COVID-19 VACCINE, MRNA (PFIZER-BIONTECH) (2025-2026 FORMULA)

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On January 5, 2026, the US Department of Health and Human Services (HHS) announced the approval of a revised US childhood and adolescent immunization schedule ([Web]). Under the revised recommendations, CDC continues to organize the childhood immunization schedule in three distinct categories (Immunizations Recommended for All Children, Immunizations Recommended for Certain High-Risk Groups or Populations, and Immunizations Based on Shared Clinical Decision-Making) but changes individual vaccine placement within those categories. For additional information, see [Web] .

Introduction

COVID-19 vaccine (Pfizer-BioNTech) is a nucleoside-modified mRNA (modRNA) vaccine used to stimulate active immunity to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1,]

Uses

■ Prevention of Coronavirus Disease 2019 (COVID-19)

COVID-19 vaccine, mRNA (Pfizer-BioNTech) is used for active immunization to prevent coronavirus disease 2019 (COVID-19) caused by SARS-CoV-2.[1,] COVID-19 vaccine, mRNA (Pfizer-BioNTech) (Comirnaty® 2025-2026 Formula) is FDA-labeled for use in individuals 65 years of age and older, or in individuals 5 through 64 years of age with at least one underlying condition that puts them at high risk for severe outcomes from COVID-19.[1,] Underlying conditions for which there is evidence indicating a higher risk of experiencing severe outcomes of COVID-19 include asthma, cancer, cerebrovascular disease, chronic kidney disease, certain chronic lung diseases, certain chronic liver diseases, cystic fibrosis, diabetes mellitus, disabilities, heart conditions, HIV, certain mental health conditions, certain neurologic conditions, obesity, physical inactivity, pregnancy or recent pregnancy, primary immunodeficiencies, smoking (current or former), solid organ or blood stem cell transplantation, tuberculosis, and use of corticosteroids (or other immunosuppressive medications).[76,]

COVID-19 vaccine, mRNA (Pfizer-BioNTech) was previously available under an emergency use authorization (EUA).[2,] The initial EUA was issued on December 11, 2020 during the COVID-19 pandemic and amended several times as the scope of authorization changed, the most recent of which was issued on August 22, 2024 for use in individuals 6 months through 11 years of age. However, on August 27, 2025, FDA revoked the EUA for COVID-19 vaccine, mRNA (Pfizer-BioNTech).[70,]

The current COVID-19 vaccine, mRNA (Pfizer-BioNTech) has been specifically formulated for the 2025-2026 season and contains nucleoside modified mRNA encoding the viral spike glycoprotein of SARS-CoV-2 Omicron variant sublineage LP.8.1 (a variant of the JN.1 family of Omicron subvariants).[1,3,] Previous vaccine presentations, including the initial monovalent formulation (Original strain) and subsequent monovalent and bivalent formulations are no longer available for use in the US.[2,] FDA approval for the current COVID-19 vaccine, mRNA (Pfizer-BioNTech) (2025-2026 Formula) is principally based on data from previous vaccine presentations.[1,]

The US Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP) has issued recommendations and clinical considerations for the use of COVID-19 vaccines, including dosage and administration, specific populations and situations, and cautionary information.[13,] CDC currently recommends COVID-19 vaccination based on a shared decision-making process between the healthcare provider and the patient or parent/guardian.[80,81,82,83,84,] The decision to administer a COVID-

19 vaccine should be individualized with consideration that the risk-benefit of vaccination is most favorable for individuals who are at increased risk for severe COVID-19 disease and lowest for those who are not at increased risk.[81,83] There are 2 types of COVID-19 vaccines available in the US (mRNA vaccines and a protein subunit vaccine).[13] An age-appropriate COVID-19 vaccine product should be administered for each dose.[81,83] ACIP states that there is no preferential recommendation for the use of any one COVID-19 vaccine over another when more than one recommended and age-appropriate vaccine is available.[13] For additional information, consult the ACIP recommendations at [Web]

The American Academy of Pediatrics (AAP) recommends COVID-19 vaccination in all infants and children 6 through 23 months of age; 1 or 2 doses of any age-appropriate COVID-19 vaccine product (the most updated version) should be administered depending on previous vaccination status.[78,79] In older children and adolescents 2-18 years of age, a single dose of COVID-19 vaccine is recommended in risk groups (e.g., persons at high risk of severe COVID-19, residents of long-term care facilities or other congregate settings, persons who have never been vaccinated against COVID-19, persons whose household contacts are at high risk for severe COVID-19).[78,79] Children 6 months through 18 years of age who are moderately or severely immunocompromised require 2 or more doses of age-appropriate COVID-19 vaccine depending on previous vaccination status.[78,79] AAP states that children 2-18 years of age not included in specified risk groups whose parent or guardian desires their protection from COVID-19 should be offered a single dose of an age-appropriate 2025-2026 COVID-19 vaccine.[78,79]

The American College of Obstetricians and Gynecologists (ACOG) provides recommendations for the use of COVID-19 vaccines in individuals who are pregnant (or may become pregnant) or lactating.[16] ACOG currently recommends that all pregnant and lactating individuals receive the seasonally updated COVID-19 vaccine booster at any time during pregnancy; the available data support the benefits of vaccination in reducing pregnancy complications and reducing neonatal morbidity and mortality.[16] Pregnant individuals have historically been at increased risk of severe disease, adverse pregnancy outcomes, and maternal death from COVID-19 infection.[16] Additionally, vaccination during pregnancy provides passive immunity to infants, protecting them from COVID-19 in the first few months of life before they can be vaccinated.[16] ACOG states that any of the currently authorized COVID-19 vaccines can be administered to pregnant, recently pregnant, or lactating patients.[16]

The Center for Infectious Disease Research and Policy (CIDRAP) has established the Vaccine Integrity Project to provide evidence-based guidance on vaccines.[77] The Vaccine Integrity Project is an initiative dedicated to providing trusted, science-based information for informed vaccine choices.[77] A multi-disciplinary group of experts was convened by the Vaccine Integrity Project to independently review the available data on vaccine efficacy, effectiveness, and safety of COVID-19, influenza, and RSV immunizations for the 2025-2026 respiratory virus season.[77] A systematic review of 511 published studies (mostly observational) was conducted.[19] Results of the evidence review found that COVID-19 mRNA vaccination against the XBB.1.5 subvariant, a previously circulating variant, was associated with pooled vaccine effectiveness against hospitalization of 46-50% in all adults and 37% in immunocompromised adults.[3,19] In a case-control study in children 5 to 17 years of age, Pfizer-BioNTech COVID-19 vaccination against the XBB.1.5 subvariant was associated with vaccine effectiveness of 65% against hospitalization or a visit to an emergency department/urgent care facility.[19] Effectiveness varied based on time since vaccination, study population, and vaccine formulation.[19] Decreased vaccine effectiveness against XBB.1.5-adapted vaccines was observed when another subvariant (JN.1) was predominant.[19] Studies combining data from both the mRNA and protein-based vaccines generally reported lower vaccine effectiveness than studies evaluating mRNA vaccines alone.[19] The evidence was generally more limited with the protein subunit COVID-19 vaccine.[19] For additional information see, [Web] .

