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REVIEW

# Facilitators and barriers to maternal immunization and strategies to improve uptake in low-income and lower-middle income countries: A systematic review

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## ABSTRACT

Maternal immunization (MI) is an emerging strategy to combat infant mortality in low-income (LIC) and lower-middle income countries (LMIC). We conducted a systematic review to identify the facilitators and barriers to MI and strategies that improve uptake in LICs and LMICs. We searched PubMed, Cochrane Library, and Scopus for quantitative, qualitative, and mixed-methods studies published in English from January 1, 2011, to October 31, 2021, from all LICs and LMICs. Data was appraised using the Mixed Methods Appraisal Tool. 55 studies were included. The major barriers were low knowledge and concern of vaccine safety among pregnant women and healthcare providers (HCP). HCP's recommendation, maternal knowledge, vaccine confidence and ≥4 antenatal care (ANC) visits facilitated uptake. The key strategies encompassed health financing, reminders, intersectoral coordination, integration, community engagement, capacity building, and education. Community-based delivery models were effective. Tailored programs are needed to improve ANC access, and educate pregnant women and HCPs.

## Introduction

Neonates and young infants are at increased risk of infectious diseases due to their underdeveloped immune systems. Pregnant women undergo physiological changes to support fetal development, increasing their suceptibility to severe disease and adverse outcomes from certain vaccine-preventable pathogens such as influenza, COVID-19, and tetanus.[1,2] Low-income (LIC) and lower-middle income or low- and middle-income countries (LMICs) carry a disproportionate burden of vaccine-preventable diseases (VPDs). Many LICs/LMICs are struggling to meet the Sustainable Development Goals related to immunization, which aim to reduce maternal, neonatal, and under-5 mortality.[3–5]

Maternal immunization (MI), vaccination of mothers during pregnancy, safeguards pregnant women, the fetus, and newborns from vaccine-preventable infections. This protection is mediated via the placental transfer of maternal antibodies to the fetus, through breast milk to the infants and indirectly through herd immunity.[1,2,6,7] MI is an important public health strategy in LICs/LMICs, where 89% of the world's pregnant population resides.[8,9]

For a considerable time pregnant women were not prioritized for receiving vaccines due to safety concerns. This was due to non-inclusion of pregnant women in vaccine research, leading to insufficient scientific data to support vaccine safety.[10] Since the late 1980s, the only vaccine recommended for pregnant women was tetanus toxoid (TT). It was not until 2005, when the WHO recommended influenza vaccination

for pregnant women, and in 2012, prioritized pregnant women as highest risk group for influenza vaccination.[11,12] Data from clinical trials showed the positive impact of maternal influenza immunization on maternal, perinatal, and infant health outcomes.[13,14] This generated a renewed interest in maternal immunization as a strategy to combat maternal, and early infant morbidity and mortality. The pertussis containing vaccine, tetanus-diptheria-acellular pertussis (Tdap), was recommended in 2015 by WHO.[15] TT or tetanus-diphtheria toxoid (Td), inactivated influenza, and Tdap vaccines are now routinely recommended during pregnancy, although the policy varies in each country.[7] During the pandemic, COVID-19 vaccines were advised during pregnancy, and implemented in many countries.[16–22] Around 194 countries have policy positions on COVID-19 vaccination during pregnancy. Among these, it has been recommended in 26, permitted in 25 and permitted with qualifications in four LICs and LMICs.[23] Some vaccines are recommended for emergencies or in outbreak situations including cholera, Ebola, hepatitis E, meningitis A, rabies, tick borne encephalitis and yellow fever.[24]

The recent developments in MI include recommendations being revised for existing vaccines, increase in clinical trials on pregnant women, introduction of new vaccines and development of novel vaccines.[25] Maternal Respiratory Syncytial Virus (RSV) vaccine (Pfizer) is approved to protect infants from lower respiratory tract infections. RSV vaccine is recommended in various high-income countries (HICs).[26–28]

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Hepatitis B vaccines are recently advised for unvaccinated pregnant women in the US to prevent perinatal transmission.[29] Pneumococcal conjugate vaccines, meningococcal and hepatitis A vaccines are recommended for those at high-risk.[29] Additional maternal vaccines are in the pipeline for group B *Streptococcus* (GBS), malaria, cytomegalovirus (CMV), and the herpes simplex virus (HSV).[30] Of these, GBS vaccine candidates are under evaluation for vaccine efficacy; HSV, malaria and CMV vaccines are under development.[30] The implementation of RSV and future GBS vaccines holds promise in reducing their substantial burden of morbidity and mortality among infants in LIC/LMICs.[31,32]

The flagship of MI, the global maternal and neonatal tetanus (MNT) elimination program, reduced neonatal tetanus death by 92% in the twenty-first century.[33] Despite this success, there are still 10 LICs/LMICs where MNT is not yet eliminated.[34] In addition, sustaining the elimination remains a challenge with reports of low TT coverage.[35] In a cross-sectional study on 95 LMICs, only 44% had reached the target of >90% TT coverage.[36] Additionally, introduction of other maternal vaccines in the national immunization programs has been delayed. Only 11 LICs and LMICs have maternal vaccination policies for influenza.[37] Maternal Tdap vaccine is recommended in only some LICs/LMICs, such as El Salvador.[38] This is concerning given the substantial burden of VPDs in LICs/LMICs, and the fact that over the past decade, neonatal and maternal mortality rates have declined more slowly in LMICs than HICs.[3–5]

Aside from the policy differences, maternal vaccination rates vary between HICs and LIC/LMICs. Even though vaccines are available in HICs, the uptake is not encouraging. Recent data on maternal influenza vaccination coverage in various HICs are as follows: the UK (41.8%),[39] the US (47.2%),[40] Canada (53%),[41] and Spain (61.5%)[42]; the rates may fluctuate annually. Tdap coverage also shows variations; USA (55.4%),[40] England (64.7%),[43] and Canada (65%).[41] COVID-19 vaccine uptake has been globally lower among pregnant women than the general population.[44] In HICs, the coverage has been about 27% (95% CI: 18.8–37.0%), due to concerns about vaccine safety.[39,40,45,46] As compared to HICs, maternal influenza and Tdap vaccination has been grossly underutilized in LICs/LMICs.[47–49] Lack of policy, awareness and limited vaccine availability partly explains lower vaccinations.[50] COVID-19 vaccinations are also reported to be low.[51,52] Concerns about vaccine safety, along with variations in vaccine policy and availability, in LICs/LMICs, impacted overall uptake.[53]

Many LICs/LMICs grapple with constrained healthcare budgets, inadequately resourced health systems, access and weak health information systems. Accordingly, they encounter obstacles in vaccine introduction for various reasons: lack of information on local disease burden; limited awareness about disease in stakeholders, programmatic considerations in terms of vaccine delivery systems; competing health priorities; political priorities for financing; limited data on vaccine safety, impact and cost-effectiveness from LICs/LMICs[54]; and socio-cultural factors that affect vaccine acceptance.[55] Emerging situations, like the COVID-19 pandemic, have disrupted antenatal care services, institutional deliveries, and child immunization services in LMICs, further exacerbating vaccine inequity.[56,57]

A delay in acceptance or refusal of vaccination defined as vaccine hesitancy is recognized by the WHO, as one of the top 10 threats to global health.[58] For MI, hesitancy exists at the individual level (pregnant women), at the family level, or at the level of health care providers (HCP).[8,59] Side effects from vaccination on pregnancy and adverse effects on fetus is a common concern among women, their families, and HCPs.[8] The factors influencing vaccine acceptance may vary in different countries and contexts. A study examining COVID-19 vaccine acceptance among pregnant women in seven LMICs found varying levels of willingness, ranging from 30% in Pakistan to 80.4% in India.[51]

Limited information exists on factors that promote vaccine uptake and the strategies that strengthen immunization programs and improve coverage in pregnant women in low-resource settings.[45] Understanding the facilitators and barriers to MI will guide in improving the uptake of vaccines and implementation of new vaccines. The majority of current research covers either the determinants[30,48,59–61] or interventions[62,63] and often centers on high-income settings,[64] or specific vaccines.[63,65]

We used the socio-ecological model to study factors influencing maternal immunization decision-making.[66] This model recognizes that individuals are part of various social systems, and their health behaviors, including vaccination decisions, are shaped by multiple levels of influence within society. These influences operate at the individual, interpersonal, health system, community, cultural context, and policy levels.[67,68] This systematic review aims to identify the available evidence on 1) key facilitators and barriers to maternal immunization in LICs and LMICs; and 2) effective strategies that promote the uptake of maternal immunization in LICs and LMICs.

## Methods

The two research questions are as follows:

(1) What factors influence maternal vaccine uptake in LICs and LMICs?
(2) What strategies have been employed to increase uptake?

The study protocol was registered in the Open Science Framework (OSF) database and can be assessed from OSF website https://osf.io/hxu6k/.[49] This review follows the JBI Manual of Evidence Synthesis on mixed methods systematic reviews with minor modifications.[69] This review was done in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and the PRISMA checklist is provided in Supplementary Table S1. The review aimed to provide a compendium of evidence on strategies and factors influencing the uptake of maternal vaccines in LIC/LMICs.

### *The search strategy and selection criteria*

We investigated studies published in the past 10 years (January 1, 2011, to October 31, 2021) because at the beginning

of this time period data on MI for influenza showed a positive impact on maternal and infant health outcomes, driving interest in MI. This was the period when influenza, Tdap and COVID-19 vaccines were approved for pregnant women. The objective of the search strategy was to include all evidence related to factors influencing the uptake of maternal vaccines or the intention to take maternal vaccines, and the interventions that influence maternal immunization coverage across all LICs and LMICs. The term "barrier" was defined as any factor that made the immunization difficult/challenging, including factors that delayed immunization. The term "facilitator" was defined as any factor whose presence promoted the immunization uptake or intention. The term "strategy" was defined as a plan of action developed to improve immunization coverage.

The literature search was conducted on three databases: PubMed, the Cochrane Library, and Scopus by two authors independently between November 5, 2021, to January 13, 2022. The search strategy combined Title abstract terms and MeSH terms using 'OR' and 'AND' for six blocks viz., i."maternal;" ii. "immunization;" iii. "vaccination refusal" and "patient acceptance;" iv. types of facilitators, barriers, strategies and interventions; v. licensed "maternal vaccines" and vi. Text words of all LICs and LMICs. PubMed search strategy is described in Supplementary Table S2 and Scopus in Supplementary Table S3. We included all countries that fall under the World Bank's list of LICs and LMICs.[70]

We included studies if they were written in English; conducted in LMIC or LIC settings; discussed licensed vaccines for MI; addressed pregnant or post-partum women and also included their partners, families, community leaders, HCP, and policy makers. All primary study designs were included: quantitative, qualitative, and mixed-methods studies.

Excluded studies included those on children and non-pregnant adults, not from LMIC/LICs, not in English and those that did not measure maternal immunization. Narrative reviews, scoping reviews, systematic reviews, blogs, abstracts, letters, conference abstracts, modeling studies, theses, guidelines, opinion pieces, commentaries, unpublished and gray literature were excluded.

### Data extraction

The primary outcomes were facilitators and barriers to maternal immunization and strategies that influence maternal vaccination rates. Retrieved articles from all databases were entered into *DistillerSR* and duplicates were removed by matching authors, titles, journals and the year of publication. Title and abstracts were screened for relevance by two independent reviewers (TK, SM, SDB, LR) and conflicts were resolved by mutual discussion with the third reviewer for final decision. Full texts of all eligible articles were screened by two reviewers (TK, SM). For a few studies, authors were contacted for full texts.

