

SPECIAL ARTICLE

Vaccinations in pregnancy: An update for a changing time

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Abstract

Maternal immunization is one of the most effective public health interventions to reduce infectious morbidity and mortality in pregnant women, fetuses, and newborns. Despite robust evidence supporting vaccine safety and effectiveness in pregnancy, global uptake has declined following the COVID-19 pandemic, contributing to resurgent outbreaks of vaccine-preventable diseases. While national immunization schedules vary, there is broad international consensus recommending influenza and tetanus-diphtheria-acellular pertussis (Tdap) vaccination during pregnancy, with increasing adoption of maternal respiratory syncytial virus (RSV) immunization. This review provides an updated, globally relevant summary of recommended vaccines before, during, and after pregnancy, highlights vaccines under development, and discusses implementation challenges. Strengthening maternal immunization requires coordinated action across governments, healthcare systems, industry, and media to improve access, trust, and equity in vaccine delivery.

KEYWORDS

antenatal, immunization, perinatal, pregnancy, vaccination

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1 | INTRODUCTION

Vaccinations in pregnancy have been proven to reduce maternal, fetal, and neonatal morbidity and mortality from infectious diseases.^{1,2} It is estimated that 154 million deaths worldwide have been avoided since the introduction of routine vaccinations. Despite the wealth of research and literature to support the safety and efficacy of vaccines in pregnancy, immunization rates have continued to fall since the COVID-19 pandemic, leading to outbreaks of infectious diseases that can have negative impacts on pregnancy outcomes.^{3,4} The reduction in vaccination rates is multifactorial, including changes to immunization schedules and global funding, media misinformation, lack of access to appropriate vaccines, and public mistrust—all leading to vaccine hesitancy.⁴ These factors combined create a challenge for governments and healthcare providers to protect pregnant women and their babies. To improve vaccination rates, it is necessary for governments, industry, the media, healthcare workers, and community-based organizations to work together to educate and optimize access to and uptake of recommended vaccines to maximize the benefits of vaccinations. To assist healthcare providers, it is important that they have access to up-to-date and easy-to-use recommendations. It is also important to understand the rationale for each vaccine; in some cases it is to protect the mother from disease, in other cases it is a strategy of maternal vaccination for infant protection. This review aims to provide an update on the evidence and recommendations for vaccination in pregnancy and is designed for ease of use by healthcare providers globally, ensuring patients are provided with up-to-date recommendations for vaccination coverage throughout pregnancy, from planning to the postpartum period. It includes recommendations on the use of new vaccines and an update on vaccine development. [Box 1](#) highlights the importance of immunization during and pre-pregnancy.

2 | RECOMMENDED VACCINES BEFORE PREGNANCY

Optimization of maternal health and well-being should be viewed as a priority by governments and healthcare providers caring for those considering pregnancy. A discussion about vaccination and prevention of infectious disease should be included whenever patients present for prepregnancy care. The preventative opportunities

BOX 1 Why maternal immunization matters

Maternal immunization is a critical, evidence-based intervention that:

- Reduces maternal morbidity and mortality
- Protects the fetus and newborn through passive immunity
- Prevents outbreaks of vaccine-preventable diseases
- Contributes to health system strengthening and equity
- Key message: Every antenatal contact is an opportunity to vaccinate and educate

may be beneficial for mother, fetus, and newborn, or all three. Any health visit with a girl or woman of reproductive age should include a prepregnancy vaccination check in case of a subsequent intended or unintended pregnancy.

2.1 | Measles, mumps, and rubella

The measles, mumps, and rubella (MMR) vaccine is a live attenuated vaccine, usually provided as a course of two doses during childhood or adolescence. Rates of measles (rubeola), mumps, and rubella have fallen significantly since the introduction of the MMR vaccine, with the World Health Organization estimating that over 59 million deaths have been avoided since the introduction of the measles vaccine alone.⁵ Most outbreaks in high-income countries could previously be traced back to under-immunized individuals traveling to endemic countries. Unfortunately, with inadequate vaccination rates, cases of measles and rubella are increasing in low- and middle-income countries (LMICs) and in high-income countries where rates were previously low.⁶⁻⁹ Infection with rubella in pregnancy is teratogenic to the fetus, causing congenital rubella syndrome (cataracts, cardiac anomalies, and sensorineural deafness). Measles infection in pregnancy can increase the risk of severe complications such as pneumonia, requiring hospitalization and intensive care admission, and preterm birth.⁶ Prepregnancy education and serological testing offer clinicians the opportunity to vaccinate patients with waning immunity or those who have previously been under-immunized,