Clinical Experience

Clinical experience with the Pfizer-BioNTech COVID-19 vaccine is based principally on studies evaluating the effectiveness, immunogenicity, and safety of the vaccine using the Original monovalent or the Original and Omicron BA.1 formulations.[2,59,68] These formulations are no longer approved or authorized for use in the US; the following sections provide some historic data.[2]

Efficacy and safety of COVID-19 vaccine, mRNA (Pfizer-BioNTech) (original strain monovalent formulation) for the prevention of COVID-19 have been evaluated principally in a multinational, randomized, double-blind, placebo-controlled, phase 1/2/3 trial (NCT04368728) using the monovalent form of the vaccine.[1,6,7,52] Healthy individuals and those with stable chronic disease (i.e., disease not requiring significant change in therapy or hospitalization for worsening disease during the 6 weeks before enrollment), including but not limited to human immunodeficiency virus (HIV), hepatitis C virus (HCV), or hepatitis B virus (HBV) infection, were included in this study; individuals who had immunocompromising diseases or were receiving immunosuppressive therapy and those with a previous clinical or microbiologic diagnosis of COVID-19 were excluded.[1,7]

Adults and Adolescents 12 Years of Age and Older

Safety and efficacy of the original formulation of the Pfizer-BioNTech COVID-19 vaccine for prevention of COVID-19 in individuals ≥12 years of age as a 2-dose vaccination series were established based on review of data accrued through March 13, 2021 from the ongoing phase 1/2/3 clinical trial.[1,68]

The population for analysis of the protocol pre-specified primary efficacy end point included 36,621 participants ≥12 years of age (18,242 in the vaccine group and 18,379 in the placebo group) who had no evidence of prior infection with SARS-CoV-2 through 7 days after the second dose.[1] This included all participants ≥12 years of age who had been enrolled from July 27, 2020 and followed for the development of COVID-19 through November 14, 2020 (enrollment for those 18–55 years of age and ≥56 years of age began July 27, 2020, enrollment for those 16–17 years of age began September 16, 2020, and enrollment for those 12–15 years of age began October 15, 2020).[1] For participants without evidence of SARS-CoV-2 infection prior to 7 days after dose 2, vaccine efficacy of the initial, original strain formulation against confirmed COVID-19 occurring at least 7 days after dose 2 was 95%, which met the pre-specified success criterion.[1] There were 8 cases of COVID-19 in the vaccine group compared with 162 cases in the placebo group.[1]

The population for the updated vaccine efficacy analysis performed for the BLA approval included participants ≥16 years of age who had been enrolled from July 27, 2020 and followed for the development of COVID-19 during blinded, placebo-controlled follow-up through March 13, 2021, representing up to 6 months of follow-up after dose 2.[1] A total of 12,796 participants in the vaccine group and 12,449 in the placebo group were followed for at least 4 months after dose 2 in the blinded, placebo-controlled follow-up period.[1] Vaccine efficacy against first COVID-19 occurrence from day 7 after dose 2 in participants ≥16 years of age without evidence of infection prior to 7 days after dose 2 was

91.1% (90.5% in those 16–64 years of age and 94.5% in those ≥65 years of age).[1] Efficacy analyses of secondary efficacy end points supported benefit of the Pfizer-BioNTech COVID-19 vaccine in preventing severe COVID-19.[1]

At the time of FDA's efficacy review of data from the phase 2/3 portion of the study that supported use of the original formulation of the Pfizer-BioNTech COVID-19 vaccine as a 2-dose primary vaccination series in adolescents 12 to 15 years of age, a descriptive efficacy analysis that included 2260 adolescents 12–15 years of age had been performed and provided data for confirmed COVID-19 cases that accrued during blinded, placebo-controlled follow-up in these adolescents through September 2, 2021.[1] Among the 2087 participants 12–15 years of age in the trial who had no evidence of existing or prior SARS-CoV-2 infection (1057 in the vaccine group and 1030 in the placebo group), there were no cases of COVID-19 with onset at least 7 days after the second dose among vaccine recipients and 28 cases among placebo recipients; this corresponds to 100% vaccine efficacy.[1] Among the 2228 participants 12–15 years of age with or without evidence of SARS CoV-2 infection prior to 7 days after the second dose (1119 in the vaccine group and 1109 in the placebo group), there were no cases of COVID-19 with onset at least 7 days after the second dose among vaccine recipients and 30 cases among placebo recipients, corresponding to 100% vaccine efficacy; the only SARS-CoV-2 variant of concern identified from COVID-19 cases from this data cutoff was B.1.1.7 (Alpha).[1]

The effectiveness of booster doses of Pfizer-BioNTech COVID-19 vaccine (original monovalent and subsequent bivalent formulations) is based principally on immunogenicity assessments of geometric mean antibody titers and seroresponse rates against previous circulating strains of SARS-Co-2.[1]

Efficacy and safety of an additional (third) primary series dose of the original formulation of the Pfizer-BioNTech COVID-19 vaccine in individuals ≥12 years of age were evaluated in a single-arm study that included a group of 99 solid organ transplant recipients.[59] Individuals included in the study had previously received various solid organ transplants (heart, kidney, liver, lung, pancreas) and were receiving immunosuppressive therapy, including glucocorticoids (87%), calcineurin inhibitors (79%), mycophenolic acid (63%), mammalian target of rapamycin [mTOR] inhibitors (30%), and belatacept (12%).[59] The transplant recipients received 2 doses of Pfizer-BioNTech COVID-19 vaccine given 1 month apart, followed by a third dose of the vaccine administered approximately 2 months after the second dose.[2,59] The time between transplantation and initiation of the vaccination series against COVID-19 ranged from 89–105 months.[2,59] Among those who had been seronegative for anti-SARS-CoV-2 spike protein antibodies prior to the third vaccine dose, 44% were seropositive for antibodies at 4 weeks after the third dose.[59] All 40 patients who were seropositive before the third vaccine dose were still seropositive 4 weeks after the dose (antibody titers were 36 prior to the third dose and 2676 at 1 month after the third dose).[2,59] Overall, anti-SARS-CoV-2 antibodies were detected in 68% of study participants when tested at 4 weeks after the third vaccine dose.[59] Patients who did not have an antibody response were older, had a higher degree of immunosuppression, and had a lower estimated glomerular filtration rate than patients who had an antibody response.[59]

Children 5–11 Years of Age

Efficacy and immunogenicity of the original formulation of Pfizer-BioNTech COVID-19 vaccine as a 2-dose primary series in children 5 through 11 years of age were established based on data accrued through May 20, 2022 from a placebo-controlled blinded period of a clinical trial.[1]

The evaluable efficacy population included 4051 children 5 through 11 years of age (2703 in the vaccine group and 1348 in the placebo group) who had no evidence of prior infection with SARS-CoV-2 through 7 days after the second dose.[1] Approximately 25% of the children had 1 or more comorbidities (e.g., obesity, chronic lung disease, prematurity at birth, neurologic disorder, immunocompromising condition, feeding tube dependency, diabetes mellitus, sickle cell disease, congenital heart disease) that increase the risk of severe COVID-19 disease.[1,75] In these children, vaccine efficacy of the initial, original strain formulation against confirmed symptomatic COVID-19 cases occurring at least 7 days after dose 2 was 88.2% (10 cases in the vaccine group and 42 cases in the placebo group).[1] SARS-CoV-2 50% neutralizing antibody titers and seroresponse rates 1 month after the second dose were compared between a subset of participants 5–11 years of age from this study and a subset of participants 16–25 years of age who received Pfizer-BioNTech COVID-19 original monovalent vaccine in a previous clinical study.[1] The prespecified noninferiority criteria were met for both geometric mean antibody titers and seroresponse rates.[1]

