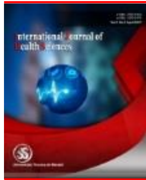

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Interventions to improve vaccination uptake: A systematic review and meta-analysis

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***Abstract*---Background:** Vaccination is a critical public health intervention that significantly reduces morbidity and mortality from vaccine-preventable diseases. Despite its effectiveness, achieving high vaccination coverage remains a challenge, particularly in low-resource settings. **Objective:** This systematic review assessed the effectiveness of various interventions designed to improve vaccination uptake. **Method:** The review was guided by Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Literature search was conducted in four databases (PubMed, Scopus, Google Scholar, and AJOL) in October 2024 yielding 246 articles. 8 articles met the eligibility criteria and were included in the review. JBI critical appraisal tool was used to assess the quality of the studies. Data were

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extracted, narratively reviewed and pooled using random effect meta-analysis. **Results:** Final review revealed 8 articles which were from Nigeria (37.5%), Pakistan (25%), Kenya (12.5%), China (12.5%), and Zimbabwe (12.5%). Interventions evaluated were phone calls or SMS (40%), SMS reminders and monetary incentive (20%), SMS reminder and health education (20%), health education (20%), bracelet reminder (20%). The review identified that mobile phone-based reminders, health education, including bracelet reminder significantly improved vaccination coverage. However the result of the meta-analysis showed no statistically pooled effect (RR = 1.05; 95% CI: 0.93-1.18), with moderate heterogeneity across studies. **Conclusion:** Although the combined effects of interventions did not show statistically significant overall impacts, findings from individual studies revealed that interventions such as SMS reminders, health education, and bracelet reminders can effectively improve vaccination uptake. Future research should explore the integration of these strategies into broader health systems to enhance and sustain vaccination coverage.

***Keywords*---**Intervention, vaccination, improve, uptake, systematic review.

Introduction

Routine immunization is essential for lowering childhood morbidity and death from diseases that can be prevented by vaccination. According to Allison et al. (2023) vaccines have been discovered to be one of the most successful therapies for preventing morbidity and mortality. Immunization continues to be one of the most significant and economical public health interventions against vaccine-preventable diseases (VPDs), with significant health and economic advantages (Tor et al., 2023). According to WHO, vaccination is projected to avert 3 million deaths annually worldwide (Galadima et al., 2021). It has been reported that vaccination is an effective public health strategy for strengthening the immune system and enhancing child survival when used to raise herd immunity and reduce the prevalence of infectious diseases (Oyo-Ita et al., 2023). According to Allison et al. (2023), the World Health Organization (WHO) currently advises all nations to attain a 95% coverage requirement for all routine vaccinations in order to achieve herd immunity levels.

Vaccination has significantly improved health around the world. Children who are not vaccinated are still susceptible to illnesses that can be prevented by vaccination (Mahachi et al., 2022). According to Obi-Jeff et al. (2021), immunizations increase survival, prevent disease, save lives, lower family expenses and poverty, and improve physical development in children. Regretfully, there are significant obstacles in the way of guaranteeing that target groups obtain the advised immunizations. Blagden et al. (2022) claim that there has been a decline in vaccine uptake because of misconceptions about the severity of the disease, parental resentment of perceived risks to their child's safety, mistrust of governments, healthcare professionals, and vaccine research, worries about the

safety and efficacy of vaccines, restricted access to vaccines due to location, timing of vaccinations, and difficulty obtaining health care. According to Oyo-Ita et al. (2023), a variety of factors, including social, economic, cultural, geographic, political, and religious ones, influence vaccination uptake in different contexts. Innovative methods of vaccine distribution and uptake may be necessary to maintain immunization rates at levels necessary to stop the spread of community diseases.

Given the variety of factors linked to poor vaccination outcomes, it is believed that multifaceted approaches could have positive impact in improving vaccination outcomes. To address people and increase their understanding of the advantages of immunization, effective intervention tactics are required. According to Oyo-Ita et al. (2023), the intervention should focus on dispelling myths, rumors, or worries that discourage people from being vaccinated and educating people about where and when to get vaccinated in order to possibly raise vaccination rates. It is difficult to overcome these complex behavioral, political, and socio-cultural issues, and doing so calls for a variety of strategies that may differ depending on the context. This systematic review aims to summarize the studies that focus on interventions to address vaccine hesitancy, low vaccine acceptance, poor vaccine knowledge and perception, and other factors that influence vaccination uptake.

Review Question
How effective are the various interventions deployed to improve vaccination uptake?

Method

Types of Studies: This systematic review was conducted using a predefined protocol and in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA). We used randomized controlled trials (RCTs), and quasi-experimental studies for the review.

