

Vaccination of Adults With Cancer: ASCO Guideline

Mini Kamboj, MD¹; Kari Bohlke, ScD² ; Deana M. Baptiste, PhD, MPH³; Kieron Dunleavy, MD⁴; Abbey Fueger, BA, BSN, RN⁵; Lee Jones, MBA⁶ ; Amar H. Kelkar, MD, MPH⁷ ; Lisa Y. Law, MD⁸ ; Kristine B. LeFebvre, DNP, RN, NPD-BC, AOCN⁹ ; Per Ljungman, MD, PhD¹⁰ ; Eric D. Miller, MD, PhD¹¹ ; Larissa A. Meyer, MD, MPH¹² ; Heather N. Moore, CPP, PharmD¹³ ; Heloisa P. Soares, MD, PhD¹⁴ ; Randy A. Taplitz, MD¹⁵ ; Edom S. Woldetsadik, MD¹⁶ ; and Elise C. Kohn, MD¹⁷

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ABSTRACT

ASCO Guidelines provide recommendations with comprehensive review and analyses of the relevant literature for each recommendation, following the guideline development process as outlined in the *ASCO Guidelines Methodology Manual*. ASCO Guidelines follow the *ASCO Conflict of Interest Policy for Clinical Practice Guidelines*.

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PURPOSE To guide the vaccination of adults with solid tumors or hematologic malignancies.

METHODS A systematic literature review identified systematic reviews, randomized controlled trials (RCTs), and nonrandomized studies on the efficacy and safety of vaccines used by adults with cancer or their household contacts. This review builds on a 2013 guideline by the Infectious Disease Society of America. PubMed and the Cochrane Library were searched from January 1, 2013, to February 16, 2023. ASCO convened an Expert Panel to review the evidence and formulate recommendations.

RESULTS A total of 102 publications were included in the systematic review: 24 systematic reviews, 14 RCTs, and 64 nonrandomized studies. The largest body of evidence addressed COVID-19 vaccines.

RECOMMENDATIONS The goal of vaccination is to limit the severity of infection and prevent infection where feasible. Optimizing vaccination status should be considered a key element in the care of patients with cancer. This approach includes the documentation of vaccination status at the time of the first patient visit; timely provision of recommended vaccines; and appropriate revaccination after hematopoietic stem-cell transplantation, chimeric antigen receptor T-cell therapy, or B-cell-depleting therapy. Active interaction and coordination among healthcare providers, including primary care practitioners, pharmacists, and nursing team members, are needed. Vaccination of household contacts will enhance protection for patients with cancer. Some vaccination and revaccination plans for patients with cancer may be affected by the underlying immune status and the anticancer therapy received. As a result, vaccine strategies may differ from the vaccine recommendations for the general healthy adult population vaccine. Additional information is available at www.asco.org/supportive-care-guidelines.

ACCOMPANYING CONTENT

 [Appendix](#)
 [Data Supplement](#)

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TARGET POPULATION AND AUDIENCE

Target Population

Adults with solid tumors or hematologic malignancies, including those who receive hematopoietic stem-cell transplantation, chimeric antigen receptor T-cell therapy and B-cell-depleting therapies, and long-term survivors, and their household contacts.

Target Audience

Adults with cancer and the clinicians who provide care to them before, during, and after cancer treatment.

INTRODUCTION

Patients with cancer often experience a compromised immune system because of a variety of factors, including chronic inflammation, impaired and/or decreased function of elements of the hematopoietic lineage, and treatments that compromise immune function.¹⁻⁴ Consequently, patients with cancer are at a heightened risk for infection, which can extend beyond cancer treatment, highlighting the need for oncologists to partner with primary care providers to obtain an up-to-date vaccine history as part of the standard oncologic evaluation and to address intervention for vaccine-preventable diseases. The efficacy of vaccines against infection in patients with cancer correlates with the degree and type of immunosuppression and/or severity of underlying malignancy.⁵⁻⁹ The purpose of vaccination is to protect from infection and attenuate the severity of disease where infection cannot be fully prevented.

Inherent variability in clinical practice, including the lack of primary care physicians for some patients with cancer, reinforces the need for an approach to vaccination applicable to the health care teams caring for the medically complex oncology population. Live virus vaccines are typically contraindicated in patients with severely compromised immune systems.^{5,10} Conversely, nonlive vaccines are generally considered safe, but their ability to produce immune responses may differ depending on the net state of immunosuppression.^{5,11,12}

To improve vaccination rates among patients with cancer, ASCO has engaged with the Centers for Disease Control and Prevention (CDC), Council of Medical Specialty Societies, and other specialty societies in a 5-year cooperative agreement.¹³ Along with supporting the development of this guideline, the cooperative agreement includes efforts in provider education, patient education, and quality improvement. ASCO has engaged with eight US health systems that are improving guideline-concordant vaccination following processes outlined in the Standards for Adult Immunization Practice.¹⁴

This ASCO guideline organizes recommended vaccines for patients with cancer and identifies unique settings where revaccination is needed and the timing for that process. Guideline recommendations are provided in [Table 1](#). Vaccines are broadly categorized into live and nonlive vaccines to follow a standard nomenclature that identifies vaccines that are safe for individuals undergoing cancer treatment and those that should be avoided.

