measles SIAs compared to households that did not receive the same intervention [64–66]. Household visits coupled with digital mobile phone technology to support education and awareness-building by health workers to household members allowed for better tailoring of pre-campaign messaging compared to mass media communication. The household visit strategy also provided more granular information that could be fed into microplanning for the overall campaign and for longer-term RI services [65]. In India, programmatic experience showed that engaging religious institutions in campaign awareness-raising helped persuade households that may have otherwise not attended a polio campaign to participate. However, there were diminishing returns on the frequency of these communication approaches [67]. A campaign in Myanmar delivered invitation cards to families ahead of campaigns and followed up with families who do not turn up. The campaigns used flags depicting Pyit Taking Htaung, a traditional doll that pops back up when it is knocked down, just as the Ministry of Health planned to ensure that children do not fall to measles [68]. Indonesian campaign planners engaged religious leaders to issue fatwas (religious edicts) to dispel conceptions that vaccines are haram (forbidden) [69].

Other evidence highlighted the importance of crafting effective and tailored approaches to social mobilization and communication strategies in historically hard-to-reach and/or hard-to-vaccinate communities, including the importance and success of engaging civil society organizations in these efforts [70]. Experience from India's polio eradication efforts highlighted that persistent distrust with the health system among historically hard-to-vaccinate communities necessitated the need for stronger engagement of community volunteers during polio SIA microplanning to help increase campaign awareness and address potential vaccine hesitancy [71,72]. In South Africa, structured engagement of community health workers in communities with measles immunity gaps was shown to be an effective strategy to increase participation in SIAs [73].

In Uttar Pradesh, India, the CORE Group Polio Project networks of "local influencers" were seen as a critical component in reaching communities with polio immunity gaps through SIAs as they were able to identify households/families that were likely to be resistant/hesitant to participate early, and then leverage community ties and training in inter-personal communication techniques to demonstrate the value of obtaining immunization services [74,75]. In Chad, appropriate messaging and engagement of hard-to-reach nomadic groups was a focus of polio SIAs, which required tailored communication strategies and additional resource to adequately reach [76]. Evidence from a regional analysis of measles elimination activities in the European region also stressed the importance of counteracting potential vaccine hesitancy as part of outreach in communities with immunity gaps prior to SIAs, as these communities were more likely to have higher vaccine hesitancy [25].

Other evidence highlighted weak community engagement and poorly timed information-sharing about a campaign to introduce a new cholera vaccine in Mozambique as an obstacle to achieving high campaign coverage [77]. In Nigeria, a review of communication approaches highlighted that external funding for campaigns contributed to higher-quality campaign social mobilization efforts compared to domestically funded social mobilization activities to increase care-seeking for RI [78]. Additionally, in Kenya, while mass media approaches have been successful in increasing awareness and demand for measles SIAs, these approaches have lacked tailored messaging to populations in high-density and/or urban areas, creating a missed opportunity to increase participation among populations at higher-risk for measles transmission [65]. At a higher level, engagement of political leaders in immunization campaigns also runs the risk of campaigns and immunization becoming politicized, possibly exacerbating social barriers to immunization, such as gender-based power dynamics within households, as politicians play to the fears of different groups [79]. Evidence also underscores the need to effectively manage communication around AEFI or outbreaks following SIAs as they can have deleterious effects on demand for RI in already hesitant populations [80].

In sum, implementation experience of communication and social mobilization strategies for polio eradication emphasized the need to track/use key communication indicators and to build local leadership and ownership of communication and social mobilization strategies for them to be effectively leveraged for RI [81].

Improving data quality and use through improved coverage estimations

The portion of the included literature that discussed improving coverage estimation for campaigns covered three main sub-themes: 1) statistical methods for producing higher-quality data to either inform campaign planning or estimate post-campaign coverage, 2) programmatic approaches to conduct real-time monitoring and course correction through digital applications, and 3) use of geospatial analysis to inform planning and campaign monitoring. A realist review on the use of immunization data by different levels of the health system demonstrated a gap in evidence on the linkages between routine data and data generated via campaigns [82].

Novel statistical methods for increasing quality of coverage estimations

Multiple resources documented the need to explore novel methodologies to improve the quality of coverage estimates from routine information sources to inform campaign planning or the estimation of post-campaign coverage. One technique explored using cross-sectional data on the number of doses distributed by service modality and age-specific vaccination coverage rates to estimate the efficiencies of different service modalities in contributing to coverage. An application of this method also contributed to improving the estimation of which populations were likely harder-to-reach through campaigns [83]. Other literature described the use of Bayesian frameworks applied to acute flaccid paralysis (AFP) data in inter-SIA periods to estimate areas in which there are persistently underimmunized or zero-dose children in Nigeria, which in turn could be used to inform future SIA targeting [84,85].