Search Strategy: Comprehensive search was conducted from 5th to 7th October 2024 using the following electronic databases; PubMed, Scopus, AJOL (African Journal Online), and Google scholar. For the PubMed, search was conducted using a combination of medical subject heading (MeSH) terms and keywords. The study characteristics were conducted using PICO (Population, Intervention, Comparison and Outcome) framework. Study areas used include any setting where vaccination interventions were implemented (e.g. healthcare facilities, schools, community environment). The search terms were “children” AND “reminder systems” OR “SMS reminders” “educational interventions” OR “workshops” OR “financial incentives” OR “training programs” OR “home visits” OR “outreach programs” AND “control group” OR “standard care” OR “usual practice” AND “vaccination uptake” OR “immunization rates”. The search was conducted using both MeSH and free-text terms. Our search was limited to the last ten years, and only studies published in English language were used.

Types of Population: The population comprised of participants of different age groups (18years and above) who can make decision regarding vaccination uptake or practice, and they include parents of the children, caregivers, adolescents, and

adults; healthcare providers administering vaccines through routine childhood immunization services.

Types of Intervention: The review comprised of any intervention designed to improve vaccination uptake among children. The following interventions were identified in the included studies of this review: educational interventions, cell phone reminder/recall-based interventions through phone calls or automated text messages; financial incentive (subsidies or cash incentives) and bracelets reminders.

Comparison: Standard immunization practices (control group) used in the study.

Outcome: The outcomes were divided into two categories: primary and secondary outcomes. The primary outcome measures the increase in the rate of vaccine uptake after the intervention, while the secondary outcome assessed the changes in attitude of clients towards vaccination services, and healthcare utilization related to vaccination.

Eligibility Criteria for Screening of Reviewed Studies

Inclusion Criteria

- Studies that evaluated interventions to improve vaccine uptake
- Original research conducted using randomized controlled trials (RCTs), or quasi-experimental studies.
- Studies that sampled parents and adults who can make decision regarding vaccine uptake
- Peer-reviewed full text publications
- Studies published within the last ten (10) years (2014 – 2024).

Exclusion Criteria

- Studies not published in English language

Study Selection

The eligibility of abstracts and titles of articles that were obtained by the electronic databases was evaluated based on the inclusion or exclusion criteria (i.e., study kinds, participants, and interventions). When choosing an article based only on the title and abstract proved to be challenging, the entire article was retrieved for screening. All papers that were deemed eligible were obtained for additional analysis. In the end, the reviewers appropriately evaluated each full-text article that was retrieved for eligibility, addressing any questions through discussion. Because there was not enough information about the included interventions, conference abstracts were not included. The selected manuscripts were randomly assigned to two different reviewers who extracted the required data.

Data Extraction: Following guidelines on Joanna Briggs Institute (JBI) data extraction form, data were extracted independently by two researchers and double-checked by the third researcher. Any conflicts over inclusion were discussed and resolved through consensus. The following data were extracted: title of the study, lead author, year of publication, study location, study aim/objectives, study population, sample size, study design, type of intervention,

results and conclusion. Extracted data was categorized according to the type of intervention and tabulated.

Assessment of Risk of Bias

The quality of peer-reviewed studies was rated for the risk of bias. Randomized control trials (RCTs) were assessed using the Joanna Briggs Institute (JBI) risk of bias tool. This tool considers eleven different scales: **true randomization of treatment group, allocation concealment, similarity of treatment groups to baseline, b**linding of participants and **assessors, identical treatment of groups, completion follow-up for groups,** p**articipants analyzed in their groups, outcomes measured in the same way,** o**utcomes measured in a reliable way,** a**ppropriateness of statistical analysis used** and a**ppropriateness of trial design used.** These items were rated as; “YES” if criterion is met, “NO” if criterion is not met or “UNCLEAR if there is insufficient information to determine if the criterion is met. Based on the rating reliability of the study was determined. For the studies included in the review, due to the nature of the interventions often there was no allocation of concealment, participant blinding were not conducted, follow-up not completed and outcomes not measured in a reliable way or the measurement pattern not clearly stated. But generally, many other aspects of the study lack bias.

Quality Assessment

The quality of the included studies was evaluated using Briggs's critical evaluation technique, which was created and revised by the Joanna Briggs Institute (JBI) in 2020. Randomization, allocation of concealments, blinding of participants and staff to the intervention, blinding of outcome assessors, incomplete outcome data, selective reporting of results, intention-to-treat analysis, and sample size justification are the eight measures that make up this tool. Based on the score, articles were categorized as strong, moderate, or weak. The results of the quality evaluation, which was carried out by two researchers, show that the research papers included in this review were of a moderate quality. Because of the nature of the interventions, participant randomization or blinding was frequently not carried out, although many parts of the research designs and testing were generally of good quality.