providing protection against these infectious diseases to both mother and baby.¹⁰ Where serological testing is not available, an individual is considered appropriately vaccinated if they have received at least two documented doses of a measles vaccine, at least 28 days apart, with the first dose given after 12 months of age and at least one dose of a rubella-containing vaccine at over 12 months of age. As this is a live attenuated vaccine, it is recommended to avoid vaccination in pregnancy, and that patients avoid conception for at least 28 days post vaccination. In the case of inadvertent vaccination in pregnancy, clinicians should be reassured that adverse effects are usually limited to pain or tenderness at the injection site, and that there have been no reported cases of congenital measles, mumps, or rubella syndrome definitively linked to the MMR vaccine; therefore, termination of pregnancy should not be recommended based on the risk of vaccination alone.¹¹

2.2 | Varicella

Varicella infection (commonly known as chickenpox) remains endemic globally,¹² with most individuals contracting the disease in childhood. Varicella infection in the first and early second trimester can result in congenital varicella syndrome (skin lesions, increased risk of limb hypoplasia, neurological and ocular anomalies). Infection in the third trimester is associated with an increased risk of maternal morbidity and mortality and neonatal varicella.¹³ While the majority of neonatal varicella infections are mild, mortality rates of up to 20% have been reported in infected infants born to women who developed varicella rash between 5 days before birth and 2 days postpartum.¹⁴

Vaccination and education about infection avoidance should be offered to all patients without a history of previous infection or serological evidence of prior vaccination. If exposure is encountered antenatally, and the patient is documented to be non-immune, immunoglobulin may be offered, if available. The most common varicella vaccines are live attenuated vaccines and may be combined with the MMR vaccine. As with the MMR vaccine, this vaccine is not recommended in pregnancy, and pregnancy is best avoided for 28 days post vaccination. No cases of congenital varicella or other congenital anomalies have been linked to varicella vaccination in pregnancy.¹⁵

2.3 | Hepatitis A, B, and E

Hepatitis A and B vaccines are available as individual or recombinant vaccines. Hepatitis A vaccination is routinely recommended for at-risk individuals as a two-dose course, either in childhood or before travel to endemic areas. Hepatitis B vaccination is recommended for all children as a four-dose course from birth or a three-dose course commencing 2 months after birth, and for at-risk adolescents and

adults as either a two- or three-dose course. The most common recombinant hepatitis A and B vaccines, and most hepatitis A vaccines, are inactivated vaccines, making them safe to use both before and during pregnancy.

Hepatitis A is endemic to many countries globally. Infection is generally mild or moderate and short lived; however, infection in pregnancy is associated with fetal ascites, polyhydramnios, and preterm delivery.^{16,17}

Hepatitis B has the potential to cause chronic disease, including hepatocellular carcinoma, and can result in vertical transmission during delivery and postpartum.^{18,19} Hepatitis A and B vaccination should be offered to all unvaccinated and serology-negative people before pregnancy or during pregnancy, in particular for those residing in or traveling to countries with high rates of hepatitis A and B. Education about risk minimization should also be provided to patients.

Hepatitis E occurs globally, mostly in fragile and conflict settings where water and sanitation are unsafe, or in the context of blood transfusions or vertical transmission. Pregnant people in the second and third trimester are at increased risk of fulminant hepatitis. Maternal mortality in the third trimester is 20%–25%. An effective vaccine has been developed and is licensed in China and Pakistan.²⁰ During outbreaks, in addition to safe water and hygiene measures, vaccination may be offered to pregnant people at significant risk of infection; however, long-term safety data have not been established for this emerging vaccine.²¹

2.4 | Tetanus

Tetanus infection can cause significant maternal and neonatal mortality and morbidity.^{22,23} Tetanus vaccination is now routinely recommended internationally, with regimes commencing in childhood and including boosters into adulthood.²⁴ Prepregnancy counseling should include a discussion about tetanus vaccination. Where supplies are limited, given the durability of tetanus antibody levels, those without clear evidence of a primary course with childhood and adolescent booster schedules (five-dose) may be prioritized for two-dose vaccination in pregnancy.^{25,26}

2.5 | Human papillomavirus

Human papilloma virus (HPV) infection remains highly prevalent, with oncogenic subtypes accounting for 70% of cervical cancers despite highly effective vaccines being available. Vaccine schedules vary based on patient age and immunocompetence, with one- and two-dose regimes most common. Women of childbearing age presenting for health care should be asked about their vaccination status. Those who are immunocompromised, have never been vaccinated, or have been under-vaccinated may be offered catch-up vaccination before or after pregnancy.²⁷

TABLE 1 Reduction in severe infectious disease since introduction of routine vaccination.