Programmatic approaches and considerations for improving campaign monitoring and coverage

Documenting programmatic and analytical approaches to improve real-time campaign monitoring was well-documented in the included literature. Some resources documented the use of data from routine sources or data collected specifically in advance of a campaign to strengthen the targeting of certain communities at higher likelihood of having underimmunized or zero-dose children. For example, the CORE Group Polio Project in India used a census-based management information system to prospectively collect population-level data to identify potentially high-risk communities that were less likely to participate in polio SIAs. Using this data, they then adapted their social behavior change communication (SBCC) approaches to increase pre-SIA outreach to those communities. This census-based information system contributed to an increase in polio SIA coverage in harder-to-reach communities [75]. Other polio programs in India documented a concerted effort to incorporate real-time data monitoring as part of a larger social mobilization network; monitoring included daily analysis and appropriate course correction to in-progress polio SIAs [86].

The use of lot-quality assurance sampling (LQAS) to guide mop-up activities at the end of campaigns was also commonly documented in the literature. In Sierra Leone and Cameroon, clustered LQAS (C-LQAS) methods were employed as part of mid-campaign evaluations. The clustered method allowed for more efficient sampling to generate higher-quality post-campaign coverage data for measles SIAs in Sierra Leone and polio and yellow fever campaigns in Cameroon. In both examples, the C-LQAS methods were particularly important in identifying lower-coverage districts as the campaigns rolled out [87,88]. Another example of successfully employed LQAS techniques during mid-campaign evaluation was an integrated vitamin A and measles campaign in Sierra Leone, where LQAS provided data to target mop-up activities at the end of the campaign [89]. In Brazil, regular rapid monitoring assessments during a national rubella campaign also provided more precise data for mop-up planning [90].

There was sparse evidence of the role of the private sector in supporting or driving the use of technology to improve campaign strategies. As one example, in 2019, Gavi partnered with Asia's largest internet services provider, Tencent, and Zenysis Technologies to use of data and artificial intelligence to support campaigns and other immunization strategies [91].

Geospatial analysis

The use of geospatial analysis at all stages of campaign planning and implementation was prevalent throughout the literature. Broadly, the use of spatial clustering methods using cross-sectional data, such as DHS data, has been described as a method to systematically analyze and identify likely areas of persistently low measles coverage, thereby providing critical information on the targeting of SIAs in sub-Saharan Africa [92]. Other geospatial approaches have also contributed to analyzing the relative effect of SIAs versus RI in increasing coverage. For example, one analysis used geospatial and administrative SIA data to unpack the relative contributions of RI and campaigns to MCV coverage. Using a sample of countries, the analysis estimated that in larger countries with relatively weak RI systems (e.g., DRC, Ethiopia, or Nigeria), the relative contribution of SIAs to MCV coverage was greater than in countries with relatively stronger RI systems (e.g., Cambodia and Mozambique). Such methods could be employed as an input into decision-making around service delivery modalities [93]. One study articulated a model for using transport network and travel times to more precisely identify hard-to-reach communities, which could be used for microplanning for campaigns or RI activities [94].

Other evidence documented the extensive use of geospatial analysis and digital applications to improve campaign performance in Pakistan. In a polio SIA in rural Pakistan, a Global System for Mobile Communications (GSM)-based tracking system was deployed to improve monitoring and accountability of campaign workers by collecting real-time information on the geographic reach of workers within target communities, allowing data on missed households to be reported to campaign planners daily to make course corrections. The outputs were then used to inform future microplanning for polio SIAs [95].

A similar application was described for a polio SIA in urban Pakistan. During the SIA, workers used mobile technologies to collect geotagged data on households they reached. This data was then used for real-time monitoring and adjustments [96]. Another campaign in Pakistan used spatial models to stratify districts by their risk of accumulation of susceptible children in advance of a polio SIAs. These models were used to improve the geographic targeting of planned subnational SIAs based on stratification by risk. The outputs of these analyses were then used as inputs into longer term district- and national-level planning for polio eradication [97].

In Nepal, a digital application for rapid convenience monitoring during a national measles-rubella campaign improved the timeliness and completeness of monitoring data reported by campaign workers compared to areas that used traditional paper-based monitoring. Automatic reporting and consolidation of the geospatial data into a central dashboard also allowed for mid-campaign adjustments for improved targeting [98].

Broader concerns on structure and funding for post-campaign surveys

The literature also documented larger concerns around funding and logistical challenges in conducting data collection following campaigns. Post-measles SIA coverage surveys often seek to collect additional RI coverage data, which could create delays or lead to lower-quality coverage data for the SIA [99]. In Southern and Eastern Africa, there is a need to standardize post-measles SIA coverage surveys given common logistical challenges such as insufficient time and funding to complete surveys or potential biases if surveys were not conducted by independent entities [100]. These experiences also emphasized the need for greater focus on strengthening capacity at subnational levels for conducting these surveys (particularly in larger countries) and mobilizing additional funds for appropriate supervision throughout the survey period [66,100]. Collectively, the review experiences underscored the need for clearer planning for post-SIA surveys as part of the larger SIA planning process [100].

