Strategies to Overcome Vaccine Hesitancy: A Systematic Review

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Abstract

**Background:** Vaccination, albeit a necessity in the prevention of infectious diseases, requires appropriate strategies for addressing vaccine hesitancy at an individual and community level. However, there remains a glaring scarcity of available literature in that regard. Therefore, this review aims to scrutinize globally tested interventions to increase the vaccination uptake by addressing vaccine hesitancy at various stages of these interventions across the globe and help policy makers in implementing appropriate strategies to address the issue.

**Methods:** A systematic review of descriptive and analytic studies was conducted using specific key word searches to identify literature containing information about interventions directed at vaccine hesitancy. The search was done using PubMed, Global Health, and Science Direct databases. Data extraction was based on study characteristics such as author details; study design; and type, duration, and outcome of an intervention.

**Results:** A total of 105 studies were identified of which 33 studies were included in the final review. Community-based interventions, monetary incentives, and technology-based health literacy demonstrated significant improvement in the utilization of immunization services. On the other hand, media-based intervention studies did not bring about a desired change in overcoming vaccine hesitancy.

**Conclusion:** This study indicates that the strategies should be based on the need and reasons for vaccine hesitancy for the targeted population. A multidimensional approach involving community members, families, and individuals is required to address this challenging issue.

**Background**

Vaccines have always been one of the most innocuous and effective approaches for the prevention of many infectious diseases. In spite of this, vaccine-preventable diseases are still widespread. In the preceding years, there have been outbreaks of infectious diseases in many parts of the world regardless of having effective vaccines against such diseases. The plausible reason for it could be “vaccine hesitancy”.[1]

Vaccine hesitancy refers to a delay in acceptance or refusal of vaccination despite availability of
vaccination services.[2] Against the backdrop of a large number of unimmunized children globally² and frequent outbreaks of vaccine-preventable diseases,[3] WHO has listed vaccine hesitancy as one of the top ten global health threats in 2019,[4] and has drawn major concerns across the world due to increase and resurgence of vaccine-preventable diseases. The reasons of reluctance or refusal are complex varying across time, place, and vaccines,[5, 6] and context-specific such as related to confidence, convenience, and complacency. Similarly, multiple factors such as religious beliefs, geographic barriers, parent-provider relationship, perceived risk of adverse events following immunization (AEFI), lack of knowledge about vaccination, and disease risk perception give rise to vaccine hesitancy.[7] A survey conducted by WHO and UNICEF showed that vaccine hesitancy emerged a decade ago;[8] however, it has gained attention due to the current changing scientific, cultural, medico-legal, and media environments, despite all the efforts made to increase the awareness and increase the vaccines uptake.[9] The trend has been realized in several countries across the world including United Kingdom, United States, and India.[9] This has triggered global researchers to understand the determinants of this emerging issue throughout the world.[10] Various strategies such as community activity by community health workers and medical interns, monetary incentives, educational videos as well as media-based approach have been piloted and evaluated in diverse settings to understand their impact on reducing the vaccine hesitancy. However, there is a paucity of critical synthesis of all these interventions across the globe and contextual summarization to guide program managers and policy makers in implementing appropriate strategies to address vaccine hesitancy. Therefore, this systematic review aims at improving vaccination coverage by retrieving the lost trust in the vaccination system through globally tested interventions for people with different degrees of vaccine hesitancy.

**Methods**

This systematic review was performed in line with the quality requirements of the PRISMA [11] guideline, from June to September and the flow chart has been mentioned as Figure 1 for understanding the method followed. The checklist of PRISMA guideline has also been added as Additional Document.
A search was conducted in the PubMed, Global Health, and Science Direct electronic databases to identify peer-reviewed literature. Search was not restricted to any time period and included literature search for title, abstract, and full-text in English language only.

**Search strategy**

The search strategy was set up using database-specific vocabularies. The literature search was conducted using the keywords “immunization,” “vaccine,” “vaccination,” “vaccine strategy,” “vaccine intervention,” “vaccine hesitant,” “vaccine hesitancy,” “vaccine refusal,” “trust in vaccination,” “vaccine confidence,” “vaccine resistance,” “vaccine impact,” “vaccine concern,” “vaccine rejection,” and “vaccine side effects” using “AND” and “OR” operators.