Disease	Disease-related complications per year (before vaccination introduction)	Disease-related complications per year (after vaccination)
Measles	2–3 million deaths worldwide/year	95 000 deaths (2024) worldwide ^{5,6,36}
Rubella	Congenital rubella syndrome 0.8–4.0/1000 live births	Congenital rubella syndrome 0.1/10000 live births (2024) ^{37–40}
Tetanus	Neonatal tetanus 787 000 (1988, globally)	27 000–32 000 (2019, globally) ^{3,22,23,41,42}
Pertussis	Pediatric deaths 15/100 000 (1990, globally)	Pediatric deaths 6/100 000 (2021, globally) ^{26,43,44}

2.6 | Other infectious diseases (yellow fever, dengue fever, malaria)

The individual risk of infectious diseases that have been proven to cause significant mortality and morbidity or have the potential to increase the risk of pregnancy complications, such as pre-eclampsia and fetal growth restriction, should be explored during prepregnancy consultations. In those deemed at increased risk of infection, vaccinations can be offered before pregnancy to reduce the risk of antenatal (prenatal) infection.

The yellow fever vaccine is a live attenuated vaccine that can be offered in pregnancy if there is a high risk of exposure. Data have not demonstrated adverse fetal or neonatal outcomes in those inadvertently vaccinated in pregnancy and termination of pregnancy due to inadvertent vaccination is not recommended.^{28,29}

There is currently only a single vaccine available for prevention of dengue fever: a live attenuated vaccine that is typically offered to children and adolescents in a three-dose course. There is a paucity of data on the impacts of dengue fever on pregnant patients; however, available studies report a possible increase in preterm birth, low birth weight, and severe maternal disease.³⁰ Pregnant patients should be educated on risk management strategies and those traveling in late pregnancy are advised to avoid endemic areas. Aedes mosquitoes are predominantly daytime biters and daytime bite prevention education is advised.

Malaria is a potentially life-threatening disease caused by parasitic infection, spread by night-biting anopheline mosquitoes. Education on vector control, bite avoidance, and bed net use should be emphasized as insecticide-treated bed nets have contributed to a decline in malaria rates.³¹ Two vaccines against malaria are currently recommended for children in malaria endemic regions. These vaccines are viral-like particle vaccines and require a prolonged course of 4–5 injections in childhood.^{32–34} While these vaccines have demonstrated efficacy and safety in children, a vaccine for adults, particularly those that are pregnant or planning pregnancy, has yet to be developed. Malaria infection in pregnancy appears to be associated with adverse neonatal outcomes. Placental studies from endemic regions have shown that malaria infection in early pregnancy may impact placental vascularization, increasing the risk of pre-eclampsia, and infection later in pregnancy may be associated with fetal growth restriction, preterm birth, and stillbirth due to placental infection and damage.³⁵ Current recommendations for patients during pregnancy or prepregnancy include education on infection avoidance, intermittent administration of sulfadoxine-pyrimethamine to those at high

BOX 2 Timing of maternal vaccination

Optimal timing depends on purpose:

- Maternal protection
 - Can be given any time in pregnancy (e.g., influenza, COVID-19, hepatitis)
- Neonatal protection (via antibody transfer):
 - Best in second or third trimester (e.g., Tdap, RSV)
- Key principle:
 - Maximize both maternal immunity and transplacental antibody transfer

risk of malaria infection, and the use of chemoprophylaxis to those intending to visit endemic areas.

Table 1 outlines the reduction in disease-related complications for measles, rubella, tetanus, and pertussis since the introduction of routine vaccination.

3 | RECOMMENDED VACCINATIONS IN PREGNANCY

In many cases, pregnancy is the only time younger patients will present for regular healthcare reviews. As such, governments and those working in health care should take this opportunity to provide education and vaccinations to improve pregnancy outcomes and maximize the benefits of mass immunization programs.