Other experience also emphasized the need for increased time and budget to update household lists prior to campaigns to reduce the risk of sampling bias in post-campaign surveys [66].

C. Leveraging campaign-generated resources and assets for RI strengthening

The literature argues that an explicit focus on using campaigns to strengthen RI holds greater potential for longer-term "trickle up" contributions to HSS [22]. Exposure to SIAs has also been associated with reductions in the likelihood of receiving routine vaccines in a sample of countries, highlighting the need for improved SIA planning to strengthen linkages to RI [101]. The included literature suggests that immunization campaigns have had both beneficial and negative effects on strengthening RI systems, and that there has been mixed success in leveraging campaign resources to identify and vaccinate hard-to-reach and hard-to-vaccinate communities through RI systems.

Strengthening RI systems

Across multiple contexts, there have been multiple examples of discrete campaign assets or resources being used to improve countries' RI systems:

- **In China,** accountability mechanisms, coverage estimates, and an internet-based immunization registration system from measles SIAs were later used for broader RI strengthening [102].
- **In Angola, Chad, DRC, Ethiopia, Nigeria, and India,** surveillance systems developed for AFP eventually evolved to become integrated disease surveillance and responses systems that monitored additional VPDs, such as measles [23].
- **In Malawi, Honduras, Timor-Leste, Tanzania, Liberia, Pakistan, and Ethiopia,** increased cold chain capacity intended to provide longer-term capacity for RI. Yet, there were also references to the often high share of SIA funds that are used to procure cold chain equipment; for example, 40% of operational funding for a measles SIA in Ethiopia in 2016 was used to procure additional cold chain equipment [16].
- **In Bangladesh,** targeted investments to the logistics system, including human capacity development, increased longer-term capacity for EPI logistics [103].
- **In India,** the use of risk assessment tools for measles SIAs had a longer term usefulness for RI planning, particularly in identifying and tracking districts at high-risk for accumulating children susceptible to polio [104].
- **In Bangladesh, Ethiopia, Tajikistan,** community engagement for measles SIAs helped to foster broader accountability of RI services at subnational levels [15].
- **In Angola, Chad, DRC, Ethiopia, Pakistan, Somalia, and India,** polio-related social mobilization networks originally supported by GPEI were used for RI, with a focus on defaulter tracing [23].

These experiences suggest that health system managers typically understand the benefits that SIAs can provide to RI; however, incorporation of these beneficial activities into larger EPI/RI multiyear plans or an appropriate strategic plan has been infrequent in many contexts, leading to missed opportunities for RI strengthening [13]. These missed opportunities include not using SIA-generated microplans for improved population targeting for RI outreaches, not using SIA-related expenditures to inform RI budgeting at local levels, not using data from SIA supervision to inform human capacity development of health workers, or not including targeted counseling on the importance of RI to households during campaigns [13].

Actionable frameworks to strengthen the linkage of SIA planning and implementation with larger RI strengthening have been proposed and emphasize 1) building political will to include explicit RI strengthening activities as part of SIAs, 2) creating clear plans on transferring SIA assets/resources to EPI managers, 3) prioritizing a set of practical actions at national and local levels, 4) budgeting and mobilizing resources to support these linkage activities, and 5) monitoring and reporting progress on prioritized actions among key national and local stakeholders [13]. However, there is less evidence of countries employing systematic actions to connect campaign resources to RI strengthening.

In practice, many actions are ad hoc — though these ad hoc actions have been successful in some situations.

One example of intentional planning to connect SIA resources to RI is the case of Nepal, which developed a five-part plan ahead of a measles-rubella SIA on how it would leverage the SIA for RI strengthening. The five domains included vaccine safety, supply chain, communications, reporting/recording, and surveillance. As part of the preparatory activities for the SIA, SIA workers received specific training on these topics, and the SIA supported a range of activities to meet these goals, such as the inclusion of referral cards for RI services for zero-dose children reached by the SIA and targeted support to incorporate data collected during SIAs into microplans and micromaps. The availability of RI microplans and maps increased 17% and 12%, respectively, following the targeted interventions during the SIA [105]. Despite these successes, health workers found that the supplementary interventions coupled with the demanding SIA were ambitious and taxing [105].

Similarly in Bangladesh, an evaluation of measles SIAs found that the SIAs were mostly well-integrated into the overall EPI system, which was partially attributable to improved coordination within the Ministry of Health and across different line ministries, as well as targeted investments into the RI systems to support campaigns [106]. Proper planning and deployment of staff also contributed to consistent or increased levels of RI coverage during SIA periods. However, staff also typically worked extended hours for both SIAs and RI clinics to maintain these high coverage levels [103]. An evaluation of a campaign in Nigeria found that staff reported that they were able to intentionally learn lessons from previous campaigns and employ guidance from WHO to better integrate the campaign with routine services, but that there were still issues of staff being diverted from RI during the SIA. The evaluation called for pre- and post-campaign data on RI performance to help evaluators better judge the success of the campaign's RI strengthening efforts [53].