Data was extracted from the included studies by two reviewers (TK, SM) using a standardized data extraction sheet in Microsoft Excel. The extracted data included details of study identification (author, year of publication, journal), country, study setting, study design, study set-up, data collection method, study population, sample size, vaccine(s) of interest (TT or tetanus diptheria, influenza, Tdap, COVID-19), vaccination coverage, key facilitators, key barriers and major findings. Authors were not contacted for missing or additional information in the full texts. Facilitators or barriers that were statistically significant in quantitative studies, or were major emerging themes in qualitative or mixed-method studies were recorded. For the strategies, information on the strategy type, intervention and controls were recorded.

### Data analysis

The extracted data was summarized into tables and figures. Odds ratios, proportions and effect size were reported as described in the included studies. No calculation was done to estimate the risk ratios and confidence intervals. Based on their nature, the facilitators and barriers identified from quantitative, qualitative or mixed-method studies were integrated and mapped into five domains of the socio-ecological model. Strategies were categorized into six different themes.

### Quality assessment

The methodological quality of the included studies was assessed by two reviewers (TK, SM) independently with the Mixed Methods Appraisal Tool (MMAT) 2018.[71] Disagreements in the quality scores were resolved by discussion between the two reviewers (TK, SM) for final decision. The MMAT allows appraisal of qualitative, quantitative, and mixed-method studies. The appraisal included questions on the methods, sampling, response rate, remark on confounders, outcome measurement and analysis. Quality scores were used to describe the quality of evidence, not for study exclusion or inclusion.

## Results

### Study selection

The database search retrieved 614 articles, 209 of which were duplicates as shown in the PRISMA flow diagram (Figure 1). At the level of title and abstract screening, 331 citations were excluded for not meeting the inclusion criteria. Full texts of three studies could not be found. Out of 82 studies reviewed in full, 27 were excluded as they did not address review objectives (Supplementary Table S4). In all, 55 studies met the inclusion criteria.

### Study characteristics

Out of 55 studies, 43 focused on the determinants of MI[72–114] and their study characteristics are described in Table 1. Out of 55 studies, 12 studies focused on the strategies that influence MI coverage[115–126] and their study characteristics are described in Table 2. The majority (37/55; 67%) of studies were published between 2017 and 2021. Studies were conducted in 25 countries; 37 in LMICs [El Salvador ($n = 1$), Cambodia ($n = 1$), Cameroon ($n = 1$), Egypt ($n = 1$), Ghana ($n = 1$), Haiti ($n = 1$), Honduras ($n = 1$), India ($n = 10$), Iran ($n = 2$), Ivory Coast ($n = 2$), Kenya ($n = 4$),
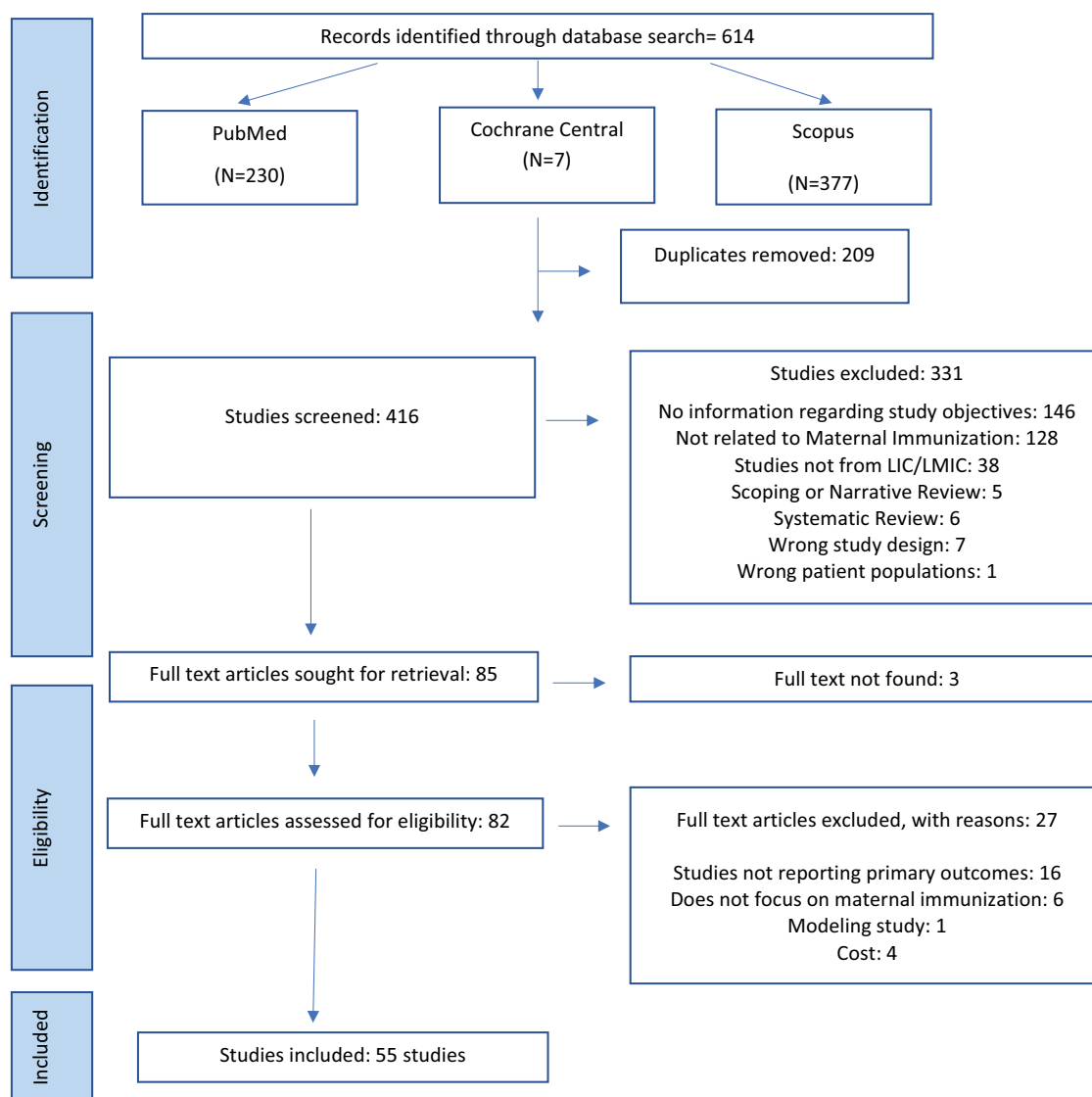
**Figure 1.** PRISMA flowchart.

Morocco (*n* = 1), Nicaragua (*n* = 2), Nigeria (*n* = 3), Pakistan (*n* = 5), Tanzania (*n* = 1)]; thirteen in LICs [Afghanistan (*n* = 1), Burundi (*n* = 2), Ethiopia (*n* = 6), Malawi (*n* = 1), Sierra Leone (*n* = 1), Uganda (*n* = 1), Zambia (*n* = 1)]; one in both LIC (Gambia) and LMIC (Senegal); one in high-income countries (HIC; Spain, Italy) and LMIC (India); and, three across multiple countries (Figure 2).

A little less than half (25/55) of the studies were from the African region (AFR), 10 each from the South-east Asian region (SEAR) and the Eastern Mediterranean region, 5 from the region of Americas, 1 from the Western Pacific region (WPR) and 4 from mixed regions.

The study settings included health facilities 24/55 (43%), communities 23/55 (42%), both 7/55 (13%), and office of experts 1/55 (2%). Studies occurred in rural areas 11/55 (20%), urban areas 12/55 (22%), or both 18/55 (33%), or were not specified 14/55 (25%). Of note, 9/55 (16%) of the studies were from countries (Afghanistan, Nigeria, Pakistan) where MNT is not yet eliminated.

Most studies (*n* = 44) utilized quantitative methods, whereas five used the qualitative, four used the mixed-method design and two had a mixed approach of narrative review with qualitative or

cross-sectional design. The quantitative studies encompassed cross-sectional studies (*n* = 27), quasi-experimental (*n* = 8), secondary research (*n* = 6), randomized controlled trial (RCT) (*n* = 2), and retrospective cohort designs (*n* = 1).

The study participants included pregnant women (16/55; 29%), or a mix of pregnant women, health care personnel, spouses, post-partum women, mothers with a recent history of giving birth, and women of reproductive age. The sample size of pregnant women ranged from 90 to 19,880, total *n* = 53,889.

Studies focused largely on tetanus toxoid (*n* = 32) followed by influenza vaccine (*n* = 13). Few studies were on maternal vaccines in general (*n* = 6); and one each on Tdap, pertussis, COVID-19, and tetanus toxoid (TT) with influenza.

### Quality assessment of studies

Supplementary Table S5 shows the quality appraisal of studies using the MMAT. The majority 50/55 (91%) of studies scored average and above. No study was excluded on the basis of quality score, given that one of the primary objectives of the

**Table 1.** Characteristics of studies on facilitators and barriers to maternal immunization in LICs and LMICs and MMAT score.

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mustafa A & Shekhar C (2021) | India | Secondary data analysis | LMIC | Rural | Community | Women of reproductive age | 190898 | Tetanus toxoid | (1) Plain area | Hard-to-reach hilly area | A woman from a hilly area (AOR: 0.46, 95% CI:0.42–49) was 54% less likely for '2 doses of TT' than a woman from a plain region. Odds of receiving TT were 25% lower for women from urban-hilly regions (AOR: 0.75, 95%CI: 0.65–86) than women from urban-plain areas, and 71% lower for women from the rural-hilly areas (AOR: 0.39, 95% CI: 0.36–43) than rural-plain areas. | ●●● ●○ |
| 2 | Chelo D et al. 2021 | Cameroon | Cross-sectional | LMIC | Semi-urban | Healthcare/ hospital | Women of reproductive age, children | 22561, 151413 | Tetanus toxoid | NA | Pandemic | Decline in TT vaccination during pandemic (April and May 2020) as compared to same months of previous years (2016-2019). | ●●● ●○ |
| 3 | John P et al. 2021 | Gambia and Senegal | Qualitative | Gambia-LIC, Senegal-LMIC | Rural | Community | Pregnant women and women with infants | 96 | Maternal vaccines in general | 1. Maternal knowledge; 2. Past vaccination experience; 3. Perception and confidence in vaccine; 4. Confidence in providers, health workers; 5. Decision influencers (husbands, health workers); 6. Free vaccine; 7. Sensitization | Women's acceptance of vaccines during pregnancy is based on previous vaccination experiences, individual weighing of risks and benefits and sensitization about risks and benefits and socio-demographic factors. The willingness was influenced by their husbands and trusted healthcare workers. | ●●● ●● |
| 4 | Madewell ZJ et al. 2021 | Honduras | Cross-sectional | LMIC | Rural | Healthcare/ hospital | Postpartum women (20 hours pp) | 842 | Influenza | 1. Receipt of recommendations by a healthcare worker; 2. Concurrent chronic disease; 3. Influenza vaccination of children in household; 4. Perceived benefits 5. Easy access | 1. Vaccine not offered, 2. Fear of side effects and pain; 3. Not advised to get vaccine | Recommendations by a healthcare worker during ANC visit (aOR:16.46; 95% CI: 9.73–27.85), concurrent chronic disease (aOR: 5.00; 95% CI: 1.25–20.07), flu vaccination of other children in house (aOR: 2.28; 95% CI: 1.19–4.39) were facilitators | ●●● ●● |

(Continued)