The effectiveness of booster doses of Pfizer-BioNTech COVID-19 vaccine (original monovalent and subsequent monovalent formulations) in children 5 through 11 years of age is based principally on immunogenicity assessments of geometric mean antibody titers and seroresponse rates against previous circulating strains of SARS-Co-2.[1]

Children 6 Months through 4 Years of Age

*Although not currently FDA-labeled for use in **children 6 months through 4 years of age [off-label]**†, the Pfizer-BioNTech COVID-19 vaccine was previously authorized for use in this age group under an EUA, supported by data from an ongoing phase 1/2/3 trial.[2] At the time of analysis, the trial had enrolled 1,776 participants 6–23 months of age, of whom 1,178 participants received at least one dose of the Pfizer-BioNTech COVID-19 vaccine (containing 3 mcg modRNA; formulated using Tris buffer) and 598 participants received at least one dose*

> *of saline placebo.[2] The trial also enrolled 2,750 participants 2–4 years of age, of whom 1,835 participants received at least one dose of the Pfizer-BioNTech COVID-19 vaccine (containing 3 mcg modRNA; formulated using Tris buffer) and 915 participants received at least one dose of saline placebo.[2] In an analysis of data from the phase 2/3 blinded, placebo-controlled portion, 570 participants 6–23 months of age had received a 3-dose primary series (386 with Pfizer BioNTech COVID-19 vaccine and 184 with placebo) and were followed for a median of 1.3 months after the third dose, and 886 participants 2–4 years of age had received a 3-dose primary series (606 with Pfizer BioNTech COVID-19 vaccine and 280 with placebo) and were followed a median of 1.4 months after the third dose.[2] Review of safety data did not reveal any specific safety concerns with administration of this formulation in these age groups.[2] Immunogenicity analyses demonstrated that neutralizing antibody titers achieved 1 month after the 3-dose primary series between a subset of participants 6–23 months of age, or a subset of participants 2–4 years of age, met immunobridging criteria for both geometric mean antibody titers and seroresponse rates compared to individuals 16–25 years of age who were enrolled in another clinical trial.[2]*

> ### Immunocompromised Individuals
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> *Safety and immunogenicity of the Pfizer-BioNTech COVID-19 vaccine (Original Monovalent) in immunocompromised individuals were evaluated in an open-label study in participants 5 years of age and older who were immunocompromised due to an autoimmune inflammatory disorder, solid organ transplant, stem cell transplant, non-small cell lung cancer, or hemodialysis.[1] The median age of participants was 9 years in the 5-11 year age group, 12 years in the 12-17 year age group, and 40 years in participants 18 years of age and older.[1] Participants received 4 doses of the vaccine (an unapproved dosage regimen); the first 2 doses were given approximately 21 days apart, the third dose given approximately 28 days after dose 2, and the fourth dose given approximately 3 to 6 months after dose 3.[1] Seroresponse rates varied based on age of participants and dose, ranging from approximately 33 to 100%.[1] Safety of the vaccine in these immunocompromised individuals was similar to that observed in immunocompetent participants in other studies.[1]*

Dosage and Administration

■ General

Pretreatment Screening

- Screen all individuals for contraindications and precautions to vaccination.[13]

Patient Monitoring

- *Monitor all individuals who receive a COVID-19 vaccine for immediate adverse reactions according to CDC (ACIP) guidelines.* [1] ACIP states that vaccination providers should consider observing the following individuals for 30 minutes after receiving the vaccine: those with a history of a non-severe, immediate (onset less than 4 hours) allergic reaction to a previous dose of COVID-19 vaccine, and those with a history of a diagnosed non-severe allergy to a component of the COVID-19 vaccine.[13] Vaccination providers should consider observing all other individuals for 15 minutes after vaccination.[13]

Premedication and Prophylaxis

- Antipyretics or analgesics (e.g., acetaminophen, nonsteroidal anti-inflammatory agents) may be taken for the treatment of postvaccination local or systemic symptoms, if medically appropriate.[13] However, these medications should not be used prophylactically for the purposes of prevention of post-vaccination symptoms.[13]

Dispensing and Administration Precautions

- Appropriate medications and supplies for managing immediate allergic reactions *must* be immediately available in the event that an acute anaphylactic reaction occurs following administration of COVID-19 vaccines.[1,13]

- Syncope may occur following administration of parenteral vaccines, especially in adolescents.[13] Patients should be seated or lying down during vaccination.[13,20] Vaccination providers should consider observing vaccine recipients (especially adolescents) for 15 minutes after vaccination.[13] If syncope develops, patients should be observed until symptoms resolve.[13]

■ Administration

IM Administration

Administer *only* by IM injection.[1]

The Pfizer-BioNTech COVID-19 vaccine 2025-2026 Formula is available in 2 presentations for different age groups.[1] The preparation containing 30 mcg of modified messenger RNA (modRNA) per 0.3 mL in single-dose prefilled syringes with gray borders is intended for use in individuals ≥65 years of age and in individuals 12–64 years of age with at least one underlying condition that puts them at high risk of severe outcomes from COVID-19; the preparation containing 10 mcg of modRNA per 0.3 mL in single-dose vials with blue caps and blue borders is intended for use in individuals 5–11 years of age with at least one underlying condition that puts them at risk of severe outcomes from COVID-19.[1]

Prior to administration, vaccine providers should verify that the 2025-2026 Formula is being used.[1]

COVID-19 vaccines must be shipped, stored, and handled under specific conditions at all times.[1,20] Improper storage or handling of vaccines may reduce or destroy vaccine potency resulting in inadequate or no immune response in vaccinees.[20] Vaccine that has been mishandled or has not been stored at the recommended temperatures should not be administered.[20]

Single-dose Vials: If the vial is frozen, thaw in refrigerator for up to 2 hours or at room temperature for 30 minutes.[1] Prior to use, gently invert 10 times to mix; do not shake.[1] The vaccine should appear as a clear to slightly opalescent suspension; do not use if vaccine is discolored or contains particulate matter.[1] To administer a dose, withdraw 0.3 mL of the vaccine from the vial using a sterile needle and syringe, and administer immediately; discard the vial and any excess volume.[1]

Prefilled syringes: Use immediately after removing the cap; if not used immediately, the syringe must be used within 4 hours.[1] Do not shake the prefilled syringe.[1] If the prefilled syringe has been frozen, discard.[1] The vaccine should appear as a white to off-white suspension; do not use if vaccine is discolored or contains particulate matter.[1] Administer the entire volume in the prefilled syringe to deliver a single 0.3 mL dose.[1]

Dosage

Prevention of COVID-19

For active immunization to prevent COVID-19, the manufacturer recommends a single 0.3 mL dose for adults ≥65 years of age, or for individuals 5 through 64 years of age with at least one underlying condition that puts them at high risk for severe outcomes from COVID-19.[1] For individuals previously vaccinated with any COVID-19 vaccine, administer the dose at least 2 months after last dose of the previous vaccine.[1]