**Inclusion and Exclusion criteria**

While searching for vaccination strategies, we considered universally recommended vaccines for children, adolescents, and adults such as diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B, measles, mumps, rubella, Hemophilus influenza b (Hib), varicella, pneumococcal vaccine, meningococcal vaccine, Human papillomavirus (HPV), and seasonal influenza vaccine. Based on the objective, we included interventions that were targeted towards addressing vaccine hesitancy among parents and caregivers. For review, descriptive and analytical studies that described the effect of strategies on addressing vaccine hesitancy were included.

Studies that were opinion-based or did not focus primarily on populations eligible to receive vaccine or their parents, or that did not allow the authors to extract information on vaccination were excluded from our analysis.

**Study selection process**

Two researchers independently reviewed the identified studies for eligibility using a two-step process. In the first step, title, abstract, and keywords were screened to segregate the eligible studies followed by a full-text retrieval and screening. Similarly, data extraction was performed independently by two researchers and unmatched studies were included or excluded in consensus with a third researcher.

**Data extraction and synthesis**
Data extraction included study characteristics such as: (1) author, year, journal, study design, study setting, study period, and study population; (2) the vaccines considered; (3) information about the intervention being studied such as type of intervention and duration of the intervention; and (4) information on follow-up time, analysis performed, and outcomes of interest.

We categorized the review under four broad themes, i.e., community health training, incentive-based approach; technology-based health literacy; and media engagement using participants, interventions, comparisons, outcomes, and study design (PICO) strategy (Figure 2).[11]

1. **Community health trainings:** It included community health information dissemination through health workers, mobilizers, medical officers; social mobilization through medical interns, prominent religious leaders; and knowledge- and experience-sharing by influential women from the community to accelerate vaccine uptake.[12]

2. **Incentive-based approach:** It involved incentives to encourage parents to immunize their children, including provision of food, other goods, and certificates of recognition or monetary support to encourage vaccination.[12]

3. **Technology-based health literacy:** It involved use of technology in informing beneficiaries through various modern age-technologies such as mobile phone. Activities in this category included mobile phone recall text messages in local languages, pictorial messages, and automated phone calls or interactive voice recording for spreading awareness.[12]

4. **Media engagement:** Mobilization through various campaigns and platforms such as radio, TV, and print media should feature concise, easily understood public service announcements by national public figures, well-known and authoritative local representatives, and representative members of the target population.[12]

**Critical appraisal**

The Effective Public Health Practice Project (EPHPP) quality assessment tool for quantitative studies
was applied to determine the risk of bias in all eligible studies.[13] Literature screening and data extraction piloting was done on five documents by all three reviewers to standardize the review and data extraction process. Furthermore, disagreements during review were resolved by consensus.

Results
The search identified 2495 peer-reviewed articles. After removing duplicates, 1141 articles were screened using title, abstract, and keywords, which excluded 1036 papers leaving 105 full-text papers for review. Of these, 33 were evaluated and described. Among the evaluated peer-reviewed literature, nine were related to community health trainings theme,[11-20] five were related to incentive-based approach,[21-24] eight were related to technology-based health literacy,[14, 20, 28-38] and eleven were related to media engagement (Tables 1 and 2). [12, 36-39]

Figure 1: Literature review data synthesis flowchart

Community health trainings
Out of the total 33 studies considered, there were nine studies that were based on community health training strategy. Majority of the studies revealed parents/caregivers of children as the study population except for one study that primarily addressed the issue of vaccine hesitancy in religious leaders of a community. The most targeted vaccines were diphtheria pertussis tetanus (DPT1, DPT2, DPT3) vaccine, Bacilli Calmette-Guerin (BCG) vaccine, poliovirus 3, measles, influenza, and HPV vaccine. Lack of knowledge, negative parental attitude, and misconceptions were the foremost encountered causes for vaccine hesitancy that were addressed predominantly by health workers/medical interns.[11,12,14,15,20] Home visits and information campaigns were the most common types of community training modalities except for the two studies that had personally controlled health management systems (PCHMS) and community-level nutrition information system for action (COLNISA) as community health training strategies that led to an overall 21% to 33% rise in vaccine coverage.[37,38,41,42] Community activity for systematic engagement of parents and home visits by community health workers and medical interns significantly improved program acceptance and utilization of immunization services (Table 2).