Table 1. (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|--------|--------|-------------------|--------------|----------|---------------|--------------|------------------|-------------|-----------------|-------------|---------|---------------|------------|
| 5 | Kajungu D et al. 2020 | Uganda | Qualitative | LIC | Rural & Semi-urban | Community and health facility | Pregnant women, health workers | PW = 90 | Tetanus toxoid | 1. Awareness about importance of vaccines; 2. Positive attitudes; 3. Delivery of maternal vaccines on the day of ANC; 4. Convenient schedule; 5. Support from partners; 6. Sensitization about vaccine safety, schedule and protection | 1. Fear for AEFI; 2. Negative attitudes of partners; 3. Use of traditional remedies, religious beliefs; 4. Partners not going to ANC; 5. Poor knowledge; 6. Amenities unfavorable; 7. Poor treatment by health workers; 8. Long waiting; 9. Workload of health workers; 10. Belief that Ugandans used for vaccine trials | Maternal immunization knowledge, attitude and willingness was positive. Religion, norms, cultures, fear for AEFI, wrongly belief about vaccines, negative attitudes of partners, abuse by health workers, long waiting at facility, workload of health workers were barriers. Proper sensitization and education of women, their partners and community is important to build confidence in vaccine safety and training of health workers to be compassionate and respectful. | ●●● ●● |
| 6 | Sherley J & Newton S 2020 | Afghanistan | Secondary data analysis | LIC | Rural and Urban | Community | Women who gave birth in past 5 years | 18782 | Tetanus toxoid | 1. Rural area; 2. Number of ANC visits; 3. Maternal education; 4. Partner's education; 5. Wealth index; 6. Easy permission for medical care | 1. Urban area; 2. No ANC; 3. Birth order; 5. Distance to health facility; 6. Problem in getting permission to seek medical care | Rural women had (62%) higher odds of being vaccinated (OR = 1.62; 95% CI = 1.18–2.24, $p$ =.003) than urban, women attending ANC than women who did not receive ANC ($p$ <.001), some maternal education ($p$ <.001) and having a husband with some education ($p$ =.011) were strongly associated. Easy permission for medical care had 28% greater odds of sufficient TTCV (OR 1.28; 95% CI =1.11–1.49, $p$ =.001). | ●●● ●● |

(Continued)

Table 1. (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Privor-Dumm L 2021 | Spain, Italy, India | Qualitative +Narrative | HIC, LMIC | Unclear | Country | Experts from a vaccine technical, maternal health, program implementation, health economic, financing, advocacy | 59 | Maternal vaccines in general | 1. Low cost; 2. Political will; 3. Disease and mortality data; 4. Advocacy. 5. Engagement of OB-GYN as champion | 1. Cost; 2. Poor data on disease; 3. Lack of advocacy and political will; 4. Vaccine supply shortage; 5. Perceived as not needed; 6. voice of OB-GYN not strong | Facilitators are advocacy (maternal health advocates, health care providers, representatives of marginalized populations), education of providers and pregnant women, engagement of champions (ob-gyn), centralized tracking, adequate supply, timing with ANC, stronger global guidance for vaccines. | ●●● ○○ |
| 8 | Giduthuri JG et al. 2021 | India | Qualitative | LMIC | Urban | Community and health facility | Women (pregnant/previously pregnant/non-pregnant), spouse, clinicians | Women = 60, Spouse = 30, Clinician = 16 | Influenza | 1. Clinician's recommendation; 2. Clinician education and training; 3. Spouse recommendation; 4 Maternal influenza vaccination policy; 5. Vaccine confidence | 1. Low awareness among community, clinicians about influenza vaccine policy; 2. Perception about low severity; 3. No mandatory policy to recommend in private sector; 4. Cost | Clinician's advice and recommendation, clinician education and training, education of community, spouse recommendation, policy on maternal influenza vaccination, vaccine confidence and demand in community were facilitators | ●●● ●● |
| 9 | Otieno NA, et al. 2020 | Kenya | Cross-sectional | LMIC | Urban, Rural, Semi-urban | Healthcare/ hospital | Pregnant women | 507 | Influenza | 1. Knowledge about disease; 2. Vaccine confidence; 3. Trust in Government offered maternal vaccines | 1. Fear of side effects; 2. Skepticism about the need and risk for NEW vaccines | Knowledge about disease, belief in influenza vaccine safety (OR 5.32; 95% CI 2.35, 12.01) and protective effect (OR 3.87; 95% CI 1.56, 9.59) on mother and baby, belief that maternal vaccines by government are beneficial | ●●● ●○ |
| 10 | Holroyd TA et al. 2020 | India | Secondary data analysis | LMIC | Rural and Urban | Community | Mothers with history of pregnancy, children | Mothers = 259627, Children = 49284 | Tetanus Toxoid | | 1. Young maternal age; 2. Low socioeconomic status; 3. Residing in a rural setting; 4. Lower maternal education; 5. Difficulty reaching a health facility; 6. Less ANC | Lower socioeconomic status, lack of ANC, and lower maternal education, residing in a rural setting, difficulty reaching a health facility were barriers | ●●● ●● |

(Continued)

Table 1. (Continued).

| S.No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Giles ML et al. 2020 | LMICs | Mixed-method | LMIC | Unclear | Healthcare/ hospital | EPI & MNCH programme officers, health facility managers | NA | Tetanus Toxoid | 1. ≥ 4 ANC visits; 2. ANC service package 3. introducing maternal and neonatal disease surveillance systems (including for stillbirth | 1. User fees for ANC and maternal immunization; 2. Non-availability of surveillance; 3. Record of maternal & neonatal tetanus deaths, information about timing of ANC visits by trimester | ≥4 ANC visits, transitioning to eight visits, ANC service package, introducing record keeping systems to identify the number and timing of visits,) financial commitment, political will are beneficial | ●●○ ○○ |
| 12 | Yaya S et al. 2020 | Sierra Leone | Cross-sectional | LIC | Unclear | Community | Women of reproductive age | 8722 | Tetanus Toxoid | 1. At least 4 ANC visits; 2. Mass media exposure (radio, TV, mobile phone); 3. Higher wealth quantile; 4. Higher parity | 1. < ANC visits; 2. Mende Ethnicity; 3. Internet | Atleast 4 ANC visits, mass media exposure (radio, TV, mobile phone), higher wealth quantile, higher parity are beneficial | ●●● ●● |
| 13 | Gebremedhin TS et al. 2020 | Ethiopia | Cross-sectional | LIC | Rural and Urban | Community | Mothers who gave birth in past 1 year | 440 | Tetanus Toxoid | 1. Urban residence; 2. Multiparity; 3.Less travel time to health facility | 1. Long distance travel to health facility; 2. maternal education; 3. Pastoralist lifestyle | Urban residence location, small distance to health facility, multiparity and maternal knowledge and ANC follow-up are beneficial | ●●● ●● |
| 14 | Otieno NA et al. 2020 | Kenya | Cross-sectional | LMIC | Sub-urban/ peri-urban | Community and health facility | Pregnant women | 604 | Maternal vaccines in general | 1. Individual belief in vaccines protect from disease; 2. Health care provider recommendation; 3. Belief in vaccine importance, effectiveness; 4. Belief in vaccines recommended by the government | 1. Concern about side effects; 2. Risk of new vaccines; 3. Low awareness about vaccine; 4. Negative vaccination experience in the past | Individual belief in vaccines prevent disease, benefit fetus, health care provider recommendation, belief in vaccine importance, vaccines are effective, belief in vaccines recommended by government are beneficial | ●●● ○○ |
| 15 | Iqbal S et al. 2020 | Pakistan | Cross-sectional | LMIC | Urban | Healthcare/ hospital | Pregnant women | 80 | Tetanus Toxoid | 1. Two and more ANC visits | | **Facilitator:** Two or more ANC visits | ●●● ○○ |

(*Continued*)

**Table 1.** (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | Fleming JA et al. 2019 | Malawi | Mixed-method | LIC | Rural, Urban, Sub-urban/peri-urban | Community and health facility | 90% [Pregnant, recently pregnant women, family, community leaders, health workers; 10% [health professional, program managers, N-G partners, policy makers] | 274 | Maternal vaccines in general | 1. Strong maternal vaccine acceptance; 2. Existing strategy for maternal tetanus vaccine delivery through ANC services; 3. Positive health workers' views about the introduction of additional maternal vaccines | 1. Identify and track target population; 2. Monitor adverse events; 3. Inadequate operational capacity to support additional vaccine; 4. Limited awareness of influenza; 5. Low prioritization among health needs 6. Vaccine stock out, staff shortage, lack of transportation, short shelf life, lack of resources to properly dispose vaccines | **Facilitator:** Positive view of MI, Mandate to receive TTV before other ANC services), Incentives for partner involvement, Respectful treatment by HCP, training and education about diseases and vaccines and safety, positive health workers views about introduction, long-term funding **Barrier:** need to ensure operational capacity of the health system to support the introduction and wide-scale use of an additional vaccine (additional work, cost of reprinting). | ●●○ ○○ |
| 17 | Mihret MS et al. 2018 | Ethiopia | Cross-sectional | LIC | Urban | Community | Mothers who gave birth in past 1 year | 511 | Tetanus Toxoid | 1. Maternal education; 2. Number of ANC visit; 3. Perceived behavior of service provider; 4. Timely ANC visit; 5. Planned last pregnancy; 6. Perceived quality of service | | Maternal education (AOR =2.09; 95%CI: 1.12, 3.90), planned last pregnancy (AOR = 6.63; 95%CI: 2.36, 18.63), 4 or more ANC (AOR = 5.16; 95%CI: 2.93, 11.14), timely ANC (AOR = 4.29; 95% CI:1.94, 9.49), and perceived good quality of service (AOR = 2.20; 95% CI: 1.26, 3.84), perceived behavior of provider (AOR = 1.84 (0.84,4.05) were positively associated. | ●●● ●● |

(*Continued*)

Table 1. (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Fleming JA 2018 | El Salvador | Mixed-method | LMIC | Unclear | Community and health facility | Pregnant, recently pregnant, Family, Community leaders, Municipal health workers, Municipal and national public health managers, International partners, communication experts | Community member = 271; Health professionals = 55 | Influenza | 1. Use of multiple vaccine delivery strategies; 2. Vaccination posts in public areas; 3. Education; 4. Community engagement; 5. Trust of health care providers; 6. Education of advisors, providers, medical school; 7. social and multimedia, 8. Education of health workers, police or community leaders | 1. Lack of information about influenza among gynecologists; 2, Hesitancy among gynecologists; 3. Need for permission (from spouse/family/employer); 4. Limited access to health services in insecure areas; 5. Mistrust of vaccine by the community; 6. Resistance to introduction of vaccine; 7. Negative publicity | Multiple strategies (region-wide, immunization campaign through ANC services/ community health system, health promoters)for vaccination are needed such as immunizations given through ANC services | ●●● ○○ |
| 19 | Williams AL et al. 2018 | Zambia | Qualitative | LIC | Unclear | Healthcare/ hospital | Postpartum women (two weeks) | 50 | Tetanus diphtheria acellular pertussis (Tdap) | 1. Vaccine acceptance/ confidence; 2. Partner involvement; 3. Feeling of maternal authority over healthcare decision-making; 4. Health professionals outreach in community | 1. Limited knowledge disease and vaccine; 2. Misinformation about disease and vaccines about association with Western medicine or Satanism; 3. Vaccine hesitancy | **Facilitator:** Acceptance/ confidence in maternal immunization, partner involvement, feelings of maternal authority over healthcare decision-making, health professionals outreach in community | ●●● ●● |
| 20 | Siddiqui M et al. 2017 | Pakistan | Cross-sectional | LMIC | Urban | Healthcare/ hospital | Pregnant women | 283 | Pertussis | 1. History of child death due to illness; 2. Awareness of disease; 3. Receipt of vaccine in childhood; 4. Receipt of tetanus vaccine in pregnancy; 5. Perceived susceptibility to disease, vaccine, safety, efficacy; 6. Recommendation of providers and ministry of health; 8. Mass media | 1. Authorization of husband or family members; 2. Fear of harm | **Facilitator:** Recommendation of healthcare provider and ministry of Health, mass media, knowledge of disease and perceived susceptibility, positive beliefs about vaccine safety, efficacy **Barrier:** Opinion of primary decision-makers in the family (husbands and in-laws) | ●●● ●● |