Cautions

Contraindications

- Known history of severe allergic reaction (e.g., anaphylaxis) to any component of the vaccine.[1]

Warnings/Precautions

Hypersensitivity Reactions

Although immediate allergic reactions were not reported in the original clinical trials evaluating COVID-19 vaccine, mRNA (Pfizer-BioNTech), severe allergic reactions, including anaphylaxis, have been reported rarely following administration of mRNA COVID-19 vaccines during postmarketing experience.[1,13,22,23,26,29,37,40]

Following issuance of the original FDA EUA for the Pfizer-BioNTech COVID-19 vaccine, safety monitoring data identified 21 cases of anaphylaxis occurring between December 14–23, 2020 among 1,893,360 individuals in the US who received the first dose of the vaccine (11.1 cases per million vaccine doses administered); this included 17 cases in individuals with a documented history of allergies or allergic reactions to drugs or medical products, foods, or insect stings (7 with a history of anaphylaxis, including one after receipt of a dose of rabies vaccine and another after receipt of influenza vaccine).[23] The median interval from receipt of the vaccine dose to onset of anaphylaxis symptoms was 13 minutes (range: 2–150 minutes); 15 of the 21 individuals with anaphylaxis (71%) had onset of symptoms within 15 minutes after receiving the dose and 19 (90%) were treated with epinephrine.[23] No fatalities from anaphylaxis were reported; 17 individuals were treated in an emergency department and the other 4 were hospitalized (including 3 in an intensive care unit).[23]

Between December 14–23, 2020, VAERs identified 83 cases of nonanaphylactic allergic reactions after administration of the first dose of the Pfizer-BioNTech COVID-19 vaccine; 72 of these cases (87%) were classified as nonserious and 56 of the cases (67%) included a documented history of allergies or allergic reactions.[23] The median interval from receipt of the vaccine dose to onset of such symptoms was 12 minutes (range: less than 1 minute to 20 hours); in 61 cases (85%), onset of symptoms occurred within 30 minutes.[23] Hypersensitivity reactions reported with the vaccine have included rash, pruritus, urticaria, itchy/scratchy sensations in the throat, angioedema, and mild respiratory symptoms.[23]

Individuals with a history of significant allergic reaction to any vaccine or to any component of the Pfizer-BioNTech COVID-19 vaccine were excluded from participating in clinical trials; however, those with a history of other significant allergic reactions were not excluded.[17] FDA independently conducted a standard MedDRA queries (SMQs) review of data from the safety population of the ongoing randomized, placebo-controlled, phase 2/3 Pfizer-BioNTech vaccine trial to evaluate for constellations of unsolicited adverse events using preferred terms that could represent various diseases and conditions including, but not limited to, allergic, neurologic, inflammatory, and autoimmune conditions.[17] The SMQs revealed a slight numerical imbalance of adverse events potentially representing allergic reactions, with more hypersensitivity-related adverse events reported in the vaccine group than the placebo group (0.63% and 0.51%, respectively).[17]

Delayed-onset local reactions (e.g., erythema, induration, pruritus, tenderness) around the injection site area have been reported in some vaccine recipients, including some clinical trial participants, after the first dose of an mRNA COVID-19 vaccine.[13,38] These local reactions may begin from a few days through the second week after the first dose and may be quite large.[13] In some reported cases, such delayed-onset local reactions after the first vaccine dose resolved in a median of 6 days (range: 2–11 days), and some individuals had similar (but less severe) local reactions after the second dose of the vaccine.[13,38] ACIP states that a delayed-onset local reaction after the first dose of an mRNA COVID-19 vaccine is *not* a contraindication or precaution to administration of a second dose.[13]

ACIP considers a history of severe allergic reaction (e.g., anaphylaxis) after a previous dose of an mRNA COVID-19 vaccine a contraindication to vaccination with the mRNA COVID-19 vaccines.[13] Consideration can be given to using an alternative COVID-19 vaccine type in such individuals provided certain measures are taken.[13] Consultation with an allergist-immunologist is encouraged.[13]

ACIP states to consider monitoring the following individuals for 30 minutes after vaccination: those with a history of a non-severe, immediate (onset less than 4 hours) allergic reaction to a previous dose of COVID-19 vaccine, and those with a history of a diagnosed non-severe allergy to a component of the COVID-19 vaccine; in all other individuals, providers should consider observing the vaccine recipient for 15 minutes after vaccination.[13,22] In addition, vaccine recipients should be instructed to seek immediate medical care if they develop signs or symptoms of an allergic reaction after their observation period ends and they have left the vaccination site.[22,23]

Appropriate medications (including age-appropriate epinephrine) and supplies to assess and manage immediate allergic reactions *must* be immediately available in the event that an acute anaphylactic reaction occurs following administration of a COVID-19 vaccine.[1,22,23] If a hypersensitivity reaction, including anaphylaxis, occurs following COVID-19 vaccination, the case should be reported to VAERS.[13]

Myocarditis and Pericarditis

Myocarditis and pericarditis have been reported in recipients of mRNA COVID-19 vaccines during post-authorization and post-marketing surveillance; the onset is typically within the first week following vaccination.[1,13,53,54,55,56,57,58] The observed risk has been highest in males 12 through 24 years of age; however, cases have also been reported in females and after other doses.[13]

Although most patients were hospitalized for short periods and some required intensive care support, available data suggest that the majority of these individuals responded to conservative treatment with rapid improvement or resolution of symptoms; additional data are needed regarding the potential for long-term sequelae.[1,13,54,55,56,57,58]

An analysis of data from commercial health insurance claims with the 2023-2024 Formula of mRNA COVID-19 vaccines found that the estimated unadjusted incidence of myocarditis and/or pericarditis was approximately 27 cases per million doses in males 12 through 24 years of age.[1] Symptoms usually resolved within a few days with conservative management; however, intensive care support was required in some cases.[1] In a longitudinal retrospective observational study, abnormal cardiac magnetic imaging findings were reported 5 months post-vaccination in patients who developed myocarditis after receiving a COVID-19 vaccine.[1] The clinical and prognostic significance of these findings is not known.[1] In a systematic review, myocarditis associated with COVID-19 vaccines occurred at rates of 1.3 to 3.1 per 100,000 doses in adolescents; there was a lower risk with longer dosing intervals.[19]

The possibility of myocarditis and pericarditis should be considered in the differential diagnosis for any individual, particularly in adolescents and young adults, who develop acute chest pain, shortness of breath, or palpitations after receipt of an mRNA COVID-19 vaccine.[13,53,54,58] During initial evaluation of suspected cases, the vaccine recipient should be queried about prior COVID-19 vaccination and pertinent medical, travel, and social history; in addition, assessment of ECG, troponin levels, and inflammatory markers such as C-reactive protein and erythrocyte sedimentation rate should be considered.[53] Expert consultation should be considered regarding diagnosis, management, and follow-up.[53]

Individuals receiving an mRNA COVID-19 vaccine, especially males 12–39 years of age, should be informed about the possibility of myocarditis or pericarditis after receiving the vaccine and the possibility of myocarditis or pericarditis occurring following SARS-CoV-2 infection and advised to seek medical care if symptoms of myocarditis or pericarditis occur after vaccination.[13] Extending the interval to 8 weeks between the first and second doses of vaccine for some people might reduce the rare risk of vaccine-associated myocarditis and pericarditis.[13]