Data Synthesis

After data extraction, the systematic review's findings were compiled and narratively described. The researchers created a table to record the data and descriptive information for each of the included studies. The lead author, year of publication, study region, target population, sample size, study design, intervention employed, outcome, and conclusion were among the information documented. The researcher synthesized the data and produced the table with assistance from two other researchers.

Results

Studies Identified

For this review, data were extracted independently by two researchers and double-checked by the third researcher. The literature search identified 246 articles, and after duplicates removal and screening for eligibility, eight articles

were selected and they are; from Nigeria (3), Pakistan (2), Kenya (1), China (1), and Zimbabwe (1). Most of these studies focused on mothers and their infants as the study population, the interventions used were phone calls or SMS (2), SMS reminders and monetary incentive (1), SMS reminder and health education (1), health education (1), and bracelet reminder (1).The review identified that the utilization of mobile phone-based reminders, health education, including bracelet reminder significantly improved vaccination coverage.

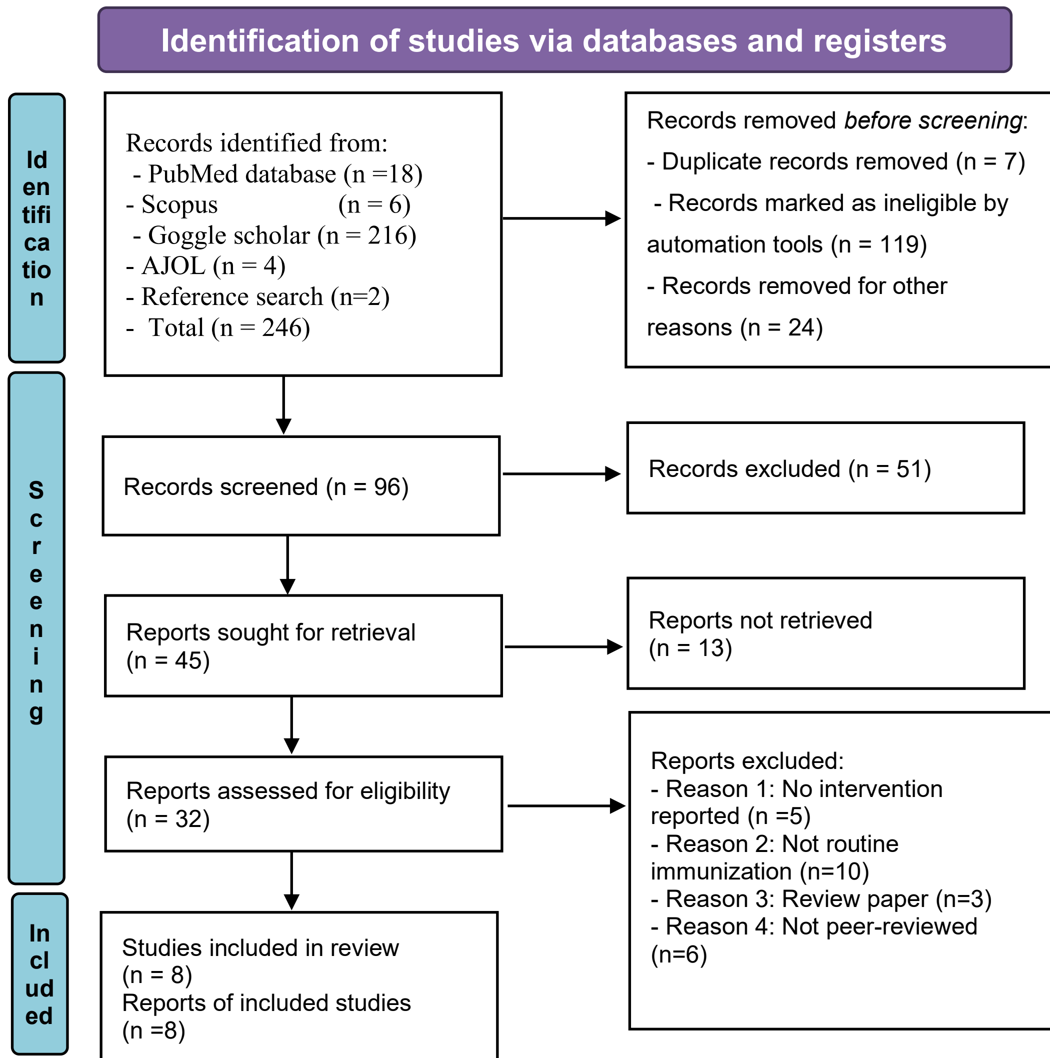

FIGURE 1: PRISMA Flow Diagram

Table 1: Summary of Articles Reviewed

Study (Author, Year)	Country	Design	Intervention Type	N (Int)	Events (Int)	N (Ctrl)	Events (Ctrl)	Prevalence	Effect Size (RR/OR)	95% CI	Follow-up
Siddiqi et al., 2020	Pakistan	RCT	Bracelet reminder	482	408	481	399	83.0% - 84.6%	1.01	0.96-1.06	12 months
Babarinde & Nnodimele, 2022	Nigeria	Quasi	Phone call + education	30	30	30	30	50%	4.242	0.84	6 weeks
Kagucia et al., 2021	Kenya	RCT	SMS + monetary incentive	179	78%	179	68%	68-78%	RR ≈ 1.16	1.01 to 1.32	12 months
Kazi et al., 2018	Pakistan	RCT	SMS reminder	150	86	150	102	Not specified	RR = 1.11	1.02–1.21	18 weeks
Hu et al., 2024	China	Cluster RCT	Training + reminder	915	679	776	556	74.5%	1.40	1.06 to 1.85	3 months
Banwat et al., 2015	Nigeria	Pre/Post	Peer education	176	106	181	99	57.3% - 70.7%	1.01	0.96-1.06	Immediate post-intervention
Brown & Oluwatosin, 2017	Nigeria	Quasi	Cell phone reminder	295	79.2%	300	46.4%	n/a	1.70	Not specified	3 months
Bangure et al., 2013	Zimbabwe	RCT	Health education + SMS reminder	152	97%	152	82%	82% -97%	1.3	12.5-28.0%	14 weeks

Characteristics of Included Studies

Of the 8 studies that meet the inclusion or exclusion criteria, all were peer-reviewed. Five were RCTs, two were quasi experimental and the remaining one was community-based intervention. For the study populations, seven articles studied parents and caregivers of children under five years, and one focused on primary school students. Studies took place in five different countries with three conducted in the Nigeria, two in Pakistan, one in Kenya and one study in Zimbabwe. Several interventions were utilized which include the use of reminder bracelets, health education, SMS reminders, monetary incentive, and peer education. Some of the studies involved more than one intervention including tools to help health workers persuade hesitant families.