Incentive-based approach
Five studies published between 2008-2013 were identified, that focused on performance-based incentives for vaccination. [18,22-25] Incentive-based approach mostly involved general hospitals in the rural and lower socio-economic strata of the society. Most of these studies suggested monetary incentives only. Influenza, BCG, polio, DPT2, DPT3, measles, HBV, meningococcal 4 (MCV4), and tetanus diphtheria-acellular pertussis (Tdap) were the most sought-after targeted vaccines. A dearth of financial burden and negligence were the suggested reasons for vaccine hesitancy. Findings of these studies suggested that incentives had a high impact on the uptake of immunization services. [23] The effect of non-financial incentives on vaccine uptake for parents and communities located in low-income settings (India) was moderate (RR: 2.16, [CI: 1.54, 2.78]) [25] except for one study that depicted no increase in vaccine acceptance using incentive-based search strategy (Table 2).

**Technology-based health literacy**

Lately, leveraging on the health literacy using technology such as informative posters, leaflets and videotapes, social media, organizing lectures, etc., were used to bring behavioral change regarding vaccination. The studies depicted that this intervention strategy was mostly acted upon in urban primary care practices and large multispecialty medical organizations. Inadequate information /rumors, parental concerns about safety and lack of awareness, clinicians’ beliefs and practice concerns attributed to vaccine hesitancy.[15-17,19,21] The eight studies available highlighted and dealt with vaccine hesitancy towards polio vaccine, pertussis, varicella, pneumococcal influenza (DTAP), hepatitis B (HBV), Hemophilus influenza B (HiB), inactive polio vaccine (IPV), and measles mumps rubella (MMR). These studies suggested that educational intervention using videos, posters, and lectures demonstrated an improved vaccine acceptance (Table 2). [32,39,40]

**Media engagement**

Interventions such as reminder calls, SMS, and emails were adopted as media-based strategy in nine studies to address vaccine hesitancy. Most of the studies targeted general vaccines whereas only three out of nine studies had interventions directed towards meningococcal (MCV4), Tetanus diphtheria-acellular pertussis (Tdap), MMR, and influenza vaccines.[26,27,29] Low income, negative attitude towards immunization, and lack of knowledge were the most recorded reasons for vaccine
hesitancy. The overall study outcome with this intervention strategy revealed that simple recall messages through SMS and email were preferred; however, these did not bring the desired change in overcoming vaccine hesitancy (Table 2). [30,31,33,35]

**Risk of Bias**

Out of the 33 studies reported, 29 studies noted a high risk of bias and one study reported no risk of bias (Table 1).

**Discussion**

The studies included interventions with diverse approaches that were implemented in different settings and targeted various populations, which helped us to get a holistic view of interventions globally to build confidence on vaccines, increase acceptance, and promote adequate immunization behaviors. In the review, we observed that the strategies suggested or evaluated were similar to traditional strategies such as through education and empowerment, financial and non-financial incentives, and technology assistance to bring about a behavioral change.

Studies done by Fiks et al,[19] Williams et al,[16] Zhang et al,[13] and Rahman et al [14] reported a lower risk of bias when compared to other studies, which could be due to variation in the study design and settings.

Most of the interventions analyzed in the review were primarily either to inform or to educate the target population about the risks and benefits of vaccination using community health training strategy, as lack of knowledge or awareness about vaccines was observed to be the major cause of vaccine hesitancy.[20] These studies reported effective improvement in vaccines uptake after the exercise. Two of these studies focused on the involvement of mothers for knowledge and experience sharing.[11] A study conducted by Brugha et al [12] revealed a significant rise of 60% to 80% in vaccine coverage after 6 months of home-visit community health training program. Involvement of mothers showed a significant improvement in vaccination coverage (33%-85%) in another similar study done by Usman et al.[42] Nine studies were based on parent-centered information or education about vaccination and social mobilization of parents by health workers/medical interns.[14,15,20] All these studies showed a significant impact in changing parents’ attitude towards their child’s
vaccination. Messaging on vaccination from political and religious leaders also imparted a positive impact on vaccination uptake.\[13,14\] A study conducted in Denver, USA, found significant difference in attitude and practices related to immunization among vaccine-hesitant and non-hesitant religious leaders.\[14\] Similarly, effective communication regarding polio vaccination with the community had shown positive impact in Nigeria.\[15\] However, variation in study sample and size with no consideration towards population dynamics was a potential limitation of all the nine studies.\[37,38,41,42\]