If myocarditis or pericarditis occurs following receipt of a COVID-19 vaccine, the case should be reported to VAERS.[13] ACIP states that development of myocarditis or pericarditis within 3 weeks after a dose of any COVID-19 vaccine is a precaution to a subsequent dose of any COVID-19 vaccine, and subsequent doses should generally be avoided.[13] People who have a history of myocarditis or pericarditis that occurred before COVID-19 vaccination or more than 3 weeks after a COVID-19 vaccine dose may receive any currently FDA-approved or FDA-authorized COVID-19 vaccine after the episode of myocarditis or pericarditis has completely resolved.[13]

Syncope

Syncope (fainting) may occur in association with administration of injectable vaccines.[1] Procedures should be in place to avoid injury from fainting.[1] ACIP states to consider observing individuals receiving the vaccine, especially adolescents, for 15 minutes after vaccination.[13]

Concomitant Illness

The decision to administer or delay vaccination in an individual with a current or recent febrile illness depends on the severity of symptoms and etiology of the illness.[20]

ACIP states that a moderate or severe acute illness is a precaution for administration of vaccines and states that a risk assessment should be performed with potential deferral of vaccination.[13] Deferring vaccination until an individual has recovered avoids superimposing adverse effects of the vaccine on the underlying illness or mistakenly concluding that a manifestation of the underlying illness resulted from vaccination.[20]

> ### Individuals with a History of Multisystem Inflammatory Syndrome
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> *ACIP states that the benefits of COVID-19 vaccination for individuals with a history of multisystem inflammatory syndrome in adults (MIS-A) or in children (MIS-C) outweigh the risks.[13] ACIP has published considerations for initiating COVID-19 vaccination in such individuals.[13]*
>
> *If MIS-A or MIS-C develops more than 60 days after the most recent COVID-19 vaccine dose, administration may be considered for those who achieve clinical recovery (including return to normal cardiac function).[13]*
>
> *If the onset of MIS is 60 days or fewer after the most recent COVID-19 dose, the decision whether or not to administer a subsequent COVID-19 vaccine dose(s) should be made on an individual basis by the clinical care team and patient or parent or guardian.[13] Subsequent doses of COVID-19 vaccine should especially be considered if there is strong evidence that MIS was a complication of a recent SARS-CoV-2 infection.[13]*

Individuals with Underlying Medical Conditions

Individuals with altered immunocompetence, including those receiving immunosuppressive therapy, may have diminished immune responses to vaccines, including the Pfizer-BioNTech COVID-19 vaccine.[13,]

Although a causal relationship has not been established, several cases of Bell's palsy have been reported in individuals receiving the Pfizer-BioNTech COVID-19 vaccine.[1,]

Individuals with Increased Bleeding Risk

Individuals who have bleeding disorders or are receiving anticoagulant therapy should be advised about the risk of hematoma from IM injections.[20,]

ACIP states that IM vaccines may be given to individuals who have bleeding disorders if a clinician familiar with the patient's bleeding risk determines that the preparation can be administered IM with reasonable safety.[20,] In these cases, a fine needle (23 gauge or smaller) should be used to administer the vaccine and firm pressure applied to the injection site (without rubbing) for at least 2 minutes.[20,] In individuals receiving therapy for hemophilia, IM vaccines can be scheduled for administration shortly after a dose of such therapy.[20,]

Individuals receiving anticoagulation therapy presumably have the same bleeding risk as patients with clotting factor disorders and should follow the same guidelines for IM administration.[20,] If possible, IM vaccines could be scheduled prior to use of an anticoagulant so that the patient's risk of bleeding is not increased by the drug's therapeutic action.[20,]

Limitation of Effectiveness

COVID-19 vaccine, mRNA (Pfizer-BioNTech) may not protect all vaccine recipients against COVID-19.[1,]

Specific Populations

Pregnancy

In a randomized, placebo-controlled study in which pregnant women 18 years of age or older received 2 doses of the Original Monovalent formulation of COVID-19 vaccine, mRNA (Pfizer-BioNTech) approximately 21 days apart (first dose administered at 24 to 34 weeks' gestation), major or minor congenital anomalies or chromosomal abnormalities were reported in 6.4% of infants born to women in the vaccine group compared with 4.4% of infants born to women in the placebo group.[1,] However, the available data from this study are insufficient to establish or exclude a vaccine-associated risk of congenital anomalies because the vaccine was not administered in the first trimester, the period when such anomalies is highest.[1,]

In a reproductive and developmental toxicity study, 0.06 mL of a vaccine formulation containing the same quantity of mRNA (30 mcg) and other ingredients included in a single human dose of the Pfizer-BioNTech COVID-19 vaccine was administered IM to female rats on 4 occasions (21 and 14 days prior to mating and on gestation days 9 and 20.[1,] No vaccine-related adverse effects on female fertility, fetal development, or postnatal development were reported in the study.[1,]

Available data suggest that, while the absolute risk is low, pregnant and recently pregnant women with COVID-19 are at increased risk of severe illness, including illness resulting in hospitalization, admission to an intensive care unit, mechanical ventilation, extracorporeal membrane oxygenation (ECMO), or death compared with women who are not pregnant.[13,16,34,] Additionally, pregnant women with COVID-19 are at increased risk of preterm birth and may be at increased risk of adverse pregnancy complications and outcomes, such as preeclampsia, coagulopathy, and stillbirth.[13,34,]

Surveillance safety data are accumulating regarding COVID-19 vaccination during pregnancy.[13,16,49,50,] Early data from VAERS, v-safe active surveillance, and v-safe pregnancy registry have not identified any safety concerns in pregnant women who were vaccinated late in their pregnancy or in their infants; additional evidence has not found an increased risk for miscarriage following receipt of an mRNA vaccine before 20 weeks gestation.[13,] There is some evidence that pregnant women who receive an mRNA vaccine (Moderna COVID-19 vaccine or Pfizer-BioNTech COVID-19 vaccine) during pregnancy have immune responses comparable to those observed in individuals who are not pregnant and may develop anti-SARS-CoV-2 antibody titers greater than those observed in women diagnosed with SARS-CoV-2 infection during pregnancy.[16,50,51,]

ACIP states that vaccination against COVID-19 is recommended for pregnant women.[13,] These experts state that evidence regarding the safety and efficacy of COVID-19 vaccines available from both animal and human studies indicates that the benefits of vaccination against COVID-19 during pregnancy outweigh any known or potential risks.[13,]

The American College of Obstetricians and Gynecologists (ACOG) also recommends that all pregnant women be vaccinated against COVID-19.[16,] Vaccination may occur in any trimester and as soon as possible to maximize maternal and fetal health.[16,]

Lactation

It is not known whether COVID-19 vaccine (Pfizer-BioNTech) is distributed into milk.[1] Data are not available to assess whether the vaccine administered to a woman who is breast-feeding has any effects on the breast-fed infant or milk production.[1]

The benefits of breast-feeding and the importance of the Pfizer-BioNTech COVID-19 vaccine to the woman should be considered along with any potential adverse effects on the breast-fed child from the vaccine or from the underlying maternal condition (i.e., susceptibility to SARS-CoV-2 infection).[1]

ACIP and ACOG recommend COVID-19 vaccination in all lactating individuals.[13,16]