Study Design and Setting

Eight studies met the inclusion criteria. Four studies were randomised controlled trials with individuals as the unit of randomization (Siddiqi et al., 2020; Kagucia, et al., 2021; Kazi, et al., 2018; Bangure, et al., 2013), two studies were quasi experimental study (Babarinde & Nnodimele, 2022; Brown & Oluwatosin, 2017), one was cluster-randomised trials that used schools as the unit of randomisation (Hu, et al., 2024), and one of the studies was non randomized trials with pre- and post-intervention groups (Banwat et al., 2015).

Two studies were conducted in Pakistan (Siddiqi et al., 2020; Kazi, et al., 2018), three in Nigeria (Babarinde & Nnodimele, 2022; Banwat et al., 2015; Brown & Oluwatosin, 2017), and one each in Kenya (Kagucia, et al., 2021), China (Hu, et al., 2024), and Zimbabwe (Bangure, et al., 2013).

Participants

Parents whose children were within the childhood immunization schedule range made up the majority of study participants. The efficiency of the numerous

strategies employed to increase vaccine uptake was the main focus of the studies. Most of these researches were conducted mostly in West Africa (Nigeria) due to the low adoption of childhood vaccinations in the country. This demonstrated that the majority of studies were still trying to identify the primary strategies that could help increase the uptake of children vaccinations.

Characteristics of the Interventions Used to Improve Vaccine Uptake

SMS Reminders and health education
The use of routine health education and phone or SMS reminders for vaccination improvement was reported in two of the analyzed studies. Bangure et al. (2015) conducted a randomized controlled experiment in Zimbabwe using SMS reminders and regular health education. Parents (n=152) in the intervention group received regular health education and received SMS reminders when their infant was 6, 10, and 14 weeks old. The SMS for the next immunization appointment was sent to the mother or other caregivers. The first SMS was sent seven days before to the vaccination deadline, the second message was sent three days prior, and the last message was delivered one day prior to the vaccination appointment date. Only health education was given to the control group (n=152). At all three time points, the intervention group had a considerably higher percentage of children immunized with the relevant vaccines than the control group (<.001), and the intervention group had a significantly lower delay in obtaining the immunizations (<.001). Babarinde and Nnodimele's (2022) who conducted quasi-experimental study in Nigeria found that vaccine uptake increased following the intervention, whereas the control group did not.