(Continued)

**Table 1. (Continued).**

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Arriola CS et al. 2018 | Nicaragua | Cross-sectional | LMIC | Unclear | Healthcare/hospital | Pregnant women, health workers | Pregnant women = 1303, Health workers = 619 | Influenza | 1. Awareness of recommendation and disease risk; 2. Positive perceptions about vaccine safety and effectiveness; 3. Vaccine recommendation and offer of vaccination by health care providers | 1. Unawareness about influenza vaccine recommendation; 2. Non-availability at health facility; 3. No recommendation by HCP; 4. Lack of time | **Facilitator:** Pregnant women and health care providers' awareness of the recommendation for vaccination, disease risk, positive perceptions about vaccine safety and effectiveness, vaccine recommendation and offer of vaccination by health care providers | ●●● ●● |
| 22 | Arriola CS et al. 2016 | Nicaragua | Cross-sectional | LMIC | Urban | Healthcare/hospital | Postpartum women (after delivery) | 1807 | Influenza | 1. 4 or more ANC visits; 2. Recommendation by health care provider | 1. Did not receive information about influenza vaccination; 2. Not offered vaccine; 3. Access problems (transportation, distance); 4. Lack of trust in vaccines | 4 ANC visits (AORs: 2.58; 95% CI: 1.15, 5.81, 5 and more ANC visits 2.37;95% CI: 1.12, 5.0, vaccine recommendation by health care provider (AOR: 14.22; 95% CI: 10.45,19.33) | ●●● ●○ |
| 23 | Pathirana J et al. 2015 | Malawi, developing countries | Narrative Review, Cross-sectional | LIC | Rural | Healthcare/hospital | District health officers, maternal and child health coordinators | 6, 5 | Tetanus Toxoid | 1. Outreach; 2. Improve awareness in women; 3. Support of family and community leaders; 4. Reminders given in the community; 5. Provider recommendation | 1. Inadequate knowledge about tetanus elimination status in Malawi; 2. Limited knowledge about maternal vaccines; 3. Inadequate ANC attendance; 4. Low awareness in women; 5. Long waiting time; 6. Vaccine stock out; 7. Inadequate storage space | Providers had low awareness about maternal immunization. MI is not addressed in detail in national EPI plans, new literature and recommendation on MI not be well covered in training and workshops requiring greater advocacy. District officers were not familiar with reporting AEFI. Low ANC attendance due to low awareness in women, long waiting times (Not statistically significant) | ●●○ ○○ |
| 24 | Lohiniva A-L et al. 2014 | Morocco | Qualitative | LMIC | Rural and Urban | Healthcare/ Hospital | Pregnant women | 123 | Influenza | [1] Perceived health benefits[2] modeling, others in community taking the vaccine; 3. Support of family, community, religious leaders and health providers; 4. Mass media (television) | [1] Fear of the (H1N1) pdm09 vaccine[2]; Belief in pandemic conspiracy[3]; Belief in the inapplicability of vaccine,[4] Lack of knowledge of disease and vaccine[5] | **Facilitator**,[1]: perceived health benefits and[2] modeling, others in community taking the vaccine. Decision-making was strongly influenced by family, community, mass media (television), religious leaders and health providers. | ●●● ●● |

*(Continued)*

Table 1. (Continued).

| S.No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Koul PA et al. 2014 | India | Cross-sectional | LMIC | Rural and Urban | Healthcare/ hospital | Pregnant women and healthcare personnel | Pregnant women = 1000; Healthcare personnel = 90 | Influenza | 1. Recommendation by clinicians; 2. Offer by clinicians; 3. Reassurance about safety | 1. Lack of knowledge about vaccine; 2. Physician did not recommend **HCP Barriers:** 1. Ignorance about availability; 2. Misperception about efficacy; 3. Belief influenza is not serious; 4. Poor confidence in safety; 5. Belief adverse events are under-reported; 6. Belief programs motivated by profit | **HCP Barrier to recommendation:** poor confidence in maternal influenza vaccine safety and efficacy, belief that adverse effects are under-reported, programs are motivated by profit. Statistical analysis not done. | ●●● ○○ |
| 26 | Honarvar B et al. 2012 | Iran | Cross-sectional | LMIC | Rural and Urban | Healthcare/ hospital | Pregnant women | 416 | Influenza | 1. Recommendation by others (not physician); 2. Belief that vaccine is necessary; 3. History of influenza infection; 4. Belief in vaccine effectiveness; 5. Multiple fetus | 1. Lack of knowledge about vaccination; 2. Belief about no need for vaccine and low risk of influenza; 3. Fear about side effects; 4 Physicians did not recommend | Recommendation by others (not physician), belief that vaccine is necessary, history of frequent influenza infection, belief about vaccine effectiveness, were facilitators. Findings not statistically significant in logistic regression | ●●● ●○ |
| 27 | Liyew AM & Ayalew HG 2021 | Ethiopia | Secondary data analysis | LIC | Rural and Urban | Community | Pregnant women or women who gave birth in past 5 years | 7043 | Tetanus Toxoid | 1. Iron uptake during pregnancy; 2. > 3 ANC visits; 3. Rich wealth index; 4. Urban residence; 5. Maternal employment | 1. No ANC visit; 2. Poor wealth index; 3. Not being exposed to media; 4. Maternal unemployment; 5. Rural residence; 6. High community illiteracy; 7. Distance to health facility | Iron uptake during pregnancy (AOR = 0.59; 95% CI: 0.51, 0.68), >3 ANC visits, **Barrier:** No ANC visit (AOR = 5.64; 95% CI: 2.48,7.30), having 1-3 ANC visit (AOR = 1.50; 95% CI: 1.19–1.82); poor wealth index (AOR = 1.26; 95% CI: 1.03, 1.54); not exposed to media (AOR = 1.29; 95% CI: 1.10, 1.51); maternal unemployment (AOR = 1.15; 95% CI: 1.10, 1.31); rural residence (AOR = 1.13; 95% CI: 1.08, 1.72); high community illiteracy (AOR = 1.28; 95% CI: 1.03, 1.58) | ●●● ●● |

*(Continued)*

Table 1. (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | Somlorm K et al. 2021 | Cambodia | Secondary data analysis | LMIC | Rural and Urban | Community | Women of reproductive age, pregnant women and women with children under 5 | 5901 | Tetanus Toxoid | 1. ANC by midwife; 2. > ANC visits; 3. Wanted pregnancy; 4. Age <30 years at delivery | 1. ANC from other than midwife; 2 had<ANC visits; 3. Late for the first ANC visit; 4. Unwanted pregnancy; 5. Aged ≥30 years at delivery | **Barrier:** received ANC from other than midwife (aOR = 1.83; 95%CI: 1.49, 2.24), had<ANC visits (aOR = 1.76; 95%CI: 1.53, 2.03), being late for the first ANC visit (aOR = 1.65; 95%CI: 1.41, 1.92), unwanted pregnancy (aOR = 1.30; 95%CI: 1.11, 1.51), aged ≥30 years at delivery (aOR = 1.45; 95%CI: 1.15, 1.46) | ●●● ●● |
| 29 | Nakhaeizadeh 2021 | Iran | Cross-sectional | LMIC | Urban | Healthcare/hospital | Pregnant women | 520 | Influenza | 1. Vaccine recommendation; 2. Knowledge about vaccine; 3. Underlying chronic disease; 4. Older age; 5. Employment; 6. Past antenatal influenza vaccination history; 7. Care by obstetrician | 1. Lack of vaccine recommendation; 2. Concern of side effects on fetus; 3. Belief that influenza is not severe; 4. Cost | Recommendation for influenza vaccination (AOR = 65.76; 95%CI: 11.04 - 391.48), knowledge of vaccine (AOR = 9.64; 95%CI: 3.87 - 24.02) were strongest facilitators, having an underlying chronic disease (AOR =4.39; 95%CI:1.33 - 14.51), age >30 years (AOR = 3.79; 95%CI: 1.5 - 9.2),and being employed (AOR = 2.44; 95%CI: 1.0 - 5.8) | ●●● ○ |
| 30 | Mose A & Yeshaneh A 2021 | Ethiopia | Cross-sectional | LIC | Unclear | Healthcare/hospital | Pregnant women | 396 | COVID-19 | 1. Maternal age (34–41 years); 2. Educational status; 3. Good knowledge; 4.Good preventive measures | 1. Fear of side effect; 2. Belief that vaccine might be ineffective; 3. Poor knowledge | Pregnant mothers 34–41 years age group [AOR = 1.464, (95% CI; 1.218–5.129)], primary education [AOR = 3.476, (95% CI; 1.520–7.947), good knowledge of COVID-19 and its preventive measures [AOR = 5.946, (95% CI; 3.147–7.065)], good practice of COVID-19 preventive measures [AOR = 9.15,(95% CI; 8.734–12.189)] had positive association | ●●● ●● |
| 31 | Chander S et al. 2021 | Kenya | Cross-sectional | LMIC | Unclear | Healthcare/hospital | ANC providers | 150 | Maternal vaccines in general | 1. Positive attitudes toward maternal vaccine; 2. Practice of recommending vaccines | | 99% providers recommended TT and agreed to provide additional vaccinations. | ●●○ ○○ |

(Continued)

Table 1. (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | Mehanna A et al. 2020 | Egypt | Cross-sectional | LMIC | Unclear | Healthcare/hospital | Mothers who gave birth in past 6 months | 700 | Tetanus Toxoid | Place of ANC | 1. Poor knowledge; 2. Perceived low susceptibility toward MNT; 3. Low socioeconomic status | 83.6% had poor knowledge of MNT and TTV. Place of ANC, level of knowledge, perceived barriers, and socio-economic level were significant predictors of immunity status ($p = .008$, $p = .032$, $p = .011$, and $p = .001$, respectively). | ●●●<br>●● |
| 33 | Saso A et al. 2020 | Multiple countries | Mixed-method | Mix of HIC UMIC MIC LMIC LIC | Unclear | Community | International Immunising Pregnant Women & Infants Network | 48 | Maternal vaccines in general | 1. Logistical support; 2. Targeted communication strategies | 1. Staff shortage; 2. Risk of getting infection from immunization appointment; 3. Logistic barrier | Access and provider issues, uncertainty among parents and healthcare providers attending routine immunization were barriers | ●●○<br>○○ |
| 34 | Mengesha MB et al. 2020 | Ethiopia | Cross-sectional | LIC | Unclear | Community | Mothers who gave birth in past 1 year | 515 | Tetanus Toxoid | Facilitator: 1. Mother age <20 years; 2. No future plan for fertility; 3. ANC visit; 4. Receive information from media | 1. Fear of side effects; 2. Lack of information | Mothers with age <20 years [AOR 0.19 (0.10, 0.32), had no plan for fertility [AOR 0.30(0.17, 0.53)], attended once ANC visits [AOR 0.38 (0.18, 0.82)] and who got information from media [AOR 4.49(1.82, 11.07] were predictors of TT. | ●●●<br>●● |
| 35 | Yaya S et al. 2019 | Ivory Coast | Cross-sectional | LMIC | Rural and Urban | Community | Pregnant women | 9583 | Tetanus Toxoid | Facilitator: 1. 4 ANC visits; 2. Lower parity; | 1. Higher parity; | Women who attended at least four ANC visits had higher TT (OR = 2.347, 95%CI = 1.384-3.981). Women with higher parity had lower odds of TT immunization (OR = 0.218, 95%CI = 0.055–0.858) than those with lower parity. | ●●●<br>●● |