In certain focal countries, GPEI and Measles and Rubella Initiative assets were also seen as contributing to improved planning, training of EPI staff, and surveillance infrastructure, but there were major sustainability issues around ensuring that these assets remained in place to help achieve longer-term RI goals [107]. In Nigeria, there are opportunities to transition assets and infrastructure to support polio elimination to measles elimination activities; however, a reliance on external financing and a lack of domestic resources to sustainably fund the transition has been a major challenge in practically leveraging these resources [108,109]. However, in Pakistan, an intervention designed to offer RI services during and between polio SIAs in priority areas in Sindh province by developing synergies in planning and vaccinator deployment was successful in reaching SIA coverage goals while increasing RI coverage; furthermore, the intervention was particularly successful in identifying zero-dose and underimmunized children Reaching underimmunized and zero-dose children

An analysis showed that the proportion of zero-dose children reached via SIAs was on average 66% (range 28-91%) across 14 high-burden countries [111]. MCV1 coverage delivered through SIAs tended to favor children in lower wealth quintiles, supporting the hypothesis that measles SIAs are a pro-equity intervention [111]. Another cross-country analysis found that measles SIAs were more likely to provide equitable MCV coverage compared to MCV delivery through RI programs in most contexts, suggesting that there is a need to strengthen the implementation of pro-equity strategies included in RI programming [112].

While the time-constraints of campaigns typically do not allow for it, multiple studies suggested that campaigns should be used to identify children with incomplete vaccination records and connect them to RI services given the natural opportunity this type of touchpoint with the health system provides [103,113]. One modeling study even estimated the introduction of immunization card reviews as part of standard protocol for measles SIAs could contribute to systems-wide cost savings, improvements in the ability of SIAs to target high-risk populations, and higher-quality coverage data useful for RI planning [113].

Cluster survey methodologies were also reported as being useful inputs into RI outreach planning, allowing for targeting of interventions to underimmunized communities and improving RI data systems in countries with fragmented information systems across multiple countries [66]

Experiences have shown that house-to-house canvassing to identify underimmunized children is a common feature in SIA preparatory activities and has been successful across multiple countries [15,16]. For example, experiences in Cameroon and Tajikistan showed that maps produced for SIAs were used to refine targeting for RI activities in hard-to-reach areas [15]. However, there are challenges to systematic follow-up during and after SIAs to determine if these identified children participated in the SIA or if they were reached with additional RI services [16]. Common reasons that this process is not done is the lack of a standard reporting indicator that would capture the successful use of this information to reach the identified children, as well as the lack of earmarked funding to ensure that the necessary follow-up happened [16].

A commonly cited opportunity for RI strengthening from campaigns was stronger implementation of microplanning and other components of RED/REC due to capacity building of health workers on these approaches and dedicated funding to complete microplans [13,16,22,23]. Data generated from campaign planning were used to update micromaps that could in turn be used for fixed-site and outreach services [86,104,114]. In some contexts, the production of digital micromaps using geospatial analysis for polio SIAs was seen as particularly valuable for RI, such as in Pakistan and Nigeria [16,95]. In India, a census-based tracking system developed for polio activities was viewed as an asset for RI activities as it provided granular details (e.g., location of defaulters) that could be readily used for more detailed microplanning [75]. However, one study in Kenya highlighted the challenges of leveraging campaign-related data for improved microplanning for RI in urban settings as the migratory nature of some urban populations meant that data quickly became out-of-date [52]. The literature also highlighted that to effectively leverage these opportunities for RED/REC, there needs to be an intentional linkage between campaign planners and RI managers [13].

Leveraging Polio Assets for Routine Immunization Strengthening in India

In India, the Social Mobilization Network (SMNet) was established to accelerate progress of polio elimination goals by deploying a network of 7,000+ community mobilizers to increase the participation of high-risk communities in polio SIAs. SMNet managers developed systems and processes to systematically track polio vaccination coverage in these communities to tailor and target SIA activities. This data was systematically used to support district-level immunization managers to update microplans for better targeting of SIA activities. SMNet also engaged community leaders in communities with historical hesitancy to participate in immunization activities to help address low coverage.

In 2017, a national campaign led by the Universal Immunization Program to increase RI coverage in low-coverage states and districts (Mission Indradhanush) leveraged the SMNet infrastructure. The RI-focused campaign used SMNet's communication, planning, tracking, monitoring, and supervision platforms to prioritize districts, tailor microplans, and conduct social mobilization activities to increase demand ahead of the campaign. Mission Indradhanush was successful in building longer-term capacity for district-level planning, social mobilization activities, and other SBCC interventions in priority districts. For example, 94% of SMNet-supported districts had regularly updated social mobilization plans compared the national average of 75%. These actions were adopted by the UIP given their contributions to increasing coverage and building trust among hard-to-reach and hard-to-vaccinate communities [76].