Findings of studies conducted by Mouzoon et al,\[18\] Banerjee et al,\[22\] and Stitzer et al \[24\] suggested that incentives had a high impact on the uptake of immunization services. Conditional cash transfer program led to a huge increase in vaccination coverage resulting in 95\% coverage in rural Nicaragua.\[22\] Incentive-based interventions were also found to be effective in a study by Barham et al\[23\] who reported an increase of more than 95\% for DPT3 in the treatment group compared with 85\% in the control group in the vaccine coverage rates for 12-23-month-old children. It was evident from the synthesis that the incentive-based strategies had a positive impact on bringing about vaccination acceptance.\[25\] The benefit of incentive-based health promotions had always been significant but sustainability and adherence after intervention was debatable.\[22\] Furthermore, the implementation of incentives in large populations remained a challenge. At the same time, integration of incentives with other mother and child health services such as the Janani Suraksha Yojana implemented by Govt. of India,\[23\] can bring a positive change in improving immunization uptake along with education on delivery and nutrition in low-income and low-education settings.

Gaps in awareness such as complete absence of knowledge, less knowledge, and misconceptions, were known to be the principal factors for lack of adequate health-seeking behavior. Strategies focusing on behavior change through knowledge and awareness will be most suitable for complex behavioral dynamics as it targets multiple layers of decision-making – individual, family, and society.\[15\] Additionally, the benefits of health literacy using technology to bring about public awareness is not only multi-faceted but also has potential to change the whole health-seeking behavior paradigm and not just the behavior towards vaccines.\[16\]
Recently, educational videos, lectures in hospital settings, mobile vaccination team visits, social marketing, and web-based questionnaires have been used to bring about a behavioral change regarding vaccination. A study conducted in the rural areas of North Carolina using social marketing campaign raised the awareness among parents and reduced barriers in accessing the HPV vaccine successfully.[19] Similarly, HPV vaccination rates were 2% higher among 9-13-year-old girls within six months of campaign launch.[40] Evaluation of social media interventions by Muehleisen et al.[21] showed a positive effect on uptake of MMR vaccine[37] in Canada. In Northern Nigeria, a relative increase of ~310% in the polio vaccination uptake was observed through an educational intervention with an 8-min video.[16]

Furthermore, the intervention focusing on the engagement of various kind of media to reach the population has also proved to be efficient in creating awareness and promoting beneficial health-seeking behaviors.[32,39] Therefore, in conjunction with awareness-creating strategies, utilization of mass media in various forms such as print, audio, television, and social media can stimulate a positive perception among the population in different settings. However, improper documentation and socio-economic disparity in demographics was the major downside in the health literacy using technology-based intervention strategy.[39]

Among all the strategies, recall strategies showed least improvement in mobilizing people from negative perception to acceptance. Furthermore, findings from a study in USA showed that parents aged 30 years and above preferred e-mail reminders as compared to other modes such as phone calls and text messages.[13] Few studies from New York city, Kansas in USA, and Nigeria have revealed a wide support and acceptability of text messages or SMS as a mode of immunization reminder or recall.[35,36] A large proportion of parents had also shown willingness to be reminded about vaccinations by their health departments and via novel modalities such as email or text messaging.[26] Urban parents preferred reminders from their child’s doctor (46.7%) as compared to rural parents (33.7%).[29,31,33]

Although the recall strategies showed improvement in vaccine uptake, they were inconsistent in all studies. Therefore, it can be perceived that these kinds of passive reminders sent through modern
communication channels may be only effective in case of technology-friendly populations. It is
unlikely that mere recall messages through SMS or email, which were found to be preferred, will bring
a desired change in the confidence on vaccines.[27]
In light of the above knowledge, it is difficult to predict the superiority of any intervention over the
other. Therefore, more studies with a better study design and targeting specific populations are
required. Another reason for the lack of literature can be our limited access to indexing databases,
which severely limits our capability to extract large amount of published literature.

Conclusions
Vaccine hesitancy not only increases an individual’s risk of contracting a disease but also increases
the risk for the community. Vaccine hesitancy is a complex issue, and no standalone strategy can
address it. Despite the complexity of vaccine hesitancy and the broad range of its determinants,
increasing awareness about benefits of vaccination, social media engagement activities, and carefully
tailored strategies addressing the determinants of the hesitancy can bring about the desired change.