Most vaccinations that rely on the transfer of antibodies across the placenta for fetal and neonatal protection should be given in the second or third trimester. Generally, live vaccines are not recommended during pregnancy; however, individual risks should be assessed and these vaccines may be offered in specific circumstances after a discussion of the risks and benefits of vaccination has occurred. Patients should be informed that recommendations to avoid live vaccines in pregnancy are based on theoretical risk, and adverse outcomes have not been demonstrated in postmarketing surveillance.^{28,45} Patients who have been inadvertently administered a live vaccine in pregnancy should be reassured and should not be offered interruption of pregnancy based on this factor alone. Box 2 highlights timing considerations for maternal vaccinations during pregnancy.

3.1 | Inactivated influenza

Influenza infection in pregnancy, particularly in the third trimester, has been demonstrated to increase the risk of severe maternal morbidity and mortality.^{46,47} Due to the increased risk to pregnant patients, the quadrivalent inactivated influenza vaccine is universally recommended and should be considered for those planning pregnancy or deemed at high risk, to reduce the risk of severe morbidity and mortality during the respiratory season. The inactivated influenza vaccine (particularly the quadrivalent influenza vaccine) should be administered in every pregnancy, at any time in pregnancy, to reduce the risk of maternal morbidity and mortality. Influenza vaccination in pregnancy reduces the risk of maternal influenza infection by approximately 50% and the risk of influenza infection in the newborn by around 45%⁴⁸ and has extensive safety data.⁴⁹ It is recommended that this vaccine is administered in each pregnancy, as the quadrivalent vaccine is updated annually to reflect current strains.

3.2 | COVID-19

Severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) infection can result in significant maternal morbidity and mortality. Evidence gained from the recent pandemic demonstrated increased risk of mortality and significant morbidity in pregnant women with COVID-19 disease⁵⁰ (acknowledging that current variants are less virulent than previous strains).

There is extensive evidence for the safety and efficacy of COVID-19 vaccination in pregnancy, with evidence that it reduces the risk of infection, maternal severity of infection, and preterm birth and neonatal infection.^{51,52} The World Health Organization recommends that never vaccinated people receive one dose of a COVID-19 vaccine during pregnancy and pregnant women receive a booster dose each pregnancy.⁵²

3.3 | Cholera

Cholera remains endemic in LMICs and remains a cause of significant morbidity and mortality internationally. While the introduction of oral rehydration solutions and education protocols on risk reduction has reduced the mortality rate, infection in pregnancy has been demonstrated to increase the risk of intrauterine fetal death, with rates reported as high as 8% in LMICs in pregnant women with severe infection in the third trimester.⁵³

A number of subunit and recombinant oral cholera vaccines have been assessed for use in pregnant women and are recommended for administration at any time in pregnancy to those residing in endemic areas or during cholera outbreaks. These vaccines have demonstrated safety and efficacy with no increased fetal or neonatal risk.⁵³

3.4 | Respiratory syncytial virus

Respiratory syncytial virus (RSV) is the most common cause of neonatal intensive care and hospital admission for neonates in high-income settings and has a significant health burden internationally, with over 33 million cases reported annually in children under 5 years of age. A recombinant viral-like protein RSV vaccine has been approved internationally for use in pregnant patients.^{54,55} Administration of the RSV vaccine in the second or third trimester (ideally at least 2 weeks prior to delivery) has been demonstrated to be safe and efficacious, reducing the risk of neonatal RSV infection by 50% and reducing the risk of severe RSV infection by 64%.^{54,56} Administration timing varies internationally; however, safety and efficacy have been demonstrated from the beginning of the third trimester, with recommended administration by 36 weeks to maximize placental antibody transfer. Maternal RSV vaccination has been approved in multiple jurisdictions following phase 3 trials demonstrating reduced infant RSV-associated lower respiratory tract disease and severe infection. There are some concerns of pregnancy-related complications among women who received RSV vaccination, including hypertensive disorders of pregnancy, premature rupture of membranes (PROM) and preterm, premature rupture of membranes (PPROM).⁵⁷ However, the evidence base is not sufficiently robust and the biological mechanisms are limited. Therefore, the recommendation remains to advocate for RSV vaccination in pregnancy as access to infant RSV monoclonal antibody may be limited. Administration in the third trimester optimizes transplacental antibody transfer. Implementation strategies must consider cost-effectiveness, equity, and integration into routine antenatal schedules. In cases where patients do not receive the RSV vaccine during pregnancy, the neonate may be given the monoclonal antibody nirsevimab to prevent RSV disease, where available.⁵⁸