D. Campaign-related risks and opportunities to the health system

Disruption of RI and other primary care services

There was a substantial portion of the literature that documented both qualitative and quantitative disruptions of campaigns on RI and routine PHC services. Broadly, the literature highlighted the lack of sufficient planning at subnational levels as a major contributor to higher levels of disruption of routine services [15]. In India, the large push for polio elimination had a detrimental impact on front-line health workers, who often did not have sufficient support, time, or funding to conduct appropriate social mobilization activities and work simultaneously to deliver RI services and support campaigns [115].

Multiple studies looked at documenting the quantitative impact of campaigns on routine services. An analysis of routine service disruption related to measles SIAs in South Africa showed that there was a significant association between the implementation of SIAs and decreases in RI coverage rates at the district level during the same year in which an SIA occurred [116]. Further analysis of these disruptive effects showed statistically significant reductions in the provision of key reproductive health services and some child health services at the district level during months in which a measles SIA was conducted [117]. The study suggested that increased monitoring of routine service delivery indicators should be part of larger campaign monitoring efforts [117]. During measles-rubella and polio SIAs in Nepal, one-fifth of health providers surveyed after the end of the campaign reported delaying routine services during the SIA [105]. Gavi has also noted occasional issues with campaigns causing supply chain insecurity as vaccine manufacturers and country cold chains are unable to cope with sudden surges in vaccine demand and storage requirements [118].

Some campaigns, such as a national rubella campaign in Haiti, attempted to counteract the potential disruption in routine services by integrating provision of other PHC services as part of the campaign. However, planners found that the integration of other services may have distracted workers from the primary goal of delivering rubella vaccines as the number of other integrated services was not particularly high [119]. There have also been similar concerns that the provision of vaccination services through CHDs may disrupt the provision of other PHC services in locations where there was not sufficient staff coverage or commodities [120].

Possible disruptions of routine systems during the introduction of new vaccines through campaigns was also explored in the literature. In some contexts, the introduction of new vaccines through campaigns was particularly disruptive to other routine health services. For example, the introduction of meningococcal vaccine in Mali through a national campaign coincided with a 79% reduction in the daily number of children receiving vaccines through RI over the period of the campaign. Reductions in daily totals also continued to decrease in the month following the campaign (87% decrease compared to a similar period) [121]. Conversely, the experience of HPV vaccine introduction through a campaign in Rwanda did not lead to an adverse effect on routine service delivery as there were continued high levels of antenatal care and RI services during the campaign period. Extensive levels of local planning was seen as a major contributor to the success in achieving high campaign coverage and high coverage of primary care services [122].

Opportunities for service expansion

While the integration of other services into SIAs has been met with variable success [123], SIAs generally present a continued opportunity for health promotion [22,112,120]. Historically, vitamin A supplementation and deworming has often been integrated with polio SIAs since the timing of the strategies syncs well [69]. In conflict or high-risk settings, humanitarian organizations were able to leverage the polio infrastructure to increase delivery of RI and other essential health services [23]. One study in Pakistan found that households that seek immunization services from private providers are as likely to participate in SIAs as those who seek regular services in the public sector despite prevailing notions that the opposite was true. In contexts where the private sector provides immunization services, there may be an untapped resource for increasing participation in SIAs [124].

Although there is not clear evidence that immunization coverage improves through campaign integration, there may be other benefits for immunization. Gavi has suggested that in places where intensive polio campaigns have led to violence towards vaccinators, such as Pakistan and Nigeria, integrating polio with delivery of other services may help to make it less visible and build trust, diluting issues of vaccine hesitancy and hostility to health workers [37].

Influence of demand- and supply-side incentives

The literature highlighted relatively few instances of the positive effects of introducing demand-side incentives on increasing campaign coverage. A randomized-control trial in rural India tested the effect of demand-side incentives on increasing immunization coverage through immunization camps (similar to a PIRI). The trial showed that introducing incentives to families led to a six-fold increase in RI coverage in particularly hard-to-reach communities. The introduction of the immunization camps without incentives was also effective in increasing coverage, though the addition of the incentive component was seen to be more cost-effective than the immunization camp intervention alone [125]. A previously discussed cost-effectiveness study also demonstrated that the introduction of an incentive to participate in measles SIAs in Ethiopia could lead to extended economic benefits of increasing short-term household income and longer-term savings through reduced risk of illness and reduced likelihood of catastrophic health spending [57].