Abbreviations
AEFI: Adverse Events Following Immunization
BCG: Bacilli Calmette-Guerin
CI: Confidence Interval
COLNISA: community-level nutrition information system for action
DPT: diphtheria pertussis tetanus
DTaP: Diphtheria, Tetanus and Pertussis vaccines
EPHPP: Effective Public Health Practice Project
HBV: Hepatitis B virus
Hib: Hemophilus influenza b
HPV: Human papillomavirus
IPV: Inactivated polio vaccine
MCV: Meningococcal Vaccine
MMR: Measles Mumps Rubella
PCHMS: Personally controlled health management systems
PICO: Participants, Interventions, Comparisons, Outcomes
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RR: Relative Risk
SMS: Short Message Service
Tdap: tetanus diphtheria-acellular pertussis
TV: Television
UNICEF: United Nations International Children's Emergency Fund
USA: The United States of America
WHO: World Health Organization

Declarations

**Ethics approval and consent to participate**

Not applicable

**Consent for publication**

Not applicable

**Availability of data and materials**

Presented in the manuscript; Any additional data can be sent if requested, specifically.

**Contributors**

PS originated the idea of the study and helped in conceptualization and review. PD, SG, GKS, PN reviewed and revised the draft. MKM, SK and SG conducted the literature search, data analysis and wrote first draft.

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**Conflict of interest**

The authors have declared that no competing interests exist.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Tables
| Author          | Study type                                      | Name of country | Study setting                                                                 | Participants                                                                 | Interventions                                      |
|-----------------|-------------------------------------------------|-----------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------|
| Oche et al, 2011| Controlled community trial                       | Nigeria         | Town with the vast majority of the population largely farmers and illiterates | Mothers of children aged 0 to 23 months                                       | Community health training                         |
| Brugha et al, 1996| Controlled trial                               | Ghana           | Town where regular immunization services were available.                     | Mothers of 12-18-month-old children                                           | Community health training                         |
| Zhang et al, 2019| Cross-sectional                                 | Australia       | Nationally representative sample                                             | Media engagement                                                              |                                                   |
| Rahman et al, 2013| Pre-post interventions with control             | Iraq            | District with both rural and urban population                                | Community health training                                                     |                                                   |
| Williams et al, 2019| Cross-sectional                                 | United States   | Urban geographic area                                                         | Community health training                                                     |                                                   |
| Nasiru et al, 2012| Pre-post interventions without control          | Nigeria         | Local council with high reported cases of polio disease and very low vaccination uptake | Children under the Community health training age of 5                        |                                                   |
| Ofstead et al, 2013| Pre-post interventions with control             | United States   | Manufacturing corporation                                                      | Community health training                                                     |                                                   |
| Ansari et al, 2007| Pre-post                                       | India           | High risk urban areas                                                         | Technology-based health literacy                                               |                                                   |
| Usman et al, 2011| Randomized controlled trial                    | Pakistan        | Rural EPI centers                                                             | Community health training                                                     |                                                   |
| Williams et al, 2013| Cluster-randomized controlled trial             | United States   | Private pediatric practices in urban area                                    | Technology-based health literacy                                               |                                                   |
| Maltezou et al, 2009| Cross-sectional                               | Greece          | Public hospitals                                                              | Technology-based health literacy                                               |                                                   |
| Mouzoon, M. et al, 2010| Retrospective study                        | United States   | A large multispecialty medical organization                                  | Incentive based approach                                                      |                                                   |
| Fiks, A.G et al, 2013| Cluster-randomized controlled trial             | United States   | Urban primary care practices                                                  | Technology-based health literacy                                               |                                                   |
| Spleen, A.M et al, 2011| Pre-post                                       | United States   | Rural population with high poverty rates, high unemployment rates, low access to healthcare, and excess cancer burden, including | Community health training                                                     |                                                   |
| Reference | Study Design | Country/City | Setting | Target Population | Intervention |
|-----------|--------------|--------------|---------|-------------------|--------------|
| Muehleisen et al, 2007 | Pre-post with control | Switzerland | Hospital in urban setting | Children aged 61 days to 17 years | Technology-based health literacy |
| Banerjee et al, 2010 | Cluster-randomized controlled trial | India | Rural Rajasthan | Children aged 1-3 years | Incentive-based approach |
| Barham et al, 2008 | Cluster-randomized controlled trial | The Republic of Rural Nicaragua | | Children 12-23-month-old and above | Incentive-based approach |
| Stitzer, M.L. et al 2009 | Randomized controlled trial | United States | General Hospital | Individual aged 18 years – 64 years | Incentive-based approach |
| Robertson et al, 2013 | Cluster-randomized trial | Zimbabwe | Four socioeconomic strata were selected: subsistence farming areas, roadside trading settlements, agricultural estates, and small towns. | Households with children younger than 18 years | Incentive-based approach |
| Stockwell et al, 2012 | Two randomized controlled trials | United States | Urban, low-income population | Parents with children aged 11 to 18 years and families with a child aged 7 to 22 months lacking 1Hib dose | Media engagement |
| Milkman et al, 2011 | Randomized controlled trial | United States | A large firm | Employees | Media engagement |
| Lemstra, M. et al 2011 | Cluster-randomised trial | Canada | Low-income setting | Parents of children Media engagement who were behind in MMR immunizations |
| Clark et al, 2015 | Internet-based cross-sectional survey | United States | Nationally representative sample | Parents of children 0 to 17 years of age | Media engagement – (preferred mode of communication) |
| Kharbanda et al, 2009 | Qualitative evaluation | United States | Three urban community health centers and two private practices in New York City | Parents with at least 1 child aged 10 to 19 years | Media engagement |
| Ahlers-Schmidt et al, 2010 | Formative survey | United States | Low-income setting | Parents with children under 6 years of age at a Midwestern Pediatric Residency clinic | Technology-based health literacy |
| Hofstetter et al, 2013 | Cross-sectional study | United States | Urban setting | Parents of 6-59-month-old children (preferred recalled reminder mode) and providers | Media engagement |
| Lau et al, 2012 | Randomized controlled trial, Cross-sectional study | Australia, Nigeria | University urban setting | University students and staff. Mothers and their infants aged 0-3 months | Community health training |
| Brown et al, 2015 | Cross-sectional study | Nigeria | Urban and suburban community health facility | Mothers of infants | Media engagement (preferred recalled reminder mode) |
Table 2: A descriptive summary of the target vaccine, reason for hesitancy, outcomes, and limitations for each strategy