3.5 | Diphtheria, tetanus, acellular pertussis (Tdap) vaccine

Maternal Tdap immunization is a critical intervention to prevent neonatal tetanus in LMICs and infant pertussis globally. In LMICs, maternal and neonatal tetanus infection remains a significant cause of morbidity and mortality in mothers who are not vaccinated or under-vaccinated and their newborns. Neonatal tetanus is vaccine preventable and has been eradicated from many regions, however it remains prevalent in a number of low-income countries where access to medical care or vaccinations is limited, and can result in neonatal death.⁴¹ While those patients who have access to early medical treatment can recover, the majority of infections occur in settings where access to high-level medical treatments is limited or delayed. The introduction of antenatal tetanus vaccination has reduced worldwide neonatal deaths attributable to neonatal tetanus by 92%.²³ Tetanus toxoid vaccines are available internationally as

TABLE 2 Timing of vaccinations in pregnancy.

Vaccine type	Vaccine	Timing of administration		
		Prepregnancy	First trimester	Second and third trimester
Inactivated	Influenza	✓	✓	✓
	Hepatitis A, B	✓	✓	✓
mRNA/protein subunit	COVID	✓	✓	✓
Live attenuated	MMR	✓	X	X
	Varicella	✓	X	X
	Yellow fever	✓	In select circumstances ^a	
Subunit vaccines	Tetanus	✓		✓ (2 doses in pregnancy if no prior vaccination history)
	Pertussis (Tdap)	✓	X	✓
	RSV	In select circumstances ^b	X	✓

Abbreviations: MMR, measles, mumps, rubella; RSV, respiratory syncytial virus.

^aIn those unable to avoid travel to endemic areas.

^bIn those deemed high risk by local guidelines (i.e., those with chronic disease).

combination vaccines and are universally recommended in every pregnancy for antenatal administration.

Pertussis remains a significant cause of neonatal morbidity and mortality globally.²⁶ Administration of the acellular pertussis vaccine during the second or third trimester (ideally at least 2 weeks prior to delivery) reduces the risk of neonatal infection by 77%.²⁶ Healthcare providers may also wish to use antenatal appointments to educate family members on vaccination to maximize the “cocoon” effect of pertussis vaccination.

Diphtheria is a potentially fatal infectious disease, caused by *Corynebacterium diphtheriae*. While it is vaccine preventable, it remains endemic in some LMICs.⁵⁹ Infections occur most frequently in children and adolescents; however, inadequate vaccination rates have resulted in increasing cases in pregnant women. The diphtheria toxoid vaccine is available as a single or combination vaccine and is included in many childhood vaccination schedules.

The combined diphtheria, tetanus, and acellular pertussis vaccine is universally recommended for administration in the second and third trimester as a single dose in each pregnancy.

Table 2 outlines the recommended timing of vaccines before pregnancy and during pregnancy.

4 | VACCINES UNDER DEVELOPMENT

Traditionally, women have been under-represented in clinical trials for vaccines and medications, resulting in a paucity of data on medication safety and efficacy for those with the capacity to conceive and those who are pregnant.⁶⁰ The increased morbidity and mortality of infectious diseases in pregnant women, fetuses, and neonates has demonstrated a need to include women and pregnant women in medical research. The need for development of pregnancy-specific vaccines, such as a vaccine for Group B Streptococcus,

requires clinical trials to include these individuals to ensure safety and efficacy. While the inclusion of pregnant women in clinical trials is not yet standard practice, development of the following vaccines is underway. This highlights the need for inclusion of women and pregnant women in medical research.

4.1 | Group B streptococcus vaccine

Group B streptococcus (GBS) is a known cause of early neonatal sepsis and is implicated in maternal infection, stillbirth, and preterm birth.⁶¹ Each year, GBS infection affects an estimated 390 000 infants, and is the leading cause worldwide of acute bacterial meningitis in newborns. Globally, GBS causes more than 500 000 premature births, and roughly 150 000 stillbirths and infant deaths each year.

Universal screening and treatment with antibiotics intrapartum has been demonstrated to reduce the risk of early-onset neonatal disease but has not demonstrated a reduction in risk of late-onset infection. Universal screening has not been demonstrated to be financially viable in some countries, and in countries where health economic considerations preclude it a risk-based approach is used instead. A number of GBS vaccines are currently in development, however most are yet to progress beyond Phase 2 trials. A hexavalent GBS vaccine is currently being developed to reduce the rates of early- and late-onset neonatal GBS infection and has recently undergone Phase 2B trials, demonstrating safety and tolerability, and is currently undergoing Phase 3 trial.⁶² At this time, the vaccine is not commercially available and is not recommended for routine use. Modeling suggests vaccination could prevent more than 50% of infant GBS cases and may also reduce the risk of preterm birth and stillbirth. While exact timelines are still uncertain, WHO anticipates that the first maternal GBS vaccines may become available by 2030.⁶³