SMS Reminders and Monetary incentives
In one study, SMS reminders were combined with financial incentives to boost vaccination uptake. 537 caregivers in Western Kenya received SMS reminders and an unconditional cash reward (150 KES) (Kagucia et al., 2021). Although it was more expensive to administer, the combination of SMS reminders and financial incentives had a similar effect on MCV1 timeliness to SMS reminders alone. However, the impact of the combined intervention on lowering the percentage of infants who were not vaccinated against measles was unclear and probably minimal. The study discovered that although SMS reminders were successful, the results were not considerably improved when a financial incentive was added in addition to SMS reminders.

Bracelet Reminder
Bracelet reminders were employed in one study to boost vaccination rates. Children below three months old were divided into two intervention groups (the Alma Sana Bracelet Group and the Star Bracelet Group) or the Control group in a randomized controlled trial carried out by Siddiqi et al. (2020). At the time of recruiting, children in the intervention groups received the two distinct bracelets. A hole was punctured in the silicone bracelet to indicate the administration of the vaccination each time the youngster went to the immunization center. Every child was monitored until the Measles-1 vaccine was administered or until they were 12 months old. The study discovered that the use of reminder bracelets greatly increased the coverage and timeliness of immunizations in the intervention group

compared to the control group as 71.2% of caregivers reported that the bracelet reminded them of oncoming vaccinations.

Meta-Analysis Findings

Meta-Analysis of Pooled Adjusted Odds Ratios from Included Studies on Vaccination Uptake and estimates of vaccination uptake by type and by Country

Table 3 presents the key statistical findings from random-effects meta-analysis of studies on vaccination uptake, and estimates of vaccination uptake by intervention type and by Country. The analysis of included studies on vaccination uptake revealed that the overall pooled risk ratio (RR) was 1.05 with a 95% confidence interval of 0.93 to 1.18, indicating no statistically significant overall association between the aggregated interventions and vaccine uptake, as the confidence interval includes 1.00. Between-study variability was moderate (I^2 = 69%, τ^2 = 0.0056, $p < 0.01$ for Cochran's Q), demonstrating that while effect estimates differ across studies the inconsistency is less extreme than previously observed.

Meta-analysis of vaccination uptake by intervention type showed that the overall pooled risk ratio (RR) was 1.05 with a 95% confidence interval of 0.93 to 1.18, indicating no statistically significant overall association between the aggregated interventions and contraceptive use, as the confidence interval includes 1.00. Between-study variability was moderate (I^2 = 69%, τ^2 = 0.0056, $p < 0.01$ for Cochran's Q), suggesting that while effect estimates differ across studies, the variability is not extreme.

Analysis of pooled effect estimates of vaccination uptake by country overall pooled risk ratio (RR) was 1.05 with a 95% confidence interval of 0.93 to 1.18, indicating no statistically significant association between the aggregated interventions and vaccination uptake, since the confidence interval includes 1.00. Between-study variability was moderate (I^2 = 69%, τ^2 = 0.0056, $p < 0.01$ for Cochran's Q), reflecting some inconsistency among the individual study results.

These findings highlight that, although certain individual studies report modest positive or negative associations, no consistent overall effect emerged once all evidence was combined. The observed heterogeneity underscores the importance of considering study-specific contexts—such as population characteristics, intervention design, and measurement of vaccine uptake, when interpreting the aggregated.

Table 2: Summary Statistics on the various meta-analyses from included studies

Meta-analysis	Statistics						
	Pooled effect estimates (AOR)	95% CI	Heterogeneity (I^2)	Tau² (between-study variance)	P-value for heterogeneity	Model	Test for subgroup difference
Vaccination Uptake	1.05	0.93; 1.18	69.0%	0.0056	< 0.01	Random effects model	
Intervention type	1.05	0.93, 1.18	68.7%	0.0056	0.0022	Random effects model	x^2 = 1.52, df = 4, p = 0.82
Uptake by country	1.05	0.93, 1.18	69.0%	0.0056	< 0.01	Random effects model	x^2 = 4.34, df = 4, p = 0.36

AOR: Adjusted Odds Ratio; CI: Confidence Interval

Forest Plots of the Pooled Effect from the Various Meta-Analyses

Figure 2a visually displays the study-level effect sizes and their weights. Most estimates cluster closely around the null line, although some lie on either side, reflecting the heterogeneity quantified above. The diamond at the bottom of the plot depicts the pooled effect (RR = 1.05), mirroring the summary of vaccination uptake in Table 2.

Figure 2b visually displays the study-level effect sizes and their weights, grouped by type of intervention. Most estimates cluster closely around the null line, although some lie on either side, reflecting the moderate heterogeneity observed. The diamond at the bottom represents the pooled estimate (RR = 1.05), which corresponds to the summary of the intervention type presented in Table 2. Subgroup analyses showed pooled estimates ranging from 0.94 (bracelet reminder) to 1.20 (SMS reminder), but the test for subgroup differences was not statistically significant ($x^2 = 1.52$, df = 4, p = 0.82), indicating that none of the intervention types demonstrated a significantly different effect compared to the others.

