

Interventions to improve vaccination coverage of children in hard-to-reach population: A systematic review

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ABSTRACT

In the last decade, vaccination has reduced a quarter of child deaths worldwide. Vaccination coverage increased, but the coverage remains low in the hard-to-reach population. We searched articles from Pubmed MEDLINE, SCOPUS, Web of Science, and Science Direct to systematically review interventions to improve children's vaccination coverage in hard-to-reach populations. The expected outcome was vaccination coverage, which mentioned Odds Ratio, mean difference, or difference-in-difference with a 95% CI or p-value. Out of 102 articles identified, five articles from four different countries met the inclusion criteria. Four of the five studies reported a positive impact in increasing vaccination coverage. Interventions that showed good effectiveness in increasing the coverage of childhood immunizations were the application of mHealth given to vaccinators, multiple interventions involving the community, modification of immunization schedules during outreach activities, and immunization screening cards. Despite the inconsistent finding, mHealth with SMS reminders was the most effective intervention to increase vaccination coverage and relatively low-cost. More research was needed in developing a strategic intervention to increase vaccination coverage of children in hard-to-reach populations.

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1. INTRODUCTION

The global vaccine action plan (GVAP) central vision is a world free from vaccine-preventable diseases [1]. Since 2010, immunization has contributed significantly to reducing a quarter of the number of child deaths due to vaccine-preventable disease worldwide, from 52 to 39 deaths per 1,000 live births [2]. Vaccinations prevented 10 million deaths between 2010 and 2015, and many more since 2000 [3]. Vaccination coverage has also reportedly increased. The second dose of measles-containing-vaccine (MCV) coverage increased from 42% in 2010 to 69% in 2018. There are 95 countries with DPT3 coverage of 90% in each region, exceeding the GVAP target of 80% in every district [4]. However, there still are disparities. In some regions with conflicts and weak health systems, remote areas, or urban slums, childhood vaccination coverage remains low [5].

Low vaccination coverage levels prevent herd immunity to build, hence vulnerable to an outbreak. Two doses of the measles vaccine with a minimum coverage of 97% are required to obtain herd immunity against the measles virus in Europe [6]. Although national coverage of measles vaccine over World Health

Organization (WHO) standards, if the clustering of non-vaccination children exists, outbreaks can occur because of the decreasing local immunity threshold [7], [8]. There are several causes for the low coverage of immunization: marginalized economic and social status, poor urban areas, remote and rural areas [2]. This condition is related to access and reachability. Hard-to-reach populations for vaccination are groups of people who experience vaccination barriers due to distance and geographic location, non-permanent residence, unavailability of health services, inadequate immunization systems, conflict, and war [9]. In Middle East, conflict-stricken populations are low in vaccination coverage and treatable disease, resulting in cholera and polio outbreaks [10]. Not only vaccination problems but also maternal health such as birth preparedness and readiness level are also lower in hard-to-reach areas [11]. All this evidence suggests that addressing hard-to-reach populations as a target intervention to improve maternal and child health, especially immunization, is crucial in achieving 14 of the 17 sustainable development goals [12].

Special efforts are needed to conduct vaccination in hard-to-reach areas. This kind of intervention is usually high-cost [13], with non-vaccine cost (program management, human resources, social mobilization, surveillance, capacity building) was higher than vaccine cost [14]. However, the finding from a previous modeling study in Kenya showed that unvaccinated children with measles vaccine from 2016 to 2020 resulted in a loss of \$9.5 million in medical costs and productivity, and conducting vaccination in geography hard-to-reach area are highly cost-effective [15]. A modeled vaccination strategy in the Democratic Republic of Congo also showed that delivering a second dose of MCV would save more than the US \$199 million [16]. This figure also indicates the importance of increasing vaccination coverage in hard-to-reach populations.

A systematic review on delivering prevention of infectious disease in women and children in conflict hard-to-reach settings had been conducted previously [17], but not evaluating the coverage increased of interventions implemented. There has been no systematic review of which strategies effectively increase childhood immunization coverage in hard-to-reach populations. Therefore, this systematic review was prepared to evaluate interventions to increase child vaccination coverage in hard-to-reach populations.