There were numerous articles that discussed the detrimental effects of staff incentives on longer-term RI activities following campaigns. Incentives provided by polio and measles SIAs were often seen as "top-up" payments by frequently underpaid public health workers. Practical experience across multiple countries suggest that incentives create short-term motivation for participating in SIAs but undermine motivation for RI activities and other routine services in the longer-term [22,15,51,13,121]. Given the typical external funding for many incentives, their magnitude relative to baseline salary payments has been inconsistent over time and geographies. For example, incentives during some campaigns were more than half of health workers' regular income in Ethiopia and Cameroon, while incentives in other countries represented a significantly lower proportion of regular income (e.g., Bangladesh, Vietnam) [15]. Despite the ongoing challenges of sustainably financing campaigns through domestic sources, some countries have sufficient domestic funding to implement incentive policies for RI outreaches (e.g., India), while others do not, leading to continued challenges in increasing RI coverage [22,13].

Other evidence highlighted that health system managers found incentives from polio SIAs created longer-term expectations for increased renumeration, leading to unrealistic expectations of payment for activities outside of health workers' regular job description [23]. The lack of appropriate incentives for unsalaried community mobilizers was also a challenge for social mobilization activities in advance of polio SIAs. For example, a lack of incentives for mobilizers in Malawi contributed to frequent resignations of mobilizers midway through an SIA and created longer-term discord during future immunization activities requiring mobilizers [126]. In countries that established large disease-specific programs to support elimination goals (e.g., India, Nigeria), there have been broader concerns around hiring practices that led health workers given incentives to leave positions in public facilities for higher pay. Given existing shortages in human resources for health, such practices were seen as disruptive to routine health services [114].

Conversely, multiple qualitative studies of health workers attitudes towards campaigns documented that the intrinsic value of providing life-saving vaccinations to large swaths of the population was a motivating factor beyond an financial incentive [121,122]. There was some qualitative evidence that SIA-related incentives helped to increase health worker retention in contexts with underpaid health workers and that incentives may have contributed to improved reporting in the immediate post-SIA period [15]. In other contexts, some campaign managers found that incentives to participate in SIAs helped to identify highly skilled and motivated staff that could be engaged for longer-term immunization activities and were sometimes more likely to engage in performance tracking and accountability activities [119,127,97].

Impact on health systems

The literature documented a range of experiences on how campaigns have positively and negatively affected health system functions. Past efforts to use measles SIAs as an opportunity for longer-term HSS have primarily focused on the provision of health system inputs. Across multiple countries, increased staff training on immunization services and safety, planning, coordination within and across sectors, cold chain equipment, waste management infrastructure, and surveillance systems were consistently cited as beneficial, campaign-derived inputs into the health system [15,16,90,105,106,120,121,128,129]. Identification of hard-to-reach or hard-to-vaccinate communities through pre-SIA mapping was also regularly seen as a positive output of campaigns that could be used to strengthen RI systems and other service delivery functions [15,66,105].

However, countries with relatively weaker health systems typically faced more difficulties in realizing these potential benefits to service delivery or the broader health system [15]. Some articles emphasized the need to more systematically consider how SIAs could be used for the improvement of service delivery and/or health system processes [16,22]. From an information system perspective, the parallel nature of some SIA reporting systems contributed to fragmentation in data at subnational levels and was viewed as a longer-term challenge for using that information for other RI activities [15].

The influence of external funding for SIAs has also been problematic for multiple countries — including Bangladesh, Cameroon, Tajikistan, and Vietnam — as the earmarking of funds for SIAs and donor restrictions were seen as obstacles to more effectively using SIAs for broader HSS [15]. Multiple countries also cited that funding models undermined subnational resource mobilization and allocation, including leading to reduced prioritization of funding for RI [15]. Inconsistent and fragmented decisions on how external funding and domestic funding would be used for SIAs over time was also a challenge faced by multiple countries [15]. Related to larger challenges presented by supply-side incentives, some countries also documented health workers needing to cover SIA-related costs out-of-pocket due to delayed disbursement of earmarked SIA funding [106].

E. Campaigns and RI during epidemics

There is a small body of literature documenting the impact of the 2014-2016 EVD outbreak in West Africa on immunization programs in the region. In March 2015, following a year of interrupted immunization activities, WHO released new guidance that the risk of outbreaks of vaccine preventable diseases, especially measles and polio, outweighed the risk of increased Ebola transmission in Guinea, Liberia and Sierra Leone [130]. It stated that countries should conduct intensified RI activities and/or vaccination campaigns so long as they could guarantee that they had a sufficient workforce available and could put infection prevention and control measures in place (including crowd control, EVD triage, handwashing, glove-wearing, waste management, communication, and social mobilization) [130]. WHO also recommended PIRIs or mini-campaigns, including for older children, in high-risk areas, and noted that mass campaigns should not impede efforts to reestablish RI services [130]. By that point, there were already calls for mass immunization campaigns, aggressive SIAs and RI strengthening [131] amid warnings that immunization coverage had fallen 25-75% in West African countries [132] and that the region could expect to see an additional 2,000-16,000 measles deaths over the next 18 months due to rising immunity gaps [133]. One author also called for rapid, small-scale reactive campaigns to bring measles outbreaks under control quickly, noting that measles compromises immune systems and could increase populations' susceptibility to Ebola [134].