Table 1. (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | Mamoro MD & Hanfore LK 2018 | Ethiopia | Cross-sectional | LIC | Unclear | Community | Mothers who gave birth in past 1 year | 837 | Tetanus Toxoid | 1. Maternal education and age; 2. Paternal education; 3. Health worker home visit; 4. ANC visits number; 5. Joint decision making with partner; 6. Use of family planning; 7. Time to reach health facility | | Age of mother who attended elementary school, husbands' education, visited by HEW's at home, making joint health decision with husband, use of modern family planning method, number of ANC visit, and time to reach the health facility were predictors of TT immunization | ●●● ●● |
| 37 | Gul R et al. 2016 | Pakistan | Cross-sectional | LMIC | Rural and Urban | Healthcare/ hospital | Pregnant, postpartum women (<6 weeks) | 500 | Tetanus Toxoid | | 1. Low knowledge; 2. Culture restrictions; 3. Misconception about TT vaccination | Low literacy rate, unemployment and lack of visits by the field workers are the main causes of low TT vaccination in pregnant women | ●●○ ○○ |
| 38 | Khan AA et al. 2015 | Pakistan | Cross-sectional | LMIC | Urban | Community | Pregnant women | 274 | Tetanus Toxoid and Influenza | 1. Doctor's recommendation; 2. Perceived safety, susceptibility and efficacy | 1. Perceived harm of vaccine; 2. Misconception that vaccine weaken immunity; 3. Lack of permission of husband/family | Role of healthcare providers, husbands, and in-laws in promoting maternal vaccine acceptance in an ethnically diverse population. | ●●● ●● |
| 39 | Patel P et al. 2014 | India | Cross-sectional | LMIC | Rural and Urban | Community | Mothers who gave birth in past 1 year | 593 | Tetanus Toxoid | 1.Residing in a rural setting | 1. Residing in an urban slum | Majority of the antenatal, postnatal and newborn health variables are significantly poorer in the urban slums, whereas intra-natal health variables were poorer in rural areas. | ●●● ●● |
| 40 | Haile ZT et al. 2013 | Kenya | Secondary data analysis | LMIC | Rural and Urban | Community | Women who gave birth in past 1 year | 1370 | Tetanus Toxoid | 1. Lower birth order; 2. Higher household wealth index; 3. Being employed; 4. Making decisions with partner; 5. Number of ANC visits | | Mothers with higher birth order, higher household wealth index, employed, made health-related decisions by themselves or with partner or other person, and who had higher ANC visits. | ●●● ●● |

**Table 1.** (Continued).

| S. No. | Author | Country of origin | Study design | LMIC/LIC | Study setting | Study set-up | Study population | Sample size | Vaccine studied | Facilitators | Barrier | Major finding | MMAT Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41 | Kouassi DP et al. 2012 | Ivory Coast | Cross-sectional | LIC | Urban | Healthcare/hospital | Pregnant women | 411 | Pandemic influenza | 1. Being in a general hospital and public out-patient settings; 2. Perceived risk of influenza | 1. Lack of information; 2. Worry about side-effects; 2. Lack of trust in vaccine; 3. Internet access | Being in a general hospital and public out-patient settings as opposed to university hospital and private-practice clinics acted as facilitator | ●● ●● |
| 42 | Khan A et al. 2012 | Pakistan | Cross-sectional | LMIC | Rural | Community | Heads of children who didn't complete vaccines | 123 | Tetanus Toxoid | | Lack of awareness about vaccination | Education of parents and awareness is important for increasing vaccine coverage. | ●● ●○ |
| 43 | Bhaskar E et al. 2012 | India | Cross-sectional | LMIC | Urban | Healthcare/hospital | Pregnant women | 140 | Pandemic influenza | 1. Recommendation by obstetrician; 2. Employed status; 3. Support from spouse | 1. Lack of advice on vaccination; 2. Lack of education; 3. unemployed status | A better involvement from health care providers may improve vaccination rates. | ●● ●● |

**Table 2.** Characteristics of studies on strategies that improve the uptake of maternal vaccines and MMAT score.

| S. No. | Author | Country | Study design | Study setting | Study set-up | Study population | Sample size | Vaccine | Strategy | Intervention | Control | Major finding | MMAT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chakrabarti S et al. 2021 | India | Quasi-experimental study | Rural & Urban | Community | Mother and child | >200000 | TT | Mamata scheme (Conditional cash incentive) | Financial incentives to pregnant and lactating women in Odisha state | Other states without Mamata scheme | Mamata cash transfer scheme marginally increased tetanus immunization in pregnant women. | ●●●● |
| 2 | Sato R & Fintan B 2020 | Nigeria | Randomized Controlled Trial | Rural | Community, healthcare/ hospital | Pregnant women and women of childbearing age | 2,482 | TT | Cash incentives to pregnant women | 300 Nigerian naira, and 800 naira | 5 Nigerian naira | Women receiving incentives more likely received one dose of TT than control. A 2-dollar cash incentive (300 naira) increased the odds of vaccine uptake 3.4 times than the control (5 naira). | ●●●○ |
| 3 | Giduthuri JG et al. 2019 | India | Quasi-experimental study | Urban | Healthcare/ hospital | Clinicians providing ANC services | 30 | Influenza | Sensitization and engagement of clinicians' for recommending influenza vaccines to pregnant women | Clinicians presented with influenza vaccine recommendations from global, academic and professional medical organizations and informed about community vaccination views | Clinicians not presented with vaccine recommendations and assessments of community vaccination views | Clinician engagement or education increased maternal influenza immunization (37.8%) in urban middle class setting, while the control clinicians were vaccinated at < 0.2% throughout study ($p$ < .05). | ●●○○ |
| 4 | Prinja S et al. 2017 | India | Quasi-experimental study | Rural | Community | Mothers with child in age <6 months and 12-23 months | 1053, 1391 | TT | mHealth application for ASHA workers for registration of pregnant women, providing realtime guidance, counseling points, timely alert, tracking | Two community development blocks in Kaushambi district, Uttar Pradesh | Two blocks from the same district without mHealth application | The coverage of 3 or more ANC visits, TT vaccination, full ANC increased in intervention area by 10.3%, 4.28%, 1.1% respectively; however, statistically insignificant. | ●●●● |
| 5 | Rudasingwa M et al. 2017 | Burundi | Quasi-experimental study | Unclear | Community | Postpartum women | 500 | TT | Performance based financing incentives to health providers for improving the quality and quantity of health services | PBF scheme in two provinces | Two provinces without PBF | No PBF effect on the number of ANC visits and TT immunization in the intervention group. | ●●●○ |
| 6 | Balakrishnan R et al. 2016 | India | Quasi-experimental study | Rural | Community | Pregnant women | 19880 | TT | mHealth Technology for frontline community health workers | Continuum of Care Services mHealth application for pregnancy registration, ANC, birth preparedness, delivery, post natal care, exclusive breastfeeding, immunization and complementary feeding and growth monitoring in one district of Bihar | Remaining districts of Bihar | Pregnant mothers received at least one TT vaccine 79.38% (58.90–80.26) compared to 74.12% in the same district the previous year and 80% in Bihar the same year. | ●●○○ |
| 7 | Falisse J-B et al. 2015 | Burundi | Quasi-experimental study | Rural & Urban | Healthcare/ hospital | Pregnant women | Unclear | TT | Performance based financing for health workers and removal of user fees for pregnant women | Performance based financing scheme rollout in 10 provinces before 2010 and removal of user fees for pregnant women | Provinces without PBF rollout before 2010 | Incentives to medical staff (PBF) was associated with an increase in TT vaccination (around +20% points, $p$ < .10). | ●●○○ |
| 8 | Lund S et al. 2014 | Tanzania | Cluster Randomized Controlled Trial | Rural & Urban | Healthcare/ Hospital | Pregnant women | 2550 | TT | Short messaging service (SMS) and mobile phone vouchers | Mobile phone text-message and voucher component | Standard care | 72% of women received 2 TT doses in intervention versus 56% in controls (OR, 1.62; 95% CI,0.81-3.26). Intervention significantly increased 4 ANC visits and there was a trend toward more receiving preventive health services, attending ANC late and antepartum complications identified. | ●●●● |
| 9 | Findley SE et al. 2013 | Nigeria | Quasi-experimental study | Rural | Community | Women who gave birth in past 5 years | Baseline: 2129 Follow-up: 2310 | TT | Integrated maternal, newborn and child health program and community-based activities | Integrated maternal, newborn and child health program (health system strengthening) and community-based activities (community volunteers training) | Areas without focused MNCH, clinical and community activities | TT vaccination increased from 69% to 85%, with increase equal in intervention and controls. The integrated approach built confidence in community. | ●●○○ |
| 10 | Findley SE et al. 2013 | Nigeria | Quasi-experimental study | Rural | Community | Women who gave birth in past 5 years | Year 2009: 6906, Year 2011: 2310 | TT | Community based service delivery (CBSD) program with community health workers and community volunteers for community education, mobilization, outreach, discussion groups, emergency systems | High intensity- community engagement with community-based service delivery through community health workers and community volunteers Low intensity-community engagement with community volunteers only | Areas with no community engagement activities | TT vaccination increased significantly from 69.2% to 84.6% and 87.6% in low and high intervention areas, verses increase to 81.1% in controls. Improvement in newborn and child care achieved from community dialogs. | ●●○○ |

(Continued)