2. RESEARCH METHOD

We conducted a systematic review of interventions to increase child vaccination coverage in hard-to-reach populations. We used the PRISMA checklist as a writing guideline to ensure all steps are carried out correctly [18]. Two reviewers were responsible for reviewing titles, abstracts, and full texts for inclusions. Population, intervention, comparison, outcome (PICO) framework was used to clarify the eligibility criteria for inclusion and exclusion of relevant articles [19], summarized in Table 1.

Table 1. PICO for inclusion and exclusion criteria

	Include	Exclude
Population	Studies on pregnant women, children under five years old, health care staffs from hard-to-reach settings	Studies on school-age children, adult, elderly, and animals
Interventions	Studies evaluated interventions to scaling up childhood vaccination coverage during routine immunization, campaign, or new program implementation.	Studies which interventions to improve childhood vaccination coverage was conducted due to response for disease outbreak.
Comparison	Standard health care service/ usual practice, or other interventions to improve childhood vaccination coverage; conditions before implementing interventions	No comparison of different actions to improve vaccination coverage
Outcome	The outcome of interest was childhood vaccination coverage before and after an intervention. The expected outcome measure was the Odds Ratio, mean difference, or difference in difference (DID) with a 95% Confidence Interval or p-value.	The outcome of interest was the proportion of childhood vaccination coverage in descriptive statistics only, without further data analysis.

We only included studies in English. Study designs included as inclusion criteria were trials, observational analytic studies, and before-after studies. Other exclusion criteria were studies with the pure qualitative design, modeling, review, editorial, opinion, and commentary. Inaccessible studies were also an exclusion criterion. To minimize the risk of bias, gray literature and studies that have not been peer-reviewed were not included.

In conducting our search, we used a combination of five sets of keywords: i) Child, infant, pediatrics; ii) hard-to-reach communities, hard-to-reach population, hard-to-reach area, remote area, difficult area; iii) vaccination, immunization; iv) uptake, coverage, rates, outcomes; v) strategies, programs, interventions.

The search was conducted on four journal databases, Pubmed MEDLINE, SCOPUS, Web of Science, and Science Direct. We searched for all studies published since 2012, one year after the initiation of GVAP, hoping that the selected studies will reflect the follow-up of the launch of GVAP in 2011. All articles obtained from the database search were imported into the Zotero database manager to identify duplicate journals, review titles, and abstracts. Data extraction was carried out on selected articles for full-text review by two reviewers independently. We use Microsoft Excel to tabulate extracted data. We included authors, year of publication, study purpose, setting, design, subjects/ participants, interventions, outcomes, and limitations of the study.

To minimize the risk of bias, we used several tools to assess risk of bias specific to each study design. We used ROBINS-I for non-randomized studies for interventions [20] and RoB 2 for randomized trials [21], with additional considerations for cluster-randomized trials [22]. For uniformity in judging the overall risk of bias, we classified serious and critical risk of bias in ROBINS-I and high risk of bias in RoB 2 as "high risk". Otherwise, we categorized it as "low risk". In the event of disagreement, we resolved any discrepancy by discussion and consensus. In this systematic review, each study's level of evidence was assessed using the National Health and Medical Research Council (NHMRC) criteria [23].

3. RESULTS AND DISCUSSION

3.1. Results

We conducted an article search on 13-20 December 2020 and identified 102 articles from four databases. After removing duplication, there were 58 articles to screen for titles and abstracts. After eliminating irrelevant articles, we found 14 articles to be thoroughly reviewed and leaving three articles for analysis. Two articles were added manually by searching on the included studies' bibliography as shown Figure 1.