Figure 2c visually presents study-level effect sizes and weights, organized by country. While most estimates cluster near the null line, several lie on either side, consistent with the moderate heterogeneity observed. The diamond at the bottom of the plot represents the pooled estimate (RR = 1.05), matching the summary of estimates of vaccination uptake by country shown in Table 2. Subgroup analyses by country revealed pooled estimates ranging from 0.94 for studies from Pakistan to 1.23 for studies from Nigeria. However, the test for subgroup differences was not statistically significant ($x^2 = 4.34$, df = 4, p = 0.36), indicating that none of the countries showed a significantly different effect from the overall pooled estimate.

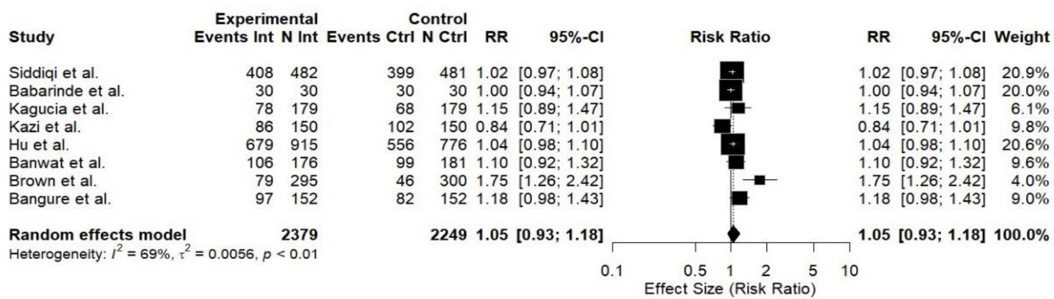

FIG 2a: Forest Plot of Pooled Adjusted Odds Ratios from Included Studies on Vaccination Uptake

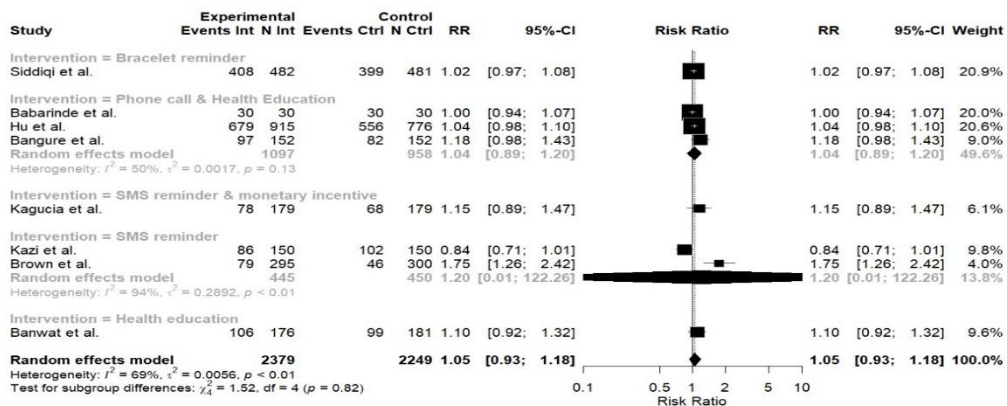

FIG 2b: Forest Plot of Pooled Effect Estimates of Key Determinants of Vaccine Uptake by Intervention-Level

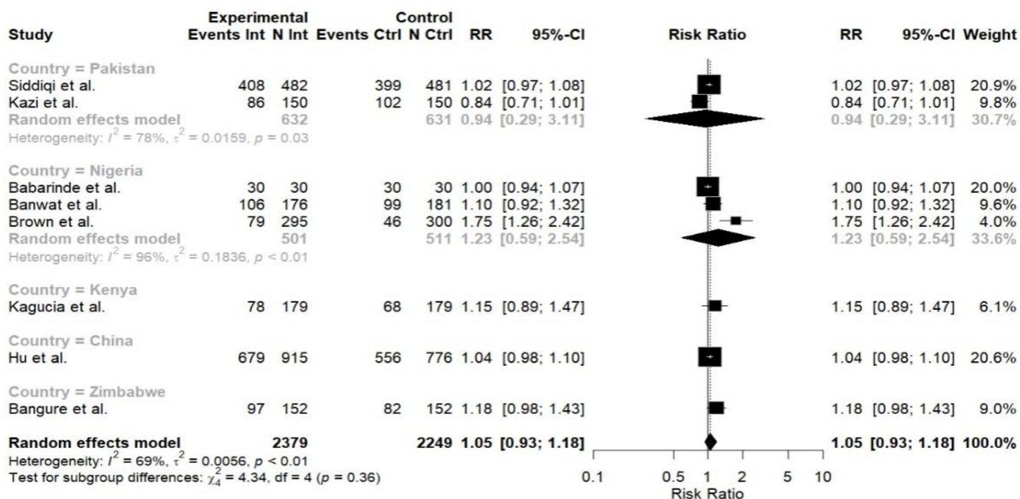

FIG 2c: Forest Plot of Pooled Effect Estimates of Vaccination Uptake by Country

Figure 2: Forest plots of the pooled effect from the various meta-analysis

Assessment of Publication Bias in the Meta-Analysis of Vaccination Uptake Studies