**Table 2.** (Continued).

| S. No. | Author | Country | Study design | Study setting | Study set-up | Study population | Sample size | Vaccine | Strategy | Intervention | Control | Major finding | MMAT |
|--------|--------|---------|--------------|---------------|--------------|------------------|-------------|---------|----------|--------------|---------|---------------|------|
| 11 | Phillips E et al. 2017 | Haiti | Cross-sectional | Unclear | Healthcare/ hospital | Pregnant women | 997 | TT | Mobile clinic | Mobile clinic- Free pre and post-natal care in locations with limited access to health service at a predetermined place and time each month. Mother's clubs for behavior change communication, rally posts for growth monitoring and vaccination, and food aid distribution. | Fixed health center | TT vaccine and iron-folic acid supplements were more likely provided in mobile clinics than fixed clinics | ●●●○ |
| 12 | Frimpong JA et al. 2014 | Ghana | Retrospective cohort study | Rural | Both | Pregnant women | 1641 | TT | Health insurance and premium exemption | Health insurance and exemption to pay premiums | Health insurance and no premium exemption (women had to pay for services) | Health Insurance registration premium exemption did not had major impact on TT vaccination (aOR:1.1, 0.74-1.62). In CHCs, Health Insurance registrants were less likely (aOR:0.6, 0.37-0.96) to be vaccinated than non-registered clients. | ●○○ |
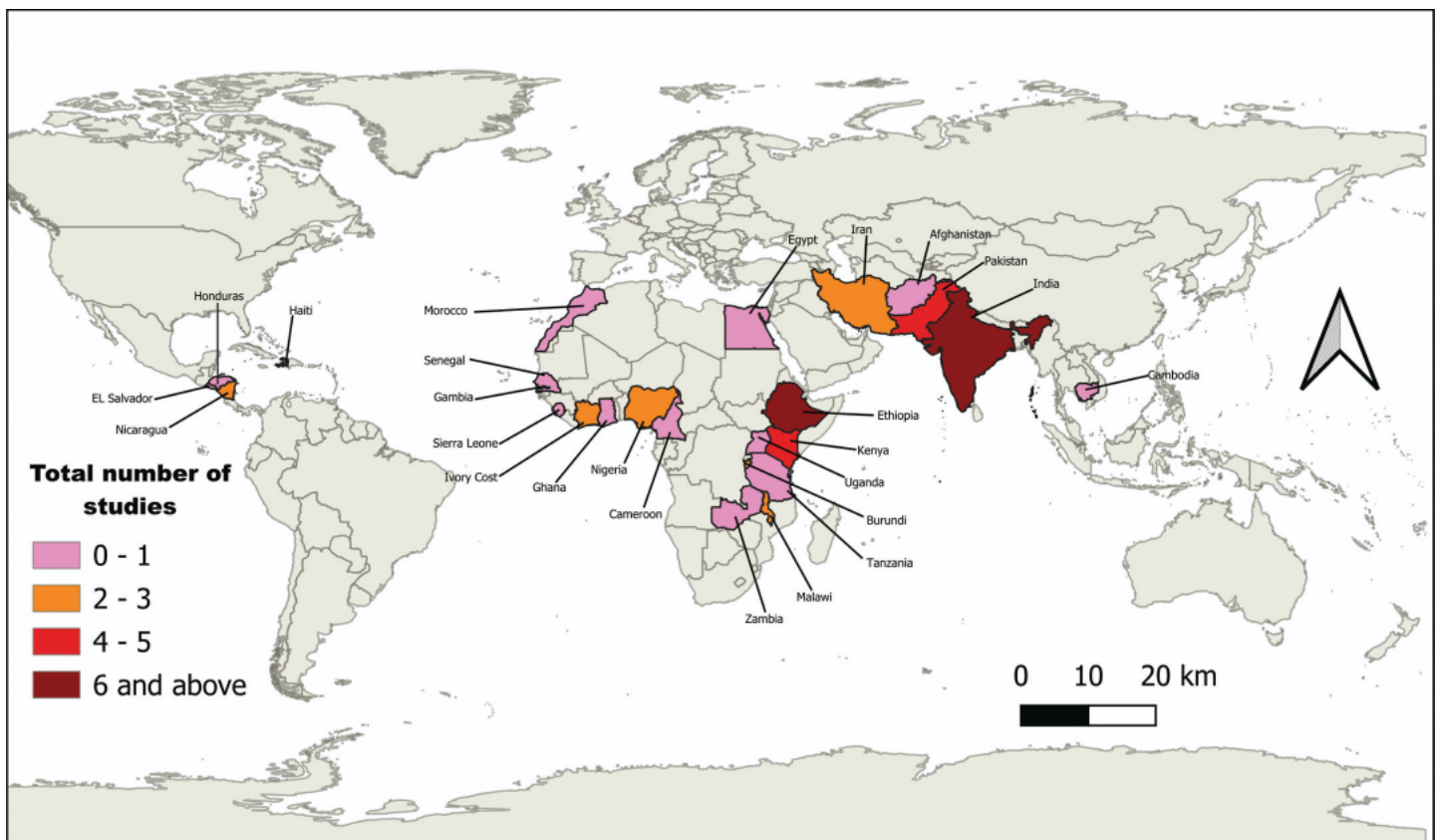
**Figure 2.** World map showing the distribution of study sites, *n* = 55.

review was to understand barriers and enablers to immunization. Even studies with a quality score below 3 out of 5, mostly from mixed-methods research, contributed valuable facilitators and barriers that would have otherwise been overlooked.

### Facilitators and barriers to maternal immunization

In all, 43 studies addressed facilitators or barriers to maternal vaccine uptake MI.[72–114] These included thirty-three quantitative,[72,73,75,77,80,81,83–86,88,91–94,96–103,105–114] six qualitative[74,76,78,79,90,95] and four with mixed-method approach.[82,87,89,104] The key facilitators and barriers were mapped into the five domains of the socio-ecological model: individual, interpersonal, health care system, community, and policy and described in Table 3 and Figure 3.

### Individual

*Socio-demographic.* The individual-level barriers for MI included maternal illiteracy or limited maternal education,[81,84,107,114] as well as maternal unemployment,[98] unwanted pregnancies,[99] and also lower wealth quintile.[81,98] Likewise, maternal education,[77,88,101,107] maternal employment,[98,100,111,114] planned pregnancies[88,99,105,107] and higher wealth quintile[83,98,103,111] were facilitators. Maternal age >30 years and parity showed mixed results.

*Awareness.* All study kinds viz., quantitative,[80,85,91,92,94,96,100,101,103,108,112,113] qualitative,[79,90,95] and, mixed-methods studies[87] identified the awareness about the disease and vaccine influenced vaccine uptake. Lack of vaccine awareness[79,85,90,92,94–96,108,112,113] and limited disease

awareness[87,90,95,101] hindered uptake. Conversely, awareness about the disease[80,91,92,101,103] and vaccine[92,94,100,103] facilitated uptake.

*Attitude.* Women were hesitant to take vaccines due to concerns about vaccine safety and side effects, as seen in many quantitative studies[75,85,105,109] and one qualitative study.[76] Two quantitative studies showed that those with no exposure to media had lower uptake.[98,105] A mixed-methods study revealed exposure to negative vaccine misinformation on media[89] had reduced uptake. Fear of needles was a barrier.[75] Seven quantitative studies and one qualitative study revealed enablers to uptake were beliefs in vaccine effectiveness,[80,85,91,92,95,103,109] vaccine safety,[80,91,92,103,109] recognizing disease susceptibility[92,112] and importance of vaccines.[91,103,109,112] Two qualitative and one quantitative study found overall positive attitudes[79,80,90] improved uptake. Three quantitative and one qualitative study identified information from mass media improved uptake.[83,91,95,105] Two qualitative studies observed that sensitization of mothers about disease and vaccines, and self-efficacy which refers to the person's confidence in making decisions,[127] facilitate vaccine uptake.[74,90]

*Location.* Vaccine uptake depends on where women are located and showed mixed results in different contexts and countries in four quantitative studies. In Ethiopia, women in urban areas had higher vaccination rates compared to rural areas[84,98]; whereas, in India rural areas had more coverage than in urban slums.[110] Similarly, rural women in Afghanistan had higher vaccination rates than urban women.[77]

**Table 3.** Key factors influencing maternal immunization in LICs and LMICs based on the socio-economic model.

| Themes |
| --- |

**1. Individual**

*Socio-demographics*

Barrier
- Maternal age >30 year[99,105]
- Lack/limited maternal education[81,84,107,114]
- Maternal unemployment[98]
- Multiparity[106]
- Unwanted pregnancy[99]
- Lower socioeconomic index[81,98]

Facilitator
- Maternal age >30 year[100,101,105,107]
- Maternal education[77,88,101,107]
- Maternal employment[98,100,111,114]
- Lower[106,111] or multiparity[83,84]
- Planned current/last[88,99,105,107] or future pregnancy[105]
- Higher socioeconomic index[83,98,103,111]

*Awareness*

Barrier
- Limited awareness about disease[87,90,95,101]
- Lack of knowledge about vaccine[79,85,90,92,94–97,108,112,113]

Facilitator
- Awareness of disease[80,91,92,101,103]
- Awareness about vaccine[92,94,100,103]

*Attitude*

Barrier
- Concern of side effects to mother or baby[75,76,85,105,109]
- Belief in pandemic conspiracy[95]
- Fear of risk of new vaccine[95]
- Fear of pregnancy[98]
- Fear of needles[75]
- Lack of prioritization of specific vaccines among health needs[87]
- Not exposed to mass media[98,105]
- Negative misinformation in social media[89]

Facilitators
- Positive perceptions towards vaccines[79,80,90]
- Belief in vaccine benefits[80,85,91,92,95,103,109]
- Belief in risk of disease[92,112], susceptibility to disease, need of vaccine[91,103,109,112]
- Belief in vaccine safety[80,91,92,103,109]
- Feeling of maternal authority over health care decisions[90]
- Sensitization of risk and benefits[74]
- Access to information from media[83,91,95,105]
- Past vaccination experience of mother[74,109] or children in household[75]
- Concurrent chronic disease[75,100]
- Iron uptake during preventive measures[101]
- Using modern family planning[107]

*Location*

Barrier
- Place of residence- rural[98], urban slum[110]

Facilitator
- Place of residence- urban[84], rural[77,110]

**2. Interpersonal**

Barrier
- Need for permission to attend services[89]

Facilitator
- Partner involvement in decision-making [74,76,90,107,109,111,114]
- Getting easy permission for medical care[77]
- Partner education[77,107]
- Parents-in-law[109] or family support[94,95]

**3. Health care system**

*Providers' recommendation*

Barrier
- Not receiving vaccine recommendation from HCP[93,114]
- Not receiving vaccine offer from HCP[75,93]
- Not receiving ANC from midwife[99]

Facilitator
- Vaccine recommendation by HCP[74,75,79,85,91–93,95,100,109,114]
- Offer of vaccine by HCP[92,102]

*Providers' knowledge and attitude*

Barrier
- Limited knowledge about maternal vaccines[89,94]
- Vaccine hesitancy for advising[89]
- Safety concerns[89]

Facilitator
- Knowledge about disease and vaccine[102]
- Vaccine confidence, knowledge about vaccine safety[87,102]
- Education and training of clinicians[79] and healthcare advisors[89]
- Health worker home visit[107]
- Good perceived behaviour of provider and quality of service[88]

*Access to Antenatal Care*

Barrier
- Not attending ANC[77,82,98,105]
- Late for first ANC[88,99]
- Low number (1-3) of ANC visits[81,98]

Facilitator
- Attending ANC[77,82,98,105]
- 4 or more ANC visits[82,83,88,93,98,99,105–107], 2 and more ANC visits[86]
- Timely ANC[88,99]
- Place of ANC [public /maternal and child health center[103,] govt and private[114], private[112]

*Access to health system*

Barrier
- Long distance travel[84], long waiting times for vaccinations[94], limited access in insecure areas[89]
- Location of health facility in hilly[72] and rural[77]areas

Facilitator
- Location of health facility in plain areas,[72] urban areas,[77] less time to reach facility[84]

*Logistics*

Barrier
- Inadequate vaccine supply, staff, cold chain and storage space[94]
- Impact of pandemic on vaccination services[73,95,104], vaccine supply issues[104], staff shortage[104]
- Identifying and tracking target population[87]

Facilitator
- Multiple vaccine delivery strategies[89]
- Ensuring operational capacity of health facility[87]

*Affordability*

Barrier
- Fees for ANC and MI[82]
- Transportation costs[115]

**4. Community**

Barrier
- Cultural restrictions[108], religious beliefs[76], pastoralist lifestyle[84]
- Lack of vaccine knowledge in community[90]
- High community literacy[98]
- Community rumors[89,90]

Facilitator
- Vaccine awareness and acceptance[87]
- Support of community leader[94], religious leaders[95]
- Community engagement[89], reminders[94]

**5. Policy**

Barrier
- Lack of political will and advocacy[78]
- Higher cost of vaccine[78]
- Insufficient disease burden data[78,87]
- Poor data on adverse events[87]
- Few immunization champion[78]