| Author            | Duration of study | Target vaccine | Reason for vaccine hesitancy | Outcome of interventions | Limitations of the study |
|-------------------|-------------------|----------------|-----------------------------|--------------------------|--------------------------|
| Community health training |
| 11 Oche et al, 2011 | 9 months          | DPT3           | Low level of knowledge amongst mothers and poor attitude of health workers | Improved program acceptance and immunization services | Cost of service: vaccines not covered |
| 12 Brugha et al, 1996 | 8 months          | BCG; poliovirus, DPT3, measles | Lack of awareness | Improvement of immunization coverage through community health training, Vaccination coverage rates improved in intervention villages | Contamination |
| 14 Rahman et al, 2013 | 6 months          | DPT1, DPT2, DPT3, measles | Lack of information/motivation | Vaccination coverage rates improved in intervention villages | Study restricted influenced by peer leaders |
| 15 Williams et al, 2019 | 5 months          | Influenza      | Religious beliefs/attitude | No significant outcome | Small study size |
| 38 Nasiru et al, 2012 | 6 months          | Polio vaccine  | Attitude/misinformation | Effective communication and polio outreach campaigns-increased vaccine uptake, Substantial increase in vaccination rate | Population dynamics not considered |
| 41 Ofstead et al, 2013 | 3 months          | Influenza      | Misconceptions | No psychometric evaluation | |
| 42 Usman et al, 2011 | 90 days           | DTP            | Lack of knowledge           | Infant vaccination increased | Lack of completion |
| Incentive-based approach |
| 40 Spleen et al, 2011 | 1 year            | HPV vaccine    | Lack of parental attitude/knowledge | Increased vaccine acceptability | Study limited to group |
| 37 Lau et al, 2012 | 6 months          | Influenza      | Lack of knowledge           | Improved uptake of influenza vaccination not considered, and utilization of health services | |
| 36 Saville et al, 2014 | Cross-sectional, randomized, controlled trial | United States, Australia, Both urban and rural university | Parents of children | Media engagement (preferred recalled reminder mode) | |
| 39 Cates et al, 2011 | Assessment        | Rural area     | Mothers of girls aged 11-12 | Media engagement (preferred recalled reminder mode) | |
| 40 Pandey et al, 2011 | Cross-sectional    | India          | Students of medical school | Technology-based health literacy | |
| 43 Brown, V.B et al, 2017 | Cross-sectional study | Nigeria | urban setting | Media-based approach | |
| 44 Moniz et al, 2013 | Randomized controlled trial | United States | Outpatient clinic | Media-based approach | United States, Australia | Obstetric patients at less than 28 weeks of gestation pending the flu shot |
| Study Reference          | Duration | Vaccines                                      | Lack of | Other Parameters                                                                 |
|--------------------------|----------|-----------------------------------------------|---------|----------------------------------------------------------------------------------|
| Banerjee et al, 2010     | 18 months| BCG, DPT, oral polio vaccines, Measles        | Awareness of immunization services.  | Not a blinded study                                                             |
| Stitzer et al, 2009      | 6 months | HBV                                           | Negligence | Motivation leading to attending vaccination sessions                                  |
| Barham et al, 2008       | 2 years  | BCG, MCV, OPV3, DPT3                         | Lack of finance and motivation | Vaccination coverage increased dramatically                                                   |
| Robertson et al, 2013    | 1 year   | Childhood vaccination                         | Lack of motivation                  | No increase in vaccination uptake.                                                   |
| Technology-based health literacy |          |                                               |                      | Other parameters: existing immunisation considered.                                    |
| Ansari et al, 2007       | 1-day    | Polio vaccine                                 | Misguided information/rumors     | Correct health education leading to vaccine acceptance.                            |