Figure 2 displays the funnel plot for the meta-analysis of risk ratios. Each point represents an individual study's effect estimate plotted against its standard error. The plot appears reasonably symmetrical around the pooled effect size of RR = 1.05, suggesting no substantial evidence of publication bias.

Although a few studies lie toward the margins of the funnel, the majority cluster within the central region, indicating consistent variance across studies of varying precision. There is no clear pattern of asymmetry, which further supports the visual impression that small-study effects are unlikely to have materially influenced the pooled estimate. These findings show a lack of significant results from the statistical tests due to small-study effects, as the Egger's test statistics could not be generated.

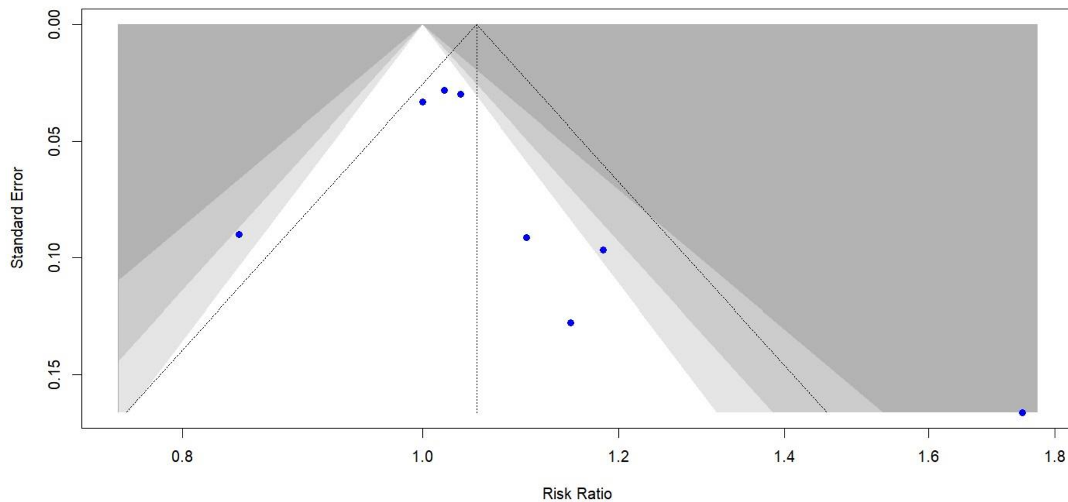

Figure 3: Funnel Plot to Assess Publication Bias in the Meta-Analysis of Vaccination Uptake Studies

Discussion

To increase vaccination uptake, the systematic review evaluated a number of strategies, especially in settings with limited resources. The results suggest that a variety of intervention measures have been successful in raising immunization rates, including health education, wristband reminders, mobile phone reminders (SMS and calls), and financial incentives. According to a number of studies, SMS reminders greatly increased vaccination compliance. Sending several SMS reminders prior to planned immunization visits raised adherence rates in comparison to control groups, as shown by Bangure et al. (2013). In a similar vein, Babarinde and Nnodimele (2022) discovered that health education and phone reminders had a favorable impact on vaccination uptake. This emphasizes how important technology is for raising vaccination rates, especially in areas with significant mobile phone adoption.

Research utilizing health education interventions, such Hu et al. (2024) and Banwat et al. (2015), shown a significant increase in vaccination uptake when parents and caregivers were informed about the value of immunization. Positive attitudes regarding vaccination seem to be fostered by educational programs that address scheduling, safety concerns, and misconceptions about vaccines.

The use of bracelets to inform caretakers of impending immunizations was one novel strategy found in this review. According to Siddiqi et al. (2020), 71.2% of caregivers in the intervention group said the wristband helped them remember their child's vaccination schedule. In areas where mobile phone access is scarce, this inexpensive intervention may be especially helpful. The combination of SMS reminders and financial incentives was examined in one study (Kagucia et al., 2021), which found that SMS reminders were successful on their own, and the addition of a financial incentive did not considerably improve results. This implies that although monetary rewards might act as motivators in certain situations, they might not always be required when other successful interventions (like reminders) are already in place.