Facilitator
- Vaccine recommendation by the Government[80,91]
- Low cost of vaccine[78]
- Outreach[94]
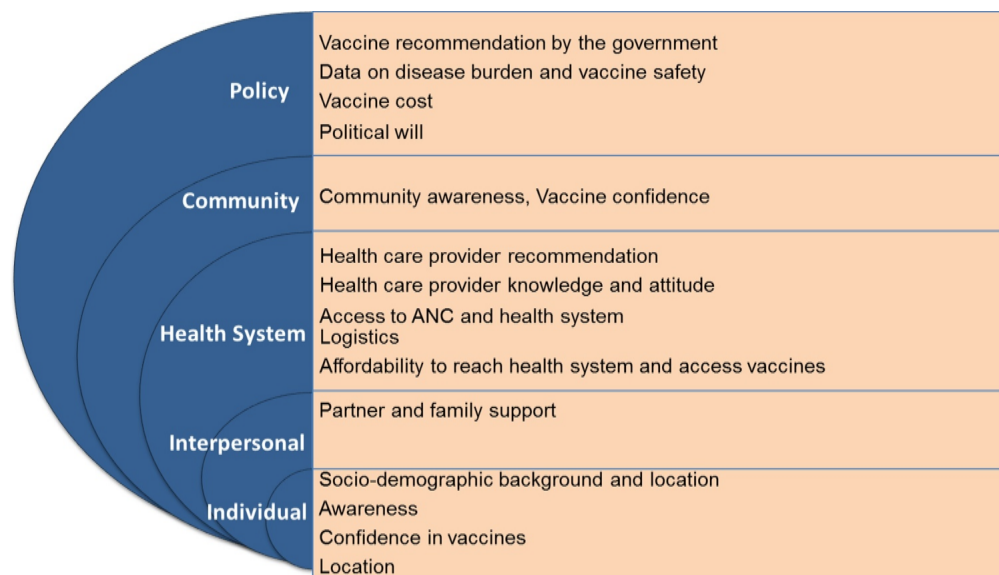- Existing strategy for maternal vaccine delivery[87]

**Figure 3.** Facilitators and barriers to maternal immunization in LICs and LMICs based on the socio-ecological model.

### Interpersonal

***Partner and family support.*** Vaccination decisions are influenced by families. In a mixed-methods study barriers in obtaining permission from their family to attend ANC hindered uptake.[89] Both qualitative and quantitative studies found the support by their partners, and involvement of partners in decision-making around vaccination facilitated uptake.[74,76,90,107,109,111,114] Likewise, education of partners,[77,107] support of family,[94,95] parents-in-law,[109] and getting permission to attend ANC were positively associated with uptake.[77]

### Health system

***Provider's recommendation.*** Five quantitative studies identified that those women who did not receive ANC from midwives,[99] or did not receive vaccine recommendation by their HCPs,[93,114] or vaccine offer from HCPs[75,93] were vaccine hesitant. While, both quantitative and qualitative studies identified vaccine recommendation by the HCPs[74,75,79,85,91–93,95,100,109,114] and the offer of vaccines by the HCPs[92,102] strongly facilitated uptake.

***Providers' knowledge and attitude.*** A mixed-methods and a quantitative study revealed the limited knowledge of HCPs about vaccines[89,94] and concerns about vaccine safety[89] were associated with hesitancy. Likewise, a mixed-methods and a quantitative study observed the providers' knowledge about the safety of vaccines,[87,102] the knowledge of the need, availability, and effectiveness of vaccines increased their confidence.[102] A qualitative study from India and a mixed-methods study from Elsalvdor observed that clinicians' education, training[79,89] facilitated vaccine uptake. While, a quantitative study found health worker home visits,[107] promoted uptake.

***Access to antenatal care.*** Multiple quantitative and one qualitative[82] study identified the association of vaccine uptake with access to ANC. Vaccine uptake was strongly associated with attendance at ANC,[77,82,98,105] especially ≥4 ANC visits,[82,83,88,93,98,99,105–107] and, timely ANC visits.[88,99] While the women who did not attend ANC[77,82,98,105] or were late to start ANC[88,99] or had <4 ANC visits[81,98] had reduced uptake.

***Access to health system.*** Women who faced barriers in accessing the health system had reduced vaccinations, noticed in quantitative[72,77,94] and mixed-methods studies.[89] This included health facilities in hills,[72] rural,[77] or insecure areas,[89] or those that required significant travel,[84] and long waiting times.[94] Facilities that were easy to access had enhanced uptake.[72,84]

***Logistics.*** Logistic barriers such as inadequate vaccine supply, insufficient storage space, and a shortage of manpower were identified in a quantitative study on district health officers and maternal and child health coordinators.[94] The COVID-19 and the H1N1pdm2009 influenza pandemics had a negative effect on MI services, seen in all three study kinds.[73,95,104] While multiple vaccine delivery strategies[89] improved uptake in a mixed-methods study.

***Affordability.*** Transportation costs[115] was found a barrier and so was paying fees to attend ANC and for vaccinations in a mixed-methods study.[82]

### Community

The community surrounding women also influence vaccination behaviors as identified by many qualitative and mixed-methods studies. For instance, limited vaccine knowledge,[90] or vaccine-related rumors,[89,90] within the community hindered uptake in a qualitative[90] and a mixed-methods[89] study. Cultural restrictions in rural Pakistan found in a quantitative study,[108] and, prohibitive religious beliefs in Pentecostal churches in rural Uganda found in a qualitative study hindered uptake.[76] Women from distant pastoralist communities in Ethiopia with reduced healthcare access faced barriers.[84] Whereas, two mixed-methods studies revealed the awareness

and vaccine confidence among the community,[87] and community engagement improved uptake.[89] One qualitative study observed the advice of religious leaders,[95] and, another quantitative study found support from community leaders as facilitators.[94]

### Policy

Studies that involved program managers, experts from program implementation, advocacy and district health officers were useful in identifying facilitators and barriers to policy.[78,87,94] A qualitative and a mixed-methods study identified barriers for MI policy such as insufficient disease burden data,[78,87] lack of political will and advocacy,[78] high vaccine costs,[78] and scant data on vaccine-associated adverse events.[87] Interestingly, the vaccine uptake increased with government recommendations,[80,91] and with outreach efforts.[94] Lower vaccine costs,[78] and existing delivery strategies[87] promoted uptake.

### Strategies improving the uptake of maternal immunization

The strategies that strengthen MI programs were addressed in 12 studies.[115–126] The key strategies are presented in Figure 4. Among the twelve studies, there was one randomized controlled trial,[115] one cluster randomized trial,[122] one retrospective cohort study,[126] eight quasi-experimental studies[116–121,123,124] and one cross-sectional study.[125] The majority of studies (11/12) focused on TT, and one on influenza. Overall six intervention types emerged: 1) health financing; 2) reminder systems; 3) intersectoral coordination; 4) community engagement; 5) capacity building; and 6) educational interventions.

### Health financing

Health financing strategies were examined in five studies: (i) conditional cash transfers (CCT) to pregnant women that link cash receipt to fulfillment of health-promoting conditions; (ii) performance-based financing incentives to HCPs and removal of user fees; and (iii) health insurance premium exemptions.[115,116,119,121,126] A randomized controlled trial from Nigeria showed that cash incentives to pregnant women were successful in increasing the uptake of TT than controls,[115] and marginally in India in a quasi-experimental study.[116] Performance-Based Financing (PBF), which involves providing financial incentives to HCPs for health care provision, aimed to modify their behavior, is widely implemented in African LMICs. Burundi rolled out PBF in 17 provinces, and, *removed user fees* for ANC for pregnant women. The impact of PBF on TT coverage was evaluated in two quasi-experimental studies: one showed 20% increase,[121] the other showed no effect.[119] A retrospective cohort study on health insurance premium exemption of rural women in Ghana had no major effect on vaccination coverage.[126]

### Reminder systems

Digital reminder systems were used in three studies including, mobile phone with short-message service (SMS) reminders for pregnant women[122] and mobile Health (mHealth) applications for community health workers assisting in pregnancy registration and tracking ANC.[118,120] Mobile health (mHealth), refers to the use of mobile devices to support health services such as data collection, delivery of health information, real-time monitoring, decision support and health care provision.[128] A cluster randomized trial on pregnant women in Tanzania



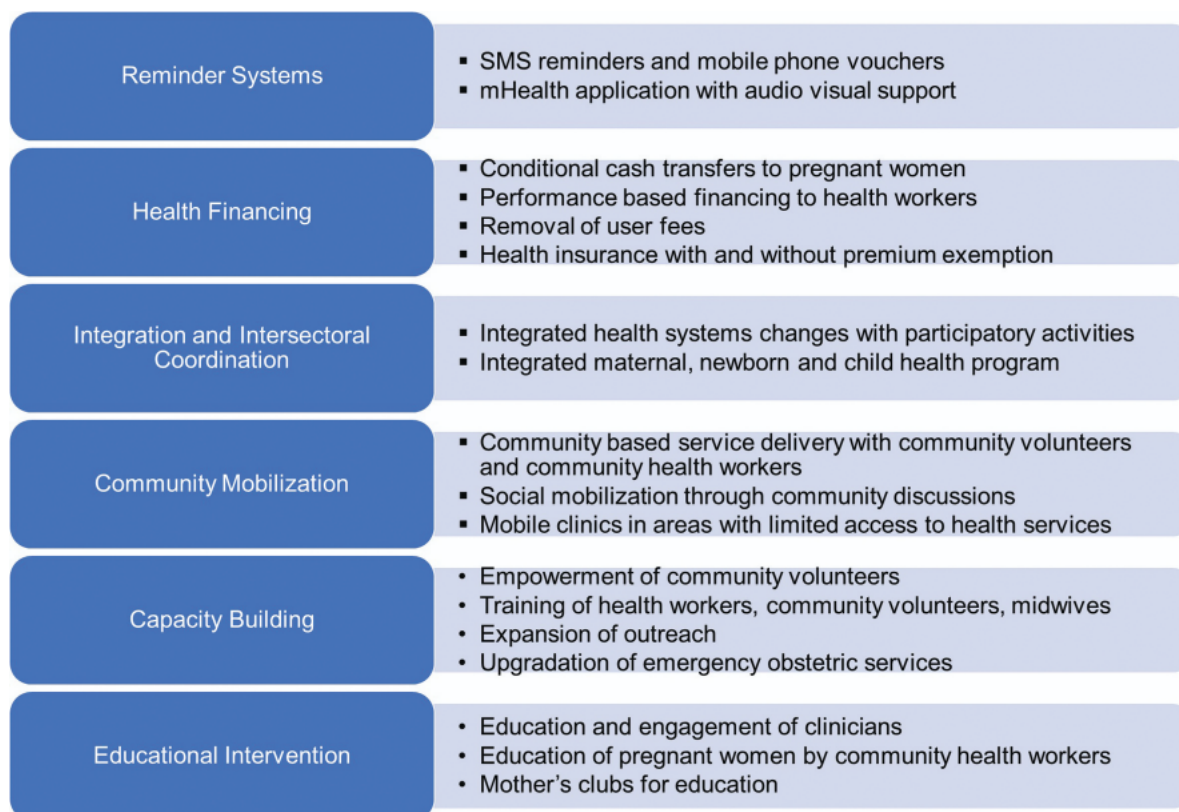| Reminder Systems | ▪ SMS reminders and mobile phone vouchers<br>▪ mHealth application with audio visual support |
|---|---|
| Health Financing | ▪ Conditional cash transfers to pregnant women<br>▪ Performance based financing to health workers<br>▪ Removal of user fees<br>▪ Health insurance with and without premium exemption |
| Integration and Intersectoral Coordination | ▪ Integrated health systems changes with participatory activities<br>▪ Integrated maternal, newborn and child health program |
| Community Mobilization | ▪ Community based service delivery with community volunteers and community health workers<br>▪ Social mobilization through community discussions<br>▪ Mobile clinics in areas with limited access to health services |
| Capacity Building | ▪ Empowerment of community volunteers<br>▪ Training of health workers, community volunteers, midwives<br>▪ Expansion of outreach<br>▪ Upgradation of emergency obstetric services |
| Educational Intervention | ▪ Education and engagement of clinicians<br>▪ Education of pregnant women by community health workers<br>▪ Mother's clubs for education |

**Figure 4.** Strategies that increase the uptake of vaccines among pregnant women in LICs and LMICs.

demonstrated that mobile phones with SMS reminders given to pregnant women increased ANC visits and tetanus toxoid vaccination rates as compared to the controls.[122] However, a mHealth application targeted to health workers from India did not show statistically significant improvement in uptake in two quasi-experimental studies.[118,120] In one of the Indian study, mHealth was used for pregnancy registration, real-time guidance, timely alert and tracking, while in another, it was used as a continuum of care for pregnancy, ANC, post-natal care and child health.