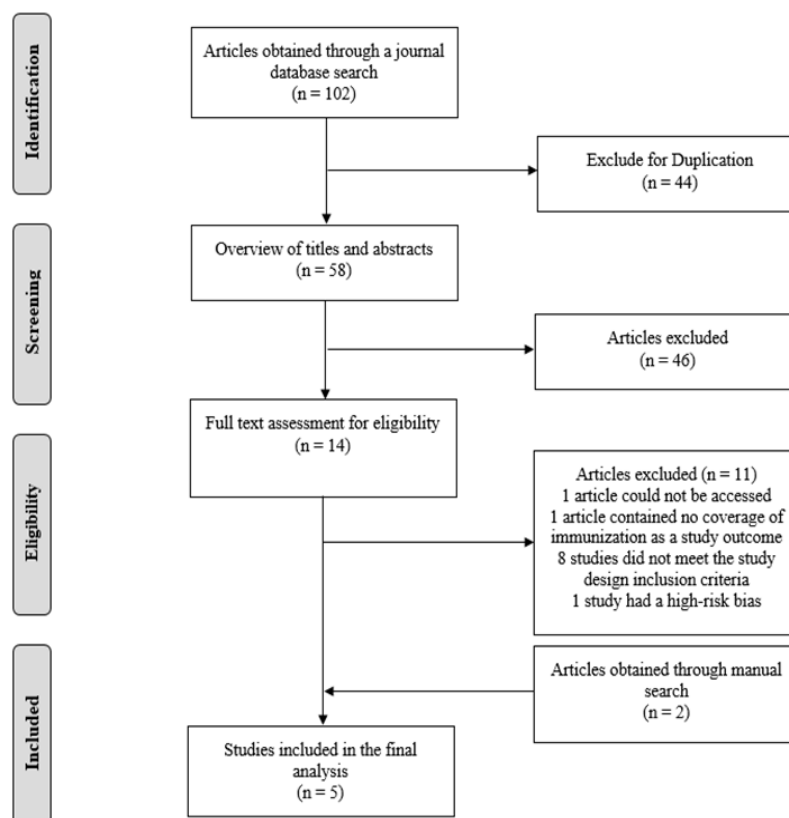


Figure 1. PRISMA diagram

The five included studies came from four different countries: Bangladesh (n=2), Afghanistan (n=1), Pakistan (n=1), and India (n=1). Two articles had a cluster-randomized trial design, two quasi-experimental, and one cross-sectional before-after study. The intervention duration varied with a minimum of 12 months and a maximum of four years as shown in Table 2.

Table 2. Summary of the design and intervention of the studies

Author, year	Setting	Length of study	Participants	Interventions and Comparators
[24]	Bangladesh Sunamgonj district and Dhaka city	April 2013 to March 2014	520 children in baseline and 520 children in end line from rural interventions area 518 children in baseline and 520 children in end line from urban interventions area 2,080 children from the control area	Intervention: MHealth mTika android and web-based application which functions are: (1) Registration of pregnant women (2) Receive short message service (SMS) notifications of baby birth sent by mothers (3) Sending automatic SMS immunization reminders for mothers (4) Vaccination reminders for health workers (5) Monitoring of immunization programs by health supervisors Comparator: The pre-existing public health system in Bangladesh
[25]	Afghanistan 54 intervention districts and 56 control districts	March 2013 to March 2017	338,798 pregnant women 1,693,872 children under five years	Intervention: Mobile health teams (MHTs) that focus on maternal and child health (MCH) were implemented in the intervention areas. MHT consists of midwife nurses and vaccination officers. MHT visits remote and conflict-affected villages for 1 to 2 days every two months for outreach. MHT-MCH services are (1) Vaccination outreach (2) Mobile clinics for adults (3) Scheduled health services for mothers and children under five years Comparator: Standard ministry of health services include vaccination outreach and mobile health services for adults
[26]	Bangladesh Sunamgonj district (haor area) and Rangamati district (hill area)	April 2008 to May 2010	1,440 mothers and children in the baseline survey and 1,441 mothers and children in the end-line survey in Sunamgonj district 1,440 mothers and children in the baseline survey and 1. mothers and children in the end-line survey in Rangamati district	Group A (1) Refresher training for immunization officers on valid dose and adverse events. (2) Re-design vaccine supply system (3) Modification of immunization schedule (4) Community support groups Group B (1) Refresher training for immunization officers on valid dose and adverse events. (2) Re-design vaccine supply system (3) Immunization screening checklist
[27]	Pakistan Banjar, Karachi, and Kashmore	Jun. 4, 2013, to May 31, 2014	Baseline: 28,760 children under five in arm A 30,098 children under five in arm B 29,126 children under five in arm C End-line 23,334 children under five in arm A 26,110 children under five in arm B 25,745 children under five in arm C	Arm A Routine immunization package with the addition of oral polio vaccine (OPV) supplementary immunization activities Arm B: (1) Arm A plus (2) Community and mobilization outreach (3) Improved communications (4) Provision of maternal and child health services through low-cost health camps Arm C: (1) Arm B plus (2) Providing additional inactivated polio vaccine (IPV) through maternal and child health camps
[28]	India 6 tribal blocks in Bharuch and Namada districts	February 2016 to January 2017	Intervention: 1,571 mothers with children aged 1-4 months 1,757 mothers with children aged 6-9 months Control: 1,452 mothers with children aged 1-4 months 1,713 mothers with children aged 6-9 months	Intervention: The use of ImTeCHO mHealth application by assisted social health activists (ASHAs) Comparator: Standard health care of ASHAs