All three countries had resumed measles SIAs by June 2015 with moderate success. There were no reports of adverse events following immunization (AEFI) or Ebola transmission due to campaigns or immunization during the outbreak, and all the campaigns achieved high administrative coverage of 90-99% [135]. Nevertheless, Liberia and Guinea experienced a 25% drop in the number of monthly immunized children in 2014-2015 from pre-outbreak levels (but not Sierra Leone).

Liberia and Sierra Leone saw increased measles incidence in 2014-2015, and Guinea saw increased incidence in 2016 [135]. MCV1 and Penta3 coverage was low in Sierra Leone prior to Ebola (71% and 80%, respectively) fell dramatically during Ebola (to 46% and 40%), and recovered somewhat following a 2015 Maternal and Child Health Week campaign (to 57% and 56%), but not nearly to pre-Ebola levels [131].

Challenges hampering the countries' ability to conduct immunization during the outbreak included severe mistrust or fear of health workers and the health system, insufficient staff for immunization delivery and supervision due to diverted resources and high health worker mortality, incomplete reporting by overburdened staff, delay in vaccine delivery to points of service, and shortages of fuel and vehicles [132,135–137]. Measles outbreak response was also impeded by poor surveillance due to underreporting of illness and death as people avoided the health system and misdiagnoses between EVD and measles, which have similar early symptoms [134,135,137].

Countries implemented intensive social mobilization strategies during campaigns to compensate for reduced health seeking behavior, building off Ebola-related investments in the health system. A 2015 integrated polio, measles and deworming campaign in Liberia used Ebola County and District Mobilization Coordinators to coordinate trainings of trainers and mobilize community members. Coverage was reported to be 101% for OPV, 99% for measles, and 99% for mebendazole tablets, which was a significant increase over earlier PIRIs that had not used as intensive an approach [136]. During measles outbreaks, successful strategies included strengthened surveillance through daily phone calls to health centers, door-to-door contact tracing, and vitamin A and nutritional supplementation for measles cases to strengthen immunity [134,137]. Campaigns would need to be repeated in 1-2 years due to low coverage and target larger age ranges to reach all missed children [134].

Once the Ebola outbreak ended, there were calls for sustained immunization system strengthening in West Africa to improve the immunization system's resiliency during outbreaks and support future outbreak response, given that Ebola response was hampered by weak health and surveillance systems in the region [138]. There has been a continued need for long-term support for personnel, public health infrastructure, surveillance, information and communication technology, cold chain, and community trust building [137]. Liberia successfully recovered its measles and Penta3 coverage rates by 2017 thanks to a large immunization system strengthening effort as part of its 2015 immunization recovery plan, though coverage in some counties remained low. From 2015-2017, Liberia made significant investments in immunization, improving staff training, strengthening microplanning, upgrading technologies and processes, and strengthening coordination and review mechanisms, increasing its immunization budget from US$50,000 in 2015 to US$650,000 in 2016. It also conducted a measles SIA, strengthened measles and AFP surveillance, and introduced three new vaccines (rotavirus, IPV, and an HPV demo) [139].

DISCUSSION

This systematic literature review sought to identify and synthesize a range of evidence on how campaigns can be deployed more effectively and/or efficiently, and how campaigns could contribute to longer-term RI strengthening, while considering an expanded set of VPDs and areas of inquiry than past analyses.

Published literature on how countries choose among multiple campaign modalities for a specific vaccine (i.e., deciding between a national non-selective SIA versus a geographically targeted SIA) is limited. This review suggests that countries have typically and appropriately followed WHO, Gavi, and/or GPEI guidance on SIA implementation, predominantly for measles and polio, but that there has been more variation in how countries implement campaigns for other vaccines. The review highlighted that the use of cost-effectiveness data is likely limited in these decision-making processes. The evolution in how Gavi funds measles SIAs demonstrates an increasing focus on creating stronger linkages between campaigns and RI strengthening, though the evidence included in this review suggests that the observed effects of campaigns on longer-term RI strengthening remains tenuous and that data on cost-effectiveness is not strong enough to guide decision-making.

Despite contributing to increasing coverage, the risks that immunization campaigns pose to RI systems and the health system as a whole are well-documented both qualitatively and quantitatively. Multiple studies highlighted the diversion of financing at sub-national levels and the redeployment of already scarce staff away from health facilities to support campaign activities, leading to reductions in PHC and RI services during campaigns. Multiple studies also highlighted the problems presented by short-term incentives paid to health workers during campaigns; while there is rationale for providing incentives for the additional work required by campaigns, they often put regular PHC service provision at risk and can create longer-term challenges around health worker remuneration and retention.