Females and Males of Reproductive Potential

ACIP recommends COVID-19 vaccination in people who are pregnant, trying to get pregnant, or might become pregnant in the future.[13]

Pediatric Use

Pfizer-BioNTech COVID-19 vaccine, mRNA (2025-2026 Formula) is FDA-labeled for use in children 5 years of age or older.[1]

Geriatric Use

Individuals ≥65 years of age have been included in clinical trials evaluating COVID-19 vaccine (Pfizer-BioNTech), and data from such individuals contribute to the overall assessment of safety and efficacy of the vaccine.[1,2]

Data from a phase 1/2/3 clinical trial indicate that, as of March 13, 2021, 20.7% of the total number of individuals who received a 2-dose primary series of the initial (Original strain; no longer authorized for use in the US) monovalent vaccine were ≥65 years of age and 4.2% were ≥75 years of age.[1] No overall differences in safety or effectiveness were observed between those ≥65 years of age and younger recipients of the vaccine.[1]

■ Common Adverse Effects

The most commonly reported adverse reactions (≥10%) in participants 12 years of age and older receiving Comirnaty® were pain at the injection site (up to 90.5%), fatigue (up to 77.5%), headache (up to 75.5%), chills (up to 49.2%), muscle pain (up to 45.5%), joint pain (up to 27.5%), fever (up to 24.3%), injection site swelling (up to 11.8%), and injection site redness (up to 10.4%).[1]

The most commonly reported adverse reactions (≥5%) in participants 5 through 11 years of age receiving Comirnaty® were pain at the injection site (up to 83.8%), fatigue (up to 51.9%), headache (up to 38.4%), injection site redness (up to 25.9%), injection site swelling (up to 20.0%), muscle pain (up to 18.1%), chills (up to 13.3%), fever (up to 7.8%), and joint pain (up to 7.6%).[1]

Drug Interactions

■ Analgesic Agents

ACIP does not recommend taking ibuprofen, aspirin, or acetaminophen prior to COVID-19 vaccination to try and prevent side effects.[13]

■ Immunosuppressive Agents

ACIP states that administration of COVID-19 vaccines should not be delayed in patients taking immunosuppressive therapies.[13] Whenever possible, COVID-19 vaccines should be administered at least 2 weeks before initiation or resumption of immunosuppressive therapies.[13] For patients who receive B-cell-depleting therapies on a continuing basis, COVID-19 vaccines should be administered approximately 4 weeks before the next scheduled therapy.[13]

■ Vaccines

ACIP states that routine administration of all age-appropriate doses of vaccines simultaneously is recommended in children, adolescents, and adults if there are no contraindications at the time of the healthcare visit.[13]

An interim analysis of a clinical study of 296 persons ≥65 years of age comparing concomitant administration of a quadrivalent inactivated influenza vaccine (HD-IIV4) and a booster dose of an mRNA COVID-19 vaccine (administered in separate upper arm sites) with administration of either vaccine alone did not identify any safety concerns or any evidence of immune interference on influenza hemagglutination inhibition or SARS-CoV-2 binding antibody responses.[589] Local reactogenicity up to 21 days postvaccination was similar between the coadministration group and the group that received the mRNA COVID-19 vaccine alone.[589] Similar frequency of systemic reactions were reported in the coadministration and mRNA groups, but with lower frequencies observed in participants who received HD-IIV4 alone.[589]

In a multicenter, randomized clinical study, 679 adult participants were recruited to receive concomitant administration of either an age-appropriate influenza vaccine or placebo along with their second dose of a COVID-19 vaccine (either an adenovirus viral vector COVID-19 vaccine or an mRNA COVID-19 vaccine).[590] Injections were administered by IM injection in the upper arm, with one injection on each side for the concomitant administration recipients.[590] Analysis up to 21 days after vaccination, did not identify safety concerns or evidence of immune interference on influenza hemagglutination inhibition or SARS-CoV-2 binding antibody responses.[590] The study found similar rates of local

reactogenicity between the coadministration group and single vaccine administration group; however, systemic reactions were reported at similar frequencies in the coadministration and mRNA vaccine groups, with lower frequencies observed in participants who received influenza vaccine alone.[590]

Description

COVID-19 vaccine (Pfizer-BioNTech) is a nucleoside-modified mRNA (modRNA) vaccine formulated in lipid nanoparticles (LNPs).[6,7,10,11]

The modRNA contained in the Pfizer-BioNTech COVID-19 vaccine encodes a membrane-anchored, full-length spike (S) glycoprotein receptor-binding domain (RBD) antigen of SARS-CoV-2 with 2 proline modifications within the central helix domain that lock the S protein in an antigenically preferred prefusion conformation.[1,10,11] The 2025-2026 Formula contains nucleoside-modified mRNA encoding the viral spike (S) glycoprotein of SARS-CoV-2 Omicron variant sublineage LP.8.1.[1] Following IM injection, the LNPs in the vaccine enable delivery of the modRNA into host cells where it is released and translated to the encoded S antigen of SARS-CoV-2.[1,11] The S antigen is then incorporated into cellular membranes and elicits an immune response to provide protection against SARS-CoV-2.[1,10]

Advice to Patients

The following information contains important points for the clinician to discuss with patients during counseling. For more comprehensive monographs suitable for distribution to the patient, please refer to the *AHFS Patient Medication Information* monographs available from MedlinePlus (in English and Spanish; written at a 6th- to 8th-grade reading level).

- Advise the vaccine recipient or caregiver to read the FDA-approved patient labeling.[1]
- Inform the vaccine recipient or caregiver of the potential benefits and risks of vaccination.[1]
- Instruct the vaccine recipient or caregiver to report any adverse events to their healthcare provider or to the Vaccine Adverse Event Reporting System at 1-800-822-7967 or [Web] .[1]
- Advise patients to inform their clinician of existing or contemplated concomitant therapy, including prescription and OTC drugs and dietary or herbal supplements, as well as any concomitant illnesses.[1]
- Advise women to inform their clinician if they are or plan to become pregnant or plan to breast-feed.[1]
- Inform patients of other important precautionary information.[1]

Additional Information

The American Society of Health-System Pharmacists, Inc. represents that the information provided in the accompanying monograph was formulated with a reasonable standard of care, and in conformity with professional standards in the field. Readers are advised that decisions regarding use of drugs are complex medical decisions requiring the independent, informed decision of an appropriate health care professional, and that the information contained in the monograph is provided for informational purposes only. The manufacturer's labeling should be consulted for more detailed information. The American Society of Health-System Pharmacists, Inc. does not endorse or recommend the use of any drug. The information contained in the monograph is not a substitute for medical care.

Preparations

Excipients in commercially available drug preparations may have clinically important effects in some individuals; consult specific product labeling for details.

COVID-19 Vaccine, mRNA (Pfizer-BioNTech)

ROUTES	FORMS	STRENGTHS	BRAND NAMES	MANUFACTURER
Parenteral	*Suspension, for IM use*	*10 mcg (of modRNA) per 0.3-mL dose*	*Comirnaty(2025-2026 Formula)® (available as single dose vials with blue caps and labels)*	*Pfizer-BioNTech*
		30 mcg (of modRNA) per 0.3-mL dose	*Comirnaty (2025-2026 Formula)® (available in single dose prefilled syringes with gray borders)*	*Pfizer-BioNTech*

† Use is not currently included in the labeling approved by the US Food and Drug Administration.