Three studies evaluated single interventions, i.e., service innovation using mHealth application [24], [28], and mobile outreach services under challenging locations [25]. Two other studies evaluated multiple interventions consisting of refresher training, modification immunization schedule, community engagement, immunization screening checklist [26], and community outreach to provide maternal and child health service [27]. Four of the five studies reported a positive impact in increasing vaccination coverage [24]-[27], and one study did not show superiority over than standard package [28]. Interventions that show good effectiveness in increasing the coverage of childhood immunizations are the application of mHealth, given to vaccinators with SMS reminders (OR 3.6, 95% CI 1.5 to 8.9, $p < 0.001$). Multiple interventions involving the community, modification of immunization schedules during outreach activities, and immunization screening cards also effectively increased coverage (OR 3.02, 95% CI 2.58 to 3.54, $p < 0.01$). Only one study using multiple interventions reached the WHO target for immunization coverage $> 80\%$ [26]. Changes in vaccination coverage after intervention can be seen in Table 3 (see in appendix).

Four of five studies had a low to moderate risk of bias due to randomization. One study had critical risk because it was not randomized, and no clear baseline for each group [25]. Deviations from intended interventions were observed in two studies [24], [26], which reported no standardized interventions delivered because of the context of intervention. All five studies had some concerns in measuring the outcome; caregiver recall was used to obtain vaccination status. Although this method had quality concerns [29], this method was still acceptable, especially in lower and middle-income countries, and encouraged to be used in combination with vaccination cards and health care facilities documentation [30]. Due to the design of quasi-experimental, repeated cross-sectional studies, there was unclear evidence of missing outcome data in three studies [24]-[26]. Based on our pre-existing criteria assessment, four studies were categorized as low [24], [26]-[28], and one study categorized as high risk of bias [25].

3.2. Discussion

This systematic review aimed to identify appropriate interventions to increase child vaccination coverage in hard-to-reach populations. The five selected studies provided an overview of potential interventions to increase child vaccination coverage in hard-to-reach populations. The limited number of studies that raised this issue showed that child immunization in hard-to-reach populations had not been given much attention, even though child vaccination coverage is still one of the world's global health problems [31].

3.2.1. Post-intervention vaccination coverage

One of the essential meanings of vaccination coverage is finding out community access to healthcare [32]. Measles coverage is an important indicator of achieving sustainable development goal (SDG) 3, “ensure healthy lives and promoting well-being for all at all ages”. The high rate of measles transmission requires at least 95% of measles1 and measles2 vaccines coverage to prevent transmission [33]. Our findings in this study indicate that despite a significant increase in coverage after interventions were reached, none of the studies achieved a minimum coverage of measles immunization of 95% as shown in Table 3 (see in appendix). Other findings in this study also show that only one study achieved the target of at least 80% of all childhood immunization coverage in every district [4]. The low post-intervention coverage indicates that difficult-to-reach populations were still a significant challenge in the immunization program. Remote and conflict-prone areas have worse maternal and child health than other areas due to the difficulty of providing prevention and treatment services [34]. More than just temporary interventions were needed. Interventions that were sustainable and applied to a broader location were expected to increase vaccination coverage with long-term impacts. Communication about the importance of vaccination and vaccine safety should be improved, and a strategy for tracking drop-out cases should also be a priority [35].

3.2.2. Intervention strategies to increase vaccination coverage

Of the five articles selected for this study, interventions that seem to give rise significantly compared to the coverage number of baseline conditions is the application of mHealth mTika and the multiple interventions in Bangladesh, with each having a value of OR more than three [24], [26]. One study with multiple interventions: community mobilization, improved communication, and health camps increased 3 to 15% over baseline despite requiring higher costs [27]. The intervention with the mobile health team in the Afghanistan study did not record baseline values and therefore could not be compared [25]. The mHealth intervention with ImTeCHO did not show a significant increase in coverage [36].