### Intersectoral coordination and integration

Improving service integration and intersectoral coordination were explored in a quasi-experimental study from Nigeria.[123] This involved system-wide changes integrating maternal, new-born, and child health (MNCH) programs through critical health systems changes to reinvigorate MNCH services, coordination of different components of primary care in one clinic and community-based activities. MNCH approach increased TT coverage (69% to 85%) in both the intervention and control groups.[123]

### Community engagement

A quasi-experimental study on community-based service delivery models improved immunization coverage in Nigeria.[124] This model involved community education, community mobilization by trained community volunteers assigned to each village for community dialogs, community health worker home visits and upgradation of emergency services of primary health facilities. The community volunteer mediated discussions, and, the combination of community volunteer mediated discussions and community health worker visits, increased uptake TT uptake (69.2% to 84.6% and 87.6%, respectively).[124] Another cross-sectional study used mobile clinics as a community-based delivery strategy in limited-access areas of Haiti for providing pre- and post-natal care such as distribution of supplements and TT, which were found marginally more effective than fixed clinics.[125]

### Capacity building

The capacity building efforts included the empowerment of community volunteers, training of health workers, training of volunteers, mid-wives and outreach expansion in studies from Nigeria.[123,124] These approaches along with integration and community engagement increased TT coverage.

### Education

A quasi-experimental study utilized the approach of sensitization and education of HCPs about influenza vaccine recommendations from global academic and medical organizations, and views of the community about influenza immunization in India. This strategy improved maternal influenza immunization practice.[117]

## Discussion

This systematic review was undertaken to present an analysis from LICs and LMICs identifying a range of facilitators and barriers for the uptake of maternal vaccines through the lens of the socio-ecological model. As well established and seen in this study, health decisions are not made in a vacuum. They rather reflect a complex interplay of individual, inter-personal, health system, community, and policy factors; which collectively influence the vaccination behaviors of women.[129] We found vaccination during pregnancy was driven by awareness among pregnant individuals about disease and vaccines, while concern about vaccine safety and lack of awareness were the common reasons for vaccine hesitancy.

The findings of this study resonate with other reviews and systematic reviews that emphasize maternal knowledge, attitudes, and beliefs as *key* factors influencing MI in LMICs.[48,59,60,130] Our findings are comparable to a meta-analysis on vaccine equity from LMICs that observed vaccine inequity in children of uneducated mothers and from low-income backgrounds.[131,132] Children whose mothers had no education had 28% less likelihood of being vaccinated compared to children whose mothers had primary level education.[131] Likewise, children from the lowest wealth quintile had 27% less likelihood of being fully vaccinated than the richest. Therefore, tailored educational programs are essential for improving awareness and health utilization of socio-economically disadvantaged populations in LMICs.[131]

Antenatal care visits provide an excellent platform for MI as it is a time period when women routinely access health system. Many studies highlight the association between ≥4 ANC visits and maternal vaccinations.[48,59] Access to health systems is another barrier in LMICs, particularly in remote locations. Therefore, strategies that improve access to health facilities and ANC, ensuring quality health care, in addition to providing vaccines at convenient locations are crucial,[33,133] for which, intersectoral coordination is essential. Additionally, the integrated MNCH program delivered as a continuum would serve to improve immunization and health outcomes for both mothers and their children.[82] In all these health decisions, engagement of partners and family decision-makers is crucial as women become more receptive when they receive encouragement from their families, especially their spouse. We have seen in our studies from West Bengal, India that the support of partner, as well as, HCP's recommendation facilitates vaccine uptake.[133]

The recommendations from HCPs strongly favor MI. In agreement, other reviews emphasized the importance of HCP's recommendation in driving uptake; the odds of receiving influenza or pertussis vaccines increased 10–12 fold in women receiving HCP's recommendation.[59,60] Consistent with our findings, another review from LMICs revealed vaccine hesitancy among HCPs for maternal influenza immunization owing to the nonexistence of government recommendation, the concerns on vaccine benefit and safety, and mistrust in manufacturers.[48] Therefore, periodic educational initiatives and advocacy efforts are needed about vaccine recommendations and building vaccine confidence in health care professionals, HCPs and policy makers.

Progress in maternal immunization has advanced both during and post COVID-19 pandemic. Pregnant women experienced higher morbidity and mortality from COVID-19,[134] leading to the approval of vaccines for emergency use. Vaccinations played a vital role in reducing hospitalizations

and deaths among infants and mothers.[22] However, the pandemic also triggered a global rise in vaccine hesitancy, especially among pregnant women, which was more pronounced than in the general population.[44,135] Similar to our findings, the primary concern of pregnant women, HCPs and decision makers, were centered on vaccine safety, fear of potential side effects on pregnancy, vaccine availability and a lack of awareness.[44] This hesitancy was mainly due to the exclusion of pregnant women from initial clinical trials contributing to knowledge gaps and uncertainty around vaccine recommendations and policies. On a positive note, the lessons from the COVID-19 pandemic prompted a shift, as evidenced by recent vaccine trials being conducted exclusively on pregnant women for RSV and GBS.[136] Maternal RSV vaccine recently received approval.[26,45,136] To improve vaccination coverage of RSV and other future maternal vaccines, targeted communication strategies would be required for improving awareness, building confidence, and for promoting maternal immunization programs.

This review identified multiple strategies that influence MI programs. The conditional cash transfers exhibited variable results in Nigeria and India, possibly due to varying study designs, conditions, and outcome estimations. The performance-based financing (PBF) scheme for HCPs also showed heterogeneous results. Notably, PBF demonstrated increase in child and maternal immunizations in Cameroon,[137] hence more research is warranted.

The recently identified strategies include digital reminders. From studies in Tanzania and India, we observed variable impact of mHealth. Although, a RCT from India (not retrieved in our search as it was not indexed in PubMed) showed improvements in vaccination.[138] Emerging evidence suggests that automated voice calls, SMS and artificial intelligence-based applications can improve digital communication for women and train health workers. India's mobile-based messaging (voice call) programs like *Kilkari* and *mMitra* are successful examples that provide health information to millions of women during pregnancy and infancy.[139] Similar programs have been scaled up in Bangladesh,[140] and South Africa.[141] Further, mobile-based audio training course like *Mobile Academy* in India serves to expand and refresh the knowledge of frontline health workers (Accredited Social Health Activists, ASHA) and improve their communication skills.[139] Additionally, leveraging the expansion of mobile phone penetration in LICs/LMICs, advocacy and awareness campaigns using easily understandable message through various mass media channels, including social media, and, involving influencers is important for addressing low knowledge, vaccine misinformation and disinformation.[59]

Each country has different health infrastructure capability, service delivery model and immunization structure. LICs and LMICs need overall health system strengthening to become robust and resilient. Our review suggests that strengthening MI programs may necessitate a multi-faceted approach, tailored to the need, context and geography. The MNTE status could be maintained by integrating MNCH programs, intersectoral coordination, reminders, and enhancing access to ANC and health systems. This includes validating MNTE status, supporting neonatal tetanus surveillance, organizing supplementary immunization activities and community engagement in low-performing regions.[33]

This study underscores the importance of improving the knowledge and confidence of pregnant women, their families and HCPs, as well as decision-makers to improve vaccine uptake. These findings show that clear guidelines and communication strategies would be needed to target pregnant women and HCPs that are context and culture-specific. Additionally, efforts to increase ANC access and behavioral studies engaging the primary beneficiaries (pregnant women) and HCPs to understand the barriers and facilitators they encounter, are crucial for the success of maternal immunization programs.

At the policy level, LMICs face many barriers to implement new vaccines. These arise from inadequate disease burden data, limited reporting and monitoring systems, programmatic suitability (cold chain management), vaccine cost, weak supply chains and restricted funding.[61] Influenza and Tdap vaccines are expensive and are manufactured in HICs. Influenza vaccines are reformulated twice per year, leading to issues of procurement, distribution and availability in LMICs.[50] Only 5% of the total distributed share of influenza vaccines reach the African, Middle Eastern and Southeast Asian regions, which account for 50% of the global population.[50] Further, influenza seasonality differs with the geography, impacting the availability and timing of vaccination. The COVID-19 pandemic also witnessed inequitable distribution of COVID-19 vaccines in LMICs.[142] Therefore, this requires a coordinated response from global and regional partners, international financing, timely regulatory approvals, changes in intellectual property rights, technology transfer, political prioritization and regional vaccine production so that vaccines are equitably accessible.[142] On a positive side, countries can leverage the existing maternal immunization systems for introducing new vaccines.

The study's strengths are its robust search strategy encompassing three databases, all country names, all study types, settings, and, a large number of articles reviewed, offering a comprehensive analysis. The inclusion of qualitative and mixed-methods studies revealed factors related to the attitudes, vaccination experiences, culture, family and community. The qualitative and mixed-methods studies provided insights relevant for the determinants of policy.[78,87] This review is pioneering in highlighting the determinants and strategies for strengthening MI in resource-limited nations, offering valuable insights for individual countries.

The study has limitations which reflect the nature of studies published at present. The barriers and facilitators are complex and vary with context. However, these findings provide useful insights into the development of interventions. The studies only represented 26 of 72 LICs/LMICs. The WPR, SEAR and the rest of African region were not fully represented. Studies from conflict-affected and refugee populations were lacking. The majority of studies focused on tetanus which limits their applicability for other vaccines such as influenza, pertussis and COVID-19, however, it suggests the commitment of LICs/LMICs toward MNTE. Limited studies were available on HCPs, and on strategies, which were mostly non-randomized, although those studies helped understand the utility of different strategies in low-income settings. The inclusion of only English language articles may have missed

regional language publications. Furthermore, studies conducted in the private sector might have been missed as well as those on COVID-19 vaccines after October 2021. Lastly, it is challenging to compare the effectiveness of one strategy with others due to heterogeneity in the nature of strategies and outcome measures.

Limited coverage of influenza and pertussis articles might be attributed to their exclusion from MI programs in LMICs. Knowledge gaps persist about the attitudes of HCPs, underscoring the need for further qualitative research. Conducting ethnographic research in hesitant communities and in young adults is crucial to identify the enablers for uptake.[59,143] Future research in different settings can demonstrate effectiveness of strategies in different populations, which can support transferability of findings. The effectiveness of innovative approaches successful in developed countries or in other populations should be investigated through high-quality research and cost–benefit analyses.[144]

To conclude, for improving maternal immunization tailored programs are required to improve access for pregnant women to ANC and health system in LICs and LMICs. Additionally, strategies to educate pregnant women, their providers and, involving partners during the immunization process are required for achieving universal coverage.

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## Disclosure statement

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## Notes on contributor

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## Author contributions

S Desai, SD Bhattacharya and T Khan conceived the study. T Khan drafted the search strategy, study protocol, prepared the screening forms and data extraction sheet with input from all authors. T Khan did the literature search. T Khan, S Malik, L Rafeekh and SD Bhattacharya performed the article screening. T Khan and S Malik extracted data and conducted quality assessment. T Khan synthesized the data and prepared the first draft of the manuscript. S Halder prepared the world map. All authors reviewed the manuscript and provided critical inputs. T Khan was involved in project administration, software management and coordination. SD Bhattacharya and S Desai provided guidance and supervision throughout the review process. We confirm that all authors had full access to all the data in the study, read, and approved the final manuscript, and had final responsibility for the decision to submit for publication.

## Data sharing

All data generated or analyzed during this study are included in this article and the appendix.

## Ethics committee approval

As a review of publicly available literature, ethics approval was not required

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