References

1. BioNTech Pfizer. Comirnaty® (COVID-19 vaccine, mRNA) suspension for injection for IM use 2025-2026 Formula. New York, NY; 2026 Feb.

2. US Food and Drug Administration. Revised letter of authorization: Emergency use authorization (EUA) for emergency use of Pfizer-BioNTech COVID-19 vaccine for the prevention of coronavirus disease 2019 (COVID-19). August 22, 2024. From FDA website.

3. Vaccines and Related Biological Products Advisory Committee. FDA Considerations and Recommendations for the 2025-2026 Formula of COVID-19 Vaccines in the United States. May 22,2025. From FDA website.

6. Walsh EE, Frenck RW Jr, Falsey AR. Safety and Immunogenicity of Two RNA-Based Covid-19 Vaccine Candidates. *N Engl J Med*. 2020; 383:2439-50
PubMed

7. Polack FP, Thomas SJ, Kitchin N. Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine. *N Engl J Med*. 2020; 383:2603-2615
PubMed

10. Vaccines and Related Biological Products Advisory Committee. Vaccines and Related Biological Products Advisory Committee meeting December 10, 2020: FDA briefing document Pfizer-BioNTech COVID-19 vaccine. Available at FDA website.

11. Vaccines and Related Biological Products Advisory Committee. Vaccines and Related Biological Products Advisory Committee meeting December 10, 2020: Pfizer-BioNTech briefing document Pfizer-BioNTech COVID-19 vaccine (BNT162, PF-07302048). Available at FDA website.

13. Advisory Committee On Immunization Practices (ACIP). Interim clinical considerations for use of COVID-19 vaccines currently approved or authorized in the United States. Last updated Nov 4, 2025. From CDC website. Updates may be available at CDC website.

16. American College of Obstetricians and Gynecologists. COVID-19 vaccination considerations for obstetric-gynecologic care. Practice Advisory. Last updated . From ACOG website. Updates may be available at ACOG website.

17. US Food and Drug Administration. Emergency use authorization for an unapproved product review memorandum: Pfizer-BioNTech COVID-19 vaccine/BNT162b2. From FDA website. Accessed 2020 Dec 27.

19. Scott J, Abers MS, Marwah HK et al. Updated Evidence for Covid-19, RSV, and Influenza Vaccines for 2025-2026. N Engl J Med. 2025 Dec 4;393(22):2221-2242. doi: 10.1056/NEJMsa2514268. Epub 2025 Oct 29. PMID: 41160817.

20. Kroger A, Bahta L, Hunter P. General best practice guidelines for immunization. Best practices guidance of the Advisory Committee on Immunization Practices (ACIP). From CDC website. Accessed 2021 Dec 3.

22. US Centers for Disease Control and Prevention. Interim considerations: preparing for the potential management of anaphylaxis after COVID-19 vaccination. From CDC website. Last updated Mar 22, 2024. Updates may be available at CDC website.

23. CDC COVID-19 Response Team., Food and Drug Administration. Allergic Reactions Including Anaphylaxis After Receipt of the First Dose of Pfizer-BioNTech COVID-19 Vaccine - United States, December 14-23, 2020. *MMWR Morb Mortal Wkly Rep*. 2021; 70:46-51
PubMed

24. Dooling K, Marin M, Wallace M. The Advisory Committee on Immunization Practices' Updated Interim Recommendation for Allocation of COVID-19 Vaccine - United States, December 2020. *MMWR Morb Mortal Wkly Rep*. 2021; 69:1657-1660
PubMed

26. Castells MC, Phillips EJ. Maintaining Safety with SARS-CoV-2 Vaccines. *N Engl J Med*. 2021; 384:643-649
PubMed

27. Stone CA Jr, Liu Y, Relling MV. Immediate Hypersensitivity to Polyethylene Glycols and Polysorbates: More Common Than We Have Recognized. *J Allergy Clin Immunol Pract*. 2019; 7:1533-1540.e8
PubMed

28. Vaccines and Related Biological Products Advisory Committee. Vaccines and Related Biological Products Advisory Committee meeting December 17, 2020: FDA briefing document Moderna COVID-19 vaccine. Available at FDA website.

29. Shimabukuro T. Allergic reactions including anaphylaxis after receipt of the first dose of Moderna COVID-19 vaccine - United States, December 21, 2020-January 10, 2021. *Am J Transplant*. 2021; 21:1326-1331
PubMed

30. Mehta N, Sales RM, Babagbemi K. Unilateral axillary Adenopathy in the setting of COVID-19 vaccine. *Clin Imaging*. 2021; 75:12-15
PubMed

33. Munavalli GG, Guthridge R, Knutsen-Larson S. COVID-19/SARS-CoV-2 virus spike protein-related delayed inflammatory reaction to hyaluronic acid dermal fillers: a challenging clinical conundrum in diagnosis and treatment. *Arch Dermatol Res*. 2021;
PubMed

34. Metz TD, Clifton RG, Hughes BL. Disease Severity and Perinatal Outcomes of Pregnant Patients With Coronavirus Disease 2019 (COVID-19). *Obstet Gynecol*. 2021; 137:571-580
PubMed

36. US Centers for Disease Control and Prevention. Advisory Committee on Immunization Practices (ACIP) recommended child and adolescent immunization schedule for ages 18 years or younger, United States, 2021. Updates may be available at CDC website.

37. Blumenthal KG, Robinson LB, Camargo CA Jr. Acute Allergic Reactions to mRNA COVID-19 Vaccines. *JAMA*. 2021; 325:1562-1565
PubMed

38. Blumenthal KG, Freeman EE, Saff RR. Delayed Large Local Reactions to mRNA-1273 Vaccine against SARS-CoV-2. *N Engl J Med*. 2021; 384:1273-1277
PubMed

39. Wallace M, Woodworth KR, Gargano JW. The Advisory Committee on Immunization Practices' Interim Recommendation for Use of Pfizer-BioNTech COVID-19 Vaccine in Adolescents Aged 12-15 Years - United States, May 2021. *MMWR Morb Mortal Wkly Rep*. 2021; 70:749-752
PubMed

40. Shimabukuro TT, Cole M, Su JR. Reports of Anaphylaxis After Receipt of mRNA COVID-19 Vaccines in the US-December 14, 2020-January 18, 2021. *JAMA*. 2021; 325:1101-1102
PubMed

41. Welsh KJ, Baumblatt J, Chege W. Thrombocytopenia including immune thrombocytopenia after receipt of mRNA COVID-19 vaccines reported to the Vaccine Adverse Event Reporting System (VAERS). *Vaccine*. 2021;
PubMed

42. Shimabukuro T, CDC COVID-19 Vaccine Task Force Vaccine Safety Team. Update: Thrombosis with thrombocytopenia syndrome (TTS) following COVID-19 vaccination. Meeting materials from Advisory Committee on Immunization Practices (ACIP) meeting May 12, 2021. Available at ACIP website.