mTika mHealth application showed the largest size of the impact of increasing coverage in the intervention area with OR 3.6. This strategy worked well in Bangladesh [24] but not India [28]. We estimate this is due to differences in application users. In Bangladesh, the mTika application was given directly to vaccine officers to carry out direct tracking [24]. Furthermore, periodic automatic SMS reminders to mothers before the immunization schedule made the mTika application more effective in increasing vaccination

coverage than ImTeCHO. In India, ImTeCHO application was no superior to standard immunization services. A previous study identified gaps in the performance of ASHAs in mobilizing mothers and children for immunization [36]. However, giving mobile phones to ASHAs did not answer this problem. This inconsistent benefit was also reported in a previous systematic review conducted by Cock *et al.* [37]. Furthermore, Oliver-Williams *et al.* [38] reported that only a little evidence supports mobile apps' use to increase vaccination coverage. Therefore, despite 4.5 billion people have mobile phones and SMS technology has proven to improve maternal and child health services in developing countries [39], the use of mobile apps to increase vaccination coverage in hard-to-reach populations still needs further research.

Travel to health services affects infant vaccination coverage. Penta3 vaccination coverage was lower in children who live with travel time to health services ≥ 60 minutes than < 30 minutes [40]. In this case, mobile health teams effectively reduced travel time to health care centers. A mobile clinic was a unit that aims to provide medical services, diagnosis, and treatment for patients in remote areas [41]. Although common obstacles to this type of intervention are financial problems, human resources, and logistical limitations [42], this service is considered cost-effective compared to build a permanent health unit in remote and hard-to-reach areas [41]. Therefore, to have sustainability in implementing this type of service, good planning of various programs and funding must be done simultaneously by stakeholders.

A good schedule of team visits also enhanced mobile health teams' effectiveness. Studies in Nigeria showed that immunization utilization was affected by health care problems. Lack of services, lack of health personnel, and vaccines' absence on a predetermined schedule lead to low immunization utilization [43]. Modifications to the immunization schedule such as those carried out in Bangladesh were a strategic way of dealing with this. Changing the outreach schedule by mobile immunization from one day monthly to every two months for two days provides more opportunities for every child to access immunizations. More children can be served by staying longer because the vaccination service is not limited to particular hours. Parents who work in the morning can bring their child in the afternoon or the following day. For officers, this schedule modification also saves expenses because they do not need to come every month. This schedule change is also in accordance with the WHO routine immunization schedule recommendations, which allows intervals between DPT vaccines of four and eight weeks [44].

One of the things that are very crucial in immunization services besides coverage is the quality of vaccines. The most potential of the vaccine can be achieved if the cold chain system is well implemented. This includes vaccine storage and transportation from factories to health facilities where vaccinations are carried out and outreach locations. Various methods were developed to improve the vaccine delivery system, namely preventing vaccine freezing using cold water instead of ice, temperature monitoring systems in vials, and better cold chain related control and regulatory systems [45]. One of the efforts made to maintain the cold chain system's integrity in hard-to-reach areas is re-designing the vaccine delivery system, as reported by Uddin *et al.* in Bangladesh. Vaccines were no longer sent from an area's capital but rather sent from adjacent cities [26]. The goal was to cut the mileage and reduce travel time to reduce vaccine damage due to the long trip. This method is good enough but requires more coordination with other districts as it will also change their cold chain system. This needed additional work by officials from other districts to get the vaccine to a certain point, which requires additional costs and therefore should be included in the evaluation component.

In Bangladesh, the establishment of a community support group consisting of immunization hosts, mothers with fully immunized children, village defense members, male and female students, representatives of non-profit organizations, traditional birth attendants, and traditional healers increased vaccination coverage [26]. A study from Pakistan also reported increased vaccination coverage after training lady health workers and traditional birth attendants as community mobilizers [46]. Habib *et al.* reported that community communication campaigns have also effectively increased oral polio immunization coverage [27]. However, this kind of intervention is usually hindered by funding constraints, inadequate infrastructure and equipment, community stakeholders' attitudes, and political factors [47].

Uddin *et al.* reported positive outcomes from multiple interventions to improve the health system [26]. Refresher training for Public Health staff, re-design vaccine supply system, and providing immunization screening checklist increased complete immunization coverage 26 to 29%. The combination of this intervention with community engagement increased the coverage even more remarkable, with OR 3.02, compared to baseline. These interventions were worldwide accepted and recommended to improve vaccination coverage. Refresher training has been routinely recommended to strengthen the immunization program. It is recommended by WHO [48], and UNICEF recommended rapid card check for immunization to evaluate immunization program at the household level [49]. Thus, the combination of these interventions was worked better.