Meta-Analysis Findings

In addition to the narrative synthesis, a meta-analysis was conducted to quantify the pooled effectiveness of interventions aimed at improving vaccination uptake across diverse settings. The overall pooled effect size was not statistically significant (RR = 1.05; 95% CI: 0.93–1.18), suggesting that, when combined, the interventions studied did not show a uniform improvement in vaccination rates. The moderate heterogeneity ($I^2 = 69\%$) indicates considerable variability among studies, likely due to differences in study design, intervention types, populations, and contexts.

However, subgroup analyses revealed important little differences, intervention-level subgroup analysis showed that SMS reminders alone had a higher pooled effect (RR = 1.20), while bracelet reminders had the lowest effect (RR = 0.94). Although these differences were not statistically significant ($x^2 = 1.52$, df = 4, $p = 0.82$), they highlight the potential of SMS-based interventions to slightly outperform others in improving vaccine uptake.

Notably, country-level subgroup analysis suggested variation in effectiveness across geographic contexts. For example, studies from Nigeria reported a higher pooled effect (RR = 1.23), indicating more promising outcomes from interventions implemented there, while studies from Pakistan showed lower effectiveness (RR = 0.94). However, the test for subgroup differences by country was also not statistically significant ($x^2 = 4.34$, df = 4, $p = 0.36$), reinforcing the need to interpret these differences with caution.

Despite the overall non-significant findings, the meta-analysis reinforced conclusions drawn from the narrative synthesis. Specific intervention strategies—particularly SMS reminders and health education—were repeatedly associated with improved vaccination outcomes in individual studies. For instance, Bangure et al. (2013) and Babarinde & Nnodimele (2022) demonstrated significant improvements in uptake following the use of reminders and educational support.

Moreover, publication bias assessment using funnel plots did not reveal significant asymmetry, suggesting that small-study effects and reporting bias were unlikely to have substantially influenced the pooled estimates.

In conclusion, although the combined effects of interventions did not yield statistically significant overall results, the observed heterogeneity emphasizes the importance of context in intervention success. Interventions such as SMS reminders, health education, and bracelet reminders may be effective when designed to suit the socio-cultural, economic, and infrastructural realities of specific communities.

Conclusion

The systematic review's findings indicate that a number of interventions, mainly SMS reminders, health education, wristband reminders, and, to a lesser degree, financial incentives, have a quantifiable effect on raising vaccination rates, particularly in low- and middle-income nations. The usefulness of focused interventions in certain situations is supported by the persistent good results in individual research, even if the meta-analysis as a whole revealed no statistically significant pooled effect. Notably, the most successful intervention turned out to be SMS-based reminders, which provide both reach and viability in environments with low resources. Educational strategies that dispel vaccine myths and raise awareness have also been demonstrated to enhance attitudes and acceptance. According to the review, attaining sustainable vaccination coverage requires developing strategies customized for particular community requirements and health system capabilities. To optimize public health results, future research should concentrate on the long-term efficacy, cost-effectiveness, and integration of these treatments into larger health systems.

Limitations

Despite the success of these interventions, several challenges were identified. The included papers provided variable information about the effectiveness of the various interventions deployed to improve vaccination uptake often with limited detail rendering evaluation difficult. Most were single centre studies that reported on local initiatives and it is challenging to determine their wider generalisability. Although studies demonstrated improved vaccination coverage, none had evaluated cost-effectiveness and few had evaluated the medium-term/long-term impact of interventions. Nevertheless, any intervention that improves vaccination coverage is usually cost-effective, particularly if it benefits underserved groups. We did not search the grey literature and may have missed interventions used in practice via this route—this also increases the risk of publication bias. Additionally, we only included studies published in English, potentially biasing findings towards those from English-speaking countries.

Implications for Policy and Practice

The findings suggest that governments and health policymakers should integrate cost-effective, scalable interventions into routine immunization programs. SMS reminders and health education, in particular, can be implemented with minimal resources and infrastructure. For areas with limited mobile access, bracelet

reminders could serve as an alternative. Moreover, integrating these interventions into broader health system policies—such as incorporating SMS reminders into electronic health records or incentivizing health workers to conduct home visits—could further improve vaccination rates.

Recommendations

Based on the findings of this systematic review, the following recommendations are proposed:

- Governments and healthcare organizations should implement SMS and phone call reminders as standard practices in immunization programs.
- Awareness campaigns should be conducted through community engagement programs to address vaccine hesitancy and misconceptions.
- In settings with limited technological access, bracelet reminders should be considered as a viable alternative.
- Further research should explore the effectiveness of these interventions in various cultural, socioeconomic, and geographical settings to enhance generalizability.

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