BOX 3 Research and inclusion of pregnant women

- Pregnant women are historically excluded from clinical trials
- This leads to delayed access to life-saving vaccines
- Ethical inclusion of pregnant women in research is essential
- Accelerate development of pregnancy-specific vaccines (e.g., GBS, CMV)

BOX 4 FIGO recommends

- Strengthening communication and community engagement on the benefits of vaccination in pregnancy
- Integrating vaccination into routine antenatal care and leveraging midwives and frontline maternity healthcare providers to implement vaccination programs
- Ensuring equitable vaccine access globally

4.2 | Cytomegalovirus

Cytomegalovirus (CMV) infection during pregnancy is one of the leading causes of sensorineural deafness and blindness in children. While upward of 50% of people of childbearing age have serological evidence of past infection, the remainder of patients are at risk of primary infection during pregnancy. CMV infection is common among those working in caring industries or with young children. Multiple CMV vaccines have undergone Phase 1 and Phase 2 trials.^{64,65} An mRNA CMV vaccine has recently undergone Phase 3 trials in healthy females, demonstrating an adequate safety profile, however, the efficacy in preventing CMV infection was less than expected and pregnant women and those planning pregnancy were excluded from this trial.⁶⁵ Current recommendations are that all pregnant women should be educated on risk reduction strategies such as maintaining good hand hygiene.

Box 3 highlights the importance of including pregnant women in research.

5 | IMPLEMENTATION AND EQUITY

The implementation of vaccination recommendations requires coordination between governments, healthcare providers, and industry to overcome several challenges, including supply chain difficulties, cold-chain storage, cost barriers, and healthcare access. Opportunities to address some of these issues include utilizing routine antenatal care visits to optimize overall patient health

and well-being, including using the appointments as a vaccination delivery platform, and providing education about risk minimization strategies. To facilitate this, training and education of medical staff and midwives is required to ensure that patients receive up-to-date education and counseling. Involvement of midwives in vaccination counseling and administration also provides further avenues to address misinformation and ensures that people receiving midwifery-led care are provided with the opportunity to receive recommended vaccines. Box 4 highlights the FIGO recommendations to improve vaccination access and equity for pregnant women.

6 | CONCLUSION

Vaccines in pregnancy have many benefits to pregnant patients, fetuses, neonates, and the community, including the prevention of severe maternal disease, fetal and neonatal infection, and prevention of poor neonatal outcomes. The safety of vaccinations in pregnancy is also well established, and patients should be informed of recommendations to vaccinate and the associated benefits to themselves and their families. To ensure future vaccines and medications are safe and effective for pregnant women, researchers need to include women and pregnant women in clinical trials. Through joint action of governments, the media, healthcare workers, and community-based organizations, we can improve maternal and fetal well-being and pregnancy outcomes by maximizing vaccination rates.

AUTHOR CONTRIBUTIONS

All authors were involved in producing this updated statement from the FIGO Committee on Infections During Pregnancy. All authors contributed to the structure, drafting, and analysis of data included in this article, reviewed and provided feedback on draft versions of the article, and approved the final version.

ACKNOWLEDGMENTS

We thank Friday Saidi, Fernando Abarzua, Hannah Motshedi Sebiloane, Alexandre Vivanti, Nelson Yesid Aguilar Jamimes, Isabella Boucoiran, Amy Wise, Ratana Komwilaisak, Lavinia Iftene-Exbrayat, and Stephen Rusila, all of whom are members of the FIGO Committee on Infections During Pregnancy and provided expert review of this update. Open access publishing facilitated by The University of Sydney, as part of the Wiley - The University of Sydney agreement via the Council of Australasian University Librarians.

FUNDING INFORMATION

The authors of this statement did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST STATEMENT

Deborah Money has received compensation from Merck for an investigator-driven study for an HPV vaccine in women with HIV and

has been involved with Pfizer for a GBS vaccine in pregnancy study. No other conflicts of interest have been disclosed.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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How to cite this article: Hodge W, Bhuiñeáin M, Goba G, et al. Vaccinations in pregnancy: An update for a changing time. *Int J Gynecol Obstet.* 2026;00:1-9. doi:[10.1002/ijgo.71273](https://doi.org/10.1002/ijgo.71273)