3.2.3. Cost-Effectiveness of Interventions

Vaccination was known as a lifetime investment. Even in the lower and middle-income countries, vaccination contributed as protection against poverty [50]. Nevertheless, the cost is high in hard-to-reach geography. Of the five studies, mHealth mTika intervention was the most cost-effective because only using SMS reminders to obtain a significant increase in vaccination coverage. Mobile health teams and health camps that take the form of outreach activities, whether conducted in Afghanistan or Pakistan, are considered to be at a high-cost [25], [27]. Habib *et al.* noted that the cost of adding a low-cost health camp was not low. Apart from the additional costs, additional human resources, training, and supervision were added to standard immunization services. Therefore, these interventions cannot replace existing standard immunization services, although they can increase vaccination coverage [27]. The thing that needs to be considered in high-cost activities is the sustainability of these activities related to funding. If the funds needed are not available, the program's continuity is threatened so that there is concern that coverage will decline.

Uddin *et al.* wrote that multiple interventions at the study sites were provided without additional costs because they were implementing their intervention by using existing resources [26]. This kind of intervention needs to do with caution because the additional work without additional appreciation could jeopardize the system's sustainability. A study in Myanmar of health workers and cadres in hard-to-reach areas showed that government incentives, transportation support, training, and residents' acceptance affected their work productivity [51].

A study reported that ImTeCHO was cost-effective in improving India's infant mortality [52]. However, there was no record of its cost-effectiveness in overall maternal and child health programs, especially in increasing vaccination coverage. Furthermore, considering that the costs incurred with this system not only the purchase of equipment but also credit and the cost of service, and replacement when lost or stolen, the use of ImTeCHO was ineffective and costly in improving vaccination coverage.

3.2.4. Limitations

This systematic review's major limitation was the small number of studies identified. Differences in design between studies make it difficult to conclude the size of the impact of more controlled interventions. There were only two randomized controlled trial (RCT) studies with a low risk of bias, two quasi-experimental studies with a low risk of bias, and one cross-sectional study with a high risk of bias in this systematic review. Therefore, conclusions regarding the intervention's effectiveness are varying. Considering all these limitations, the level of evidence for interventions to increase vaccination coverage for children in hard-to-reach populations is therefore low (NHMRC level of evidence III-3).

4. CONCLUSION

To our knowledge, this is the first article that systematically reviewed interventions to improve vaccination coverage in hard-to-reach populations. Our systematic review shows that the mHealth application shows high effectiveness if appropriately addressed, although it needs further research. Multiple interventions involving existing health systems are highly effective and low-cost. Mobilization of health teams to hard-to-reach areas can increase vaccination coverage but requires high costs and additional resources to carry out these activities. Costs can be reduced if the intervention is integrated with the existing health system so that there is no need to bring in additional human resources. However, we recommend that additional incentives be provided to health workers and community groups who conduct outreach to motivate them to carry out their duties. Given the costs incurred, better program planning and targeting a broader program are needed to increase the effectiveness of the already incurred costs.