44. Keshavarz P, Yazdanpanah F, Rafiee F. Lymphadenopathy Following COVID-19 Vaccination: Imaging Findings Review. *Acad Radiol*. 2021;
PubMed

45. Singh B, Kaur P, Kumar V. COVID-19 vaccine induced Axillary and Pectoral Lymphadenopathy on PET scan. *Radiol Case Rep*. 2021; 16:1819-1821
PubMed

46. Schroeder DG, Jang S, Johnson DR. Frequency and Characteristics of Nodal and Deltoid FDG and 11C-Choline Uptake on PET Imaging Performed After COVID-19 Vaccination. *AJR Am J Roentgenol*. 2021;
PubMed

48. Lehman CD, D'Alessandro HA, Mendoza DP. Unilateral Lymphadenopathy After COVID-19 Vaccination: A Practical Management Plan for Radiologists Across Specialties. *J Am Coll Radiol*. 2021;
PubMed

49. Shimabukuro TT, Kim SY, Myers TR. Preliminary Findings of mRNA Covid-19 Vaccine Safety in Pregnant Persons. *N Engl J Med*. 2021;
PubMed

50. Collier AY, McMahan K, Yu J. Immunogenicity of COVID-19 mRNA Vaccines in Pregnant and Lactating Women. *JAMA*. 2021;
PubMed

51. Gray KJ, Bordt EA, Atyeo C. Coronavirus disease 2019 vaccine response in pregnant and lactating women: a cohort study. *Am J Obstet Gynecol*. 2021;
PubMed

52. Frenck RW Jr, Klein NP, Kitchin N. Safety, Immunogenicity, and Efficacy of the BNT162b2 Covid-19 Vaccine in Adolescents. *N Engl J Med*. 2021;
PubMed

53. US Centers for Disease Control and Prevention. Clinical considerations: myocarditis and pericarditis after receipt of mRNA COVID-19 vaccines among adolescents and young adults. From CDC website. Oct 10, 2023. Updates may be available at CDC website.

54. Marshall M, Ferguson ID, Lewis P. Symptomatic Acute Myocarditis in Seven Adolescents Following Pfizer-BioNTech COVID-19 Vaccination. *Pediatrics*. 2021;
PubMed

55. Gargano JW, Wallace M, Hadler SC. Use of mRNA COVID-19 Vaccine After Reports of Myocarditis Among Vaccine Recipients: Update from the Advisory Committee on Immunization Practices - United States, June 2021. *MMWR Morb Mortal Wkly Rep*. 2021; 70:977-982
PubMed

56. Kim HW, Jenista ER, Wendell DC. Patients With Acute Myocarditis Following mRNA COVID-19 Vaccination. *JAMA Cardiol*. 2021;
PubMed

57. Montgomery J, Ryan M, Engler R. Myocarditis Following Immunization With mRNA COVID-19 Vaccines in Members of the US Military. *JAMA Cardiol*. 2021;
PubMed

58. Tano E, San Martin S, Girgis S. Perimyocarditis in Adolescents After Pfizer-BioNTech COVID-19 Vaccine. *J Pediatric Infect Dis Soc*. 2021;
PubMed

59. Kamar N, Abravanel F, Marion O. Three Doses of an mRNA Covid-19 Vaccine in Solid-Organ Transplant Recipients. *N Engl J Med*. 2021; 385:661-662
PubMed

60. Hall VG, Ferreira VH, Ierullo M. Humoral and cellular immune response and safety of two-dose SARS-CoV-2 mRNA-1273 vaccine in solid organ transplant recipients. *Am J Transplant*. 2021;
PubMed

61. Hall VG, Ferreira VH, Ku T. Randomized Trial of a Third Dose of mRNA-1273 Vaccine in Transplant Recipients. *N Engl J Med*. 2021;
PubMed

62. Crombie JL, Sherman AC, Cheng CA. Activity of mRNA COVID-19 vaccines in patients with lymphoid malignancies. *Blood Adv*. 2021; 5:3062-3065
PubMed

63. Perry C, Luttwak E, Balaban R. Efficacy of the BNT162b2 mRNA COVID-19 vaccine in patients with B-cell non-Hodgkin lymphoma. *Blood Adv*. 2021; 5:3053-3061
PubMed

64. Schramm R, Costard-Jäckle A, Rivinius R. Poor humoral and T-cell response to two-dose SARS-CoV-2 messenger RNA vaccine BNT162b2 in cardiothoracic transplant recipients. *Clin Res Cardiol*. 2021; 110:1142-1149
PubMed

65. Narasimhan M, Mahimainathan L, Clark AE. Serological Response in Lung Transplant Recipients after Two Doses of SARS-CoV-2 mRNA Vaccines. *Vaccines (Basel)*. 2021; 9
PubMed

68. US Food and Drug Administration. Summary basis for regulatory action. BioNTech Manufacturing GmbH (in partnership with Pfizer, Inc) COVID-19 vaccine mRNA. 2021 Aug 23. From FDA website.

70. Revocation of Emergency Use of Three Biological Products; availability. Docket No. FDA–2025–N–3792. Fed Reg Vol 90 No 189; Oct 2, 2025.

75. Kim L, Whitaker M, O'Halloran A et al. Hospitalization Rates and Characteristics of Children Aged <18 Years Hospitalized with Laboratory-Confirmed COVID-19 - COVID-NET, 14 States, March 1-July 25, 2020. MMWR Morb Mortal Wkly Rep. 2020 Aug 14;69(32):1081-1088. doi: 10.15585/mmwr.mm6932e3. PMID: 32790664; PMCID: PMC7440125.

76. Centers for Disease Control and Prevention (CDC). Underyling conditions and the higher risk for severe COVID-19. February 6, 2025. From CDC website.

77. Center for Infectious Disease Research and Policy (CIDRAP). Vaccine Integrity Project. From the CIDRAP website.

78. Committee on Infectious Diseases. Recommendations for COVID-19 Vaccines in Infants, Children, and Adolescents: Policy Statement. Pediatrics. 2025 Nov 1;156(5):e2025073924. doi: 10.1542/peds.2025-073924. PMID: 40826495.

79. American Academy of Pediatrics. Recommended Child and Adolescent Immunization Schedule for Ages 18 Years or Younger. From AAP website.

80. Centers for Disease Control and Prevention (CDC). Adult immunization schedule by age. Oct 7. 2025. From the CDC website.

81. Centers for Disease Control and Prevention (CDC). Adult immunization schedule notes. Oct 7, 2025. From the CDC website.

82. Centers for Disease Control and Prevention (CDC). Child and Adolescent Immunization Schedule by Age. Oct 7. 2025. From the CDC website.

83. Centers for Disease Control and Prevention (CDC). Child Immunization Schedule Notes. Dec 8, 2025. From the CDC website.

84. Centers for Disease Control and Prevention (CDC). ACIP Shared Clinical Decision-making Recommendations. Jan 7, 2025. From CDC website.

589. Izikson R, Brune D, Bolduc JS, et al. Safety and immunogenicity of a high-dose quadrivalent influenza vaccine administered concomitantly with a third dose of the mRNA-1273 SARS-CoV-2 vaccine in adults aged ≥65 years: a phase 2, randomised, open-label study. Lancet Respir Med 2022;10:392–402. Epub Feb. 21, 2022.

590. Lazarus R, Baos S, Cappel-Porter H, er al. Safety and immunogenicity of concomitant administration of COVID-19 vaccines (ChAdOx1 or BNT162b2) with seasonal influenza vaccines in adults in the UK (ComFluCOV): a multicentre, randomised, controlled, phase 4 trial. Lancet 2021; 398: 2277–87.