This review has highlighted that campaigns tend to provide a substantial number of health system inputs — short-term or focused activities or goods that support an essential health system function [140] — that improve RI. These inputs include new and/or higher quality data to improve microplanning, cold chain investments, and training of health workers on a range of immunization-related capacities. However, this analysis highlights that efforts to improve campaign effectiveness or leverage campaign-generated resources for RI strengthening have focused less on strengthening systems performance drivers — policies, regulations, organizational structures, and/or behaviors [140] — that could contribute to larger impacts on immunization systems writ large. Examples of campaign-related interventions that have led to the strengthening of performance drivers related to RI include the development of social mobilization platforms and microplanning for campaigns that were later used in RI activities, opportunities for expansion of PHC services through SIAs, and strengthened management capacities at sub-national level.

More can be done to more systematically and intentionally make better use of campaign-related interventions to strengthen RI and PHC platforms. Some countries have had more success in transitioning SIA assets into RI systems, but they have often had historically high donor support for campaigns and RI services (e.g., India, Nigeria, and Pakistan).

To effectively realize the benefits that campaigns can provide to RI, there must be targeted funding — coupled with longer-term domestic resource mobilization efforts — to support the successful transition of campaign assets for RI.

With the increasing emphasis put on reaching zero-dose children in IA2030 and Gavi 5.0, there is a need for countries to identify an optimal set of immunization strategies that identify and deliver services to both hard-to-reach and hard-to-vaccinate communities (while also considering how RI activities can be better integrated into primary health care platforms). Evidence synthesized in this review suggest that measles and polio SIAs have been somewhat successful in reaching these communities, and that data on these communities generated from SIAs has been used in RI planning in some contexts. But there have been many missed opportunities to strengthen these linkages and develop more robust pro-equity immunization planning at national and sub-national levels — inclusive of RI and the appropriate use of campaigns — to address persistent inequities in immunization coverage.

The current COVID-19 pandemic will continue to disrupt the provision of immunization services regardless of the delivery modality and will threaten gains in immunization for the foreseeable future. Practical experience from mitigating immunization disruption during the EVD outbreak in West Africa in 2014-2016 highlights the need for countries to consider a wider range of immunization service delivery modalities (e.g., PIRIs or targeted sub-national campaigns) to safely maintain services. These experiences also underscore the need for more focused attention to strengthening the resiliency of service delivery platforms to be able to respond to external health system stressors while minimizing disruptions to essential services, like immunization.

LIMITATIONS

Although this review used a comprehensive search strategy of peer-reviewed and gray literature, some records could have been missed if they were located in non-queried databases not accessible to the authors or did not contain search terms used by the authors. While the authors were focused on experiences since 2010, they recognize earlier experiences on the intersection between campaigns and RI may not be reflected in these findings (e.g., polio eradication efforts in EURO and PAHO). The practical nature of many of the themes explored by the research questions suggest that there are likely additional learnings across a range of contexts that have not been documented in peer-reviewed or other resources. Further in-depth consultations with global, regional, and country-level actors within the immunization space would provide an additional level of nuance to this analysis that is not possible through document review alone.

CONCLUSIONS

This literature review provides a comprehensive synthesis of published peer-reviewed and gray literature documenting efforts to improve campaign effectiveness and strengthen meaningful use of immunization campaign-derived resources for RI strengthening, as well as the ways in which immunization programs have adapted in times of epidemics. Building upon past analyses that looked at the ways in which immunization campaigns can negatively and positively affect RI and the larger health system, this review took an expanded scope in research themes and VPDs. The findings of this review demonstrate that there is a large evidence base on ways in which campaigns have become more effective at reaching their target populations, as well as the general risks and opportunities that immunization campaigns pose to LMICs' health systems. The availability of evidence on the use of campaign-derived resources and assets for RI is variable by topic-area; for example, the successful use of campaign-derived social mobilization platforms for RI activities and the use of campaign data for RI planning (including improving targeting of hard-to-reach and hard-to-vaccinate communities) is more developed than other areas.

Based on this analysis, there are multiple evidence gaps that if explored could provide important information for immunization and health system managers in LMICs to strengthen the linkage between immunization campaigns and RI systems. These gaps include: 1) processes through which countries decide among different campaign modalities, including understanding the role that external financing plays in influencing decision-making; 2) cost-effectiveness of alternative campaign delivery modalities at varying coverage levels to inform country-level decision-making; 3) ways in which early campaign planning can more holistically identify complementary areas for RI strengthening; 4) success factors in creating effective feedback loops between campaign managers and RI managers to make more productive use of campaign assets for RI;

5) more effective ways to identify and reach zero-dose and underimmunized children through RI and campaigns; 6) strategies to mitigate the impact health worker campaign incentives have on RI service delivery; 7) how to design campaign funding models to minimize potential disincentives at all system levels, and 8) strategies to minimize disruption of RI and safely conduct contextually appropriate immunization campaigns during the COVID-19 pandemic.

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