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APPENDIX

Table 3. Vaccine coverage before and after interventions

Table 3. Vaccine coverage before and after interventions						
Author, year	Pre % (95% CI)	Post % (95% CI)	Change % (95% CI)	Importance	RoB /NHMRC	
[24]	Children aged >298 days received complete BCG + Penta3 + MR vaccination				Low /III-2	
	<i>Intervention (rural)</i>					
	58.9	76.8	(+)18.8 (5.7 to 31.9) <i>p</i> <0.001	DID (+)29.5 OR 3.6 (1.5 to 8.9) <i>p</i> <0.001		
	<i>Control (rural)</i>					
	65.9	55.2	(-)10.7 (-25.2 to 3.9) <i>P</i> <0.001	There was an increase in coverage in the intervention group and decreased coverage in the control group, which were statistically significant.		
	Children aged >298 days never vaccinated.					
	<i>Intervention (rural)</i>					
	9.2	1.4	(-)7.7 (-13.4 to -2.0) <i>p</i> <0.001	DID (-)9.9 OR 0.04 (0 to 0.09) <i>p</i> <0.001		
	<i>Control (rural)</i>					
	0.8	3.0	(+)2.2 (-2.2 to 6.6)	There was a statistically significant reduction in the coverage of children who never received the vaccine in the intervention areas.		
[25]	The proportion of infants receiving Penta3 vaccine				High /III-3	
	<i>Intervention</i>					
	No data	76.4 SD 28.7		Mean difference 7.55 (-4.2 to 19.3) <i>p</i> 0.20		
	<i>Control</i>					
	No data	62.4 SD 33.9		There was no statistically significant difference between the intervention and control groups for the proportion of infants receiving the Penta3 vaccine.		
	The proportion of infants receiving measles vaccine-1					
	<i>Intervention</i>					
	No data	73.8 SD 26.6		Mean difference 12.78 (2.08 to 23.48) <i>p</i> 0.02		
[26]	<i>Control</i>					
	No data	57.3 SD 30.5		There was a statistically significant difference in the mean proportion of infants receiving measles1 vaccine between the intervention and control groups		
	Vaccination coverage for children aged 12-23 months				Low /III-2	
	<i>Group A haor</i>					
	Complete BCG-DPT3-Measles immunization					
	29	83	54 (49.7 to 58.3) <i>p</i> <0.001			
	Immunization left-out					
	15	2	13 (30.6 to 39.3) <i>p</i> <0.001	Complete immunization for children aged 12-23 months Group B compared to group A: OR 2.09 (1.73 to 2.53) <i>p</i> <0.01		
	<i>Group A hill</i>					
	Complete BCG-DPT3-Measles immunization					
	69	89	20 (15.9 to 24.1) <i>p</i> <0.001	End-line versus baseline: OR 3.02 (2.58 to 3.54) <i>p</i> <0.01		
	Immunization left-out					
	6	0	-6 (0)	Hill versus haor: OR 1.54 (1.30 to 1.82) <i>p</i> <0.01		
	<i>Group B haor</i>					
	Complete BCG-DPT3-Measles immunization					
	52	81	29 (24.4 to 33.6) <i>p</i> <0.001	The increase in vaccination coverage for children aged 12-23 was statistically significant in the intervention groups A and B, with groups B and hill having a higher probability of experiencing an increase in coverage.		
	Immunization left-out					
	4	1	3 (1.3 to 4.6) <i>p</i> <0.001			
	[27]	<i>Group B hill</i>				
		Complete BCG-DPT3-Measles immunization				
55		81	26 (21.4 to 30.6) <i>p</i> <0.001			
Immunization left-out						
9		5	4 (1.4 to 6.6) <i>p</i> <0.001			
Complete immunization according to age						
<i>Arm A</i>				Low /II		
22 (22 to 24)		25 (22 to 27)	3	Increased proportion of complete immunizations Arm B versus arm A 7.3 (4.5 to 10.0) Arm C versus arm A		

	<i>Arm B</i>			9.5 (6.9 to 12.0)	
	22 (19 to 24)	32 (29 to 35)	10	<i>p</i> <0.0001	
	<i>Arm C</i>			There was a significant increase in the proportion of children who received complete immunization after the intervention in arm B and C compared to arm A (control)	
	22 (20 to 24)	34 (31 to 37)	12		
	Immunization left out				
	<i>Arm A</i>				
	42 (39 to 46)	36(32 to 40)	6		
	<i>Arm B</i>				
	42 (38 to 46)	28 (25 to 31)	14		
	<i>Arm C</i>				
	42 (38 to 46)	27 (24 to 30)	15		
	The proportion of mean vaccine dose received during the scheduled supplemental immunization			Intervention B effect 9% (7 to 11)	
	<i>Arm A</i>			Intervention C effect 11% (9 to 13)	
	39 (37 to 42)	43 (40 to 45)	4		
	<i>Arm B</i>			<i>p</i> <0.0001	
	39 (36 to 41)	52 (49 to 55)	13	There was an increase in the mean proportion of vaccines received as the addition of interventions (B and C) was statistically significant.	
	<i>Arm C</i>				
	39 (36 to 42)	54 (51 to 56)	15		
				Adjusted effect size: 1.1	
				(-2.7 to 4.9)	
				<i>p</i> 0.589	
				There was no significant difference between the intervention and control groups receiving the Penta3 dose for infants aged 6-9 months.	
[28]	Percentage of Penta3 vaccine acceptance in infants aged 6-9 months				Low /II
	Intervention: 73.0 (70.3 to 75.8)				
	Control: 73.6 (70.9 to 76.4)				

RoB – Risk of Bias; NHMRC - National Health and Medical Research Council