| Williams et al, 2013     | 2 months | Pertussis, Varicella, Pneumococcal            | Negative parent attitude regarding safety/necessity of vaccine | Educational intervention with 8-min video improved vaccine acceptance. |
| Maltezou et al, 2009     | 1 year   | Influenza                                     | Lack of time and inconvenience    | Lectures in hospital/mobile vaccination team visit-significant impact               |
| Fiks et al, 2013         | 1 year   | HPV                                           | Parental concerns, clinicians’ beliefs and practice concerns. | Combined interventions increased vaccination rates.                                  |
| Muehleisen et al, 2007   | 9 months | DTAP, HBV, HiB, IPV, MMR, Td                  | Lack of parental awareness       | Increased reporting of immunization.                                                |
| Ahlers-Schmidt et al, 2010 | Not mentioned | General vaccine                   | Parental concerns about safety and lack of knowledge | Increased vaccine acceptability.                                                    |
| Cates et al, 2011        | 6 months | HBV                                           | Lack of awareness                | Increased in vaccination acceptance and uptake                                      |
| Pandey et al, 2011       | Not mentioned | HPV                                      | Inadequate information             | Female students had better awareness; medical teaching had better impact             |
| Media-based approach     |          |                                               |                      | Study not including population.                                                     |
| Brown et al, 2015        | Not mentioned | Routine vaccine                   | Not mentioned                      | 60% mothers preferred immunization reminders by cellphones and SMS.                  |
| Saville et al, 2014      | 4 months | General vaccine                               | Not mentioned                      | Preferred modality email or telephone.                                              |
| Hofstetter et al, 2013   | 3 months | General vaccine                               | Not mentioned                      | Text messages recall widely accepted.                                               |
| Kharbanda et al, 2009    | Not mentioned | General vaccine                   | Not mentioned                      | Preferred method was text messages.                                                 |
| Clark et al, 2015        | Not mentioned | General vaccination                   | Not mentioned                      | Parents more willing to communicate by phone call.                                  |
| Lemstra et al, 2011      | 1 year   | MMR                                           | Low income                        | Lack of specific population.                                                        |
| Milkman et al, 2011      | 1 month  | Influenza                                     | Lack of knowledge                 | Substantial study able to be conducted on a small sample                             |
| Stockwell et al, 2012    | 6 months | Meningococcal (MCCV); Tetanus diphtheria-acellular pertussis | Low income                        | Increased vaccination rate.                                                         |
|                          |          |                                               |                                    | Immunization reminders beneficial; recorded in cell.                                 |
13 Zhang et al, 2019
Not mentioned (Tdap) Acceptance of new target vaccination policy
Negative attitude towards immunization
Public figures/media messages can influence attitudes
Small study size. Did not identify predictors.

43 Brown et al, 2017
Not mentioned Routine vaccine
Lack of awareness
Preference of immunization reminders through cell phones
Study conducted in urban setting. No rural involvement

44 Moniz et al, 2013
2 years Influenza
Lack of awareness
Text messages not effective
Single socio-demographic group

Figure 1
Literature review data synthesis flowchart
Figure 2

Strategies to remove a vaccine hesitancy