Live vaccines: Live-attenuated vaccines contain an attenuated but replicating virus or bacteria. They induce durable immunity by causing a low-grade infection in otherwise healthy individuals. However, in patients with weakened immune systems, live vaccines can pose a risk of uncontrolled infection from the vaccine strain and are therefore avoided. Examples of live vaccines include varicella; the measles, mumps, and rubella (MMR) vaccine; and oral typhoid.

Nonlive vaccines: These vaccines are safe for use in patients with cancer. Currently available nonlive vaccines include inactivated vaccines; subunit vaccines, including recombinant, polysaccharide vaccines and polysaccharide-protein conjugate vaccines; toxoids; and mRNA vaccines.

Practical questions about vaccines in patients with cancer were considered to provide recommendations on types and timing of vaccines for different scenarios faced by patients, including the nuances of immunizations in patients with solid tumors, hematologic malignancies, patients receiving transplant and chimeric antigen receptor T-cell (CAR-T) therapy, and unique needs for long-term survivors. [Table 2](#) collates the currently advised vaccination schedule from the CDC's Advisory Committee on Immunization Practices (ACIP) for immunocompromised hosts. This guideline will refer to this table and identify if, when, and what changes are recommended for an oncology population. Patients with cancer and coexisting medical conditions may also be eligible to receive additional vaccines. These vaccines and the specific risk situations where they should be considered or avoided are shown in [Table 3](#). Finally, [Table 4](#) shows the recommended vaccinations for patients with cancer who might not have received all or some of the routinely recommended immunizations as children. This guideline does not address vaccination recommendations for patients younger than 19 years, nor does it specify unique recommendations for patients living with HIV who also have cancer.

GUIDELINE QUESTIONS

This clinical practice guideline addresses four overarching clinical questions: (1) What are the recommended routine preventative vaccinations for adults with cancer? (2) What additional vaccinations and revaccinations are recommended for adults undergoing hematopoietic stem-cell transplantation (HSCT), CD19 CAR-T treatment, or B-cell-depleting therapy? (3) What additional vaccinations are recommended for adults with cancer who are traveling outside the United States?

TABLE 1. Summary of All Recommendations

Clinical Question	Recommendation	Evidence Quality	Strength of Recommendation
What are the recommended routine preventative vaccinations for adults with cancer?	1.1. Clinicians should determine vaccination status and ensure that adults newly diagnosed with cancer and about to start treatment are up to date on seasonal vaccines as well as age- and risk-based vaccines (see Tables 2-4)	Moderate	Strong
	1.2. Vaccination should ideally precede any planned cancer treatment by 2-4 weeks. However, nonlive vaccines can be administered during or after chemotherapy or immunotherapy, hormonal treatment, radiation, or surgery	Moderate	Strong
What additional vaccinations and revaccinations are recommended for adults undergoing hematopoietic stem-cell transplantation, CD19 CAR-T treatment, or B-cell-depleting therapy?	2.1. Complete revaccination starting 6-12 months after hematopoietic stem-cell transplant should be offered in order to restore vaccine-induced immunity. Live and live attenuated vaccines should be delayed for at least 2 years and only given in the absence of active GVHD or immunosuppression. COVID-19, influenza, and pneumococcal vaccines can be administered as early as 3 months after transplant	Moderate	Strong
	2.2. Adults with hematopoietic malignancies receiving CAR-T therapy directed against B-cell antigens (CD19, BCMA) should receive influenza and COVID-19 vaccine no sooner than 3 months after the completion of therapy. Nonlive vaccines should be administered no sooner than 6 months after completion of therapy	Very Low	Weak
	2.3. Adults who receive B-cell-depleting therapy should be revaccinated for COVID-19 only, no sooner than 6 months after completion of treatment	Moderate	Strong
	2.4. Long-term survivors of hematologic malignancy with or without active disease or those who have long-standing B-cell dysfunction or hypogammaglobulinemia from therapy or B-cell lineage malignancies should receive the recommended nonlive vaccines even though the response may be attenuated	Moderate	Strong
What additional vaccinations are recommended for adults with cancer who are traveling outside the United States?	3.0. Adults with solid and hematologic cancers traveling to an area of risk should follow the CDC standard recommendations for the destination <i>Note.</i> Hepatitis A, intramuscular typhoid vaccine, inactivated polio, hepatitis B, rabies, meningococcal, and nonlive Japanese encephalitis vaccines are safe	Moderate	Strong
What are vaccination recommendations for household and close contacts of adults with cancer?	4.0. It is recommended that all household members and close contacts, where feasible, be up to date on vaccinations	Moderate	Strong

Abbreviations: BCMA, B-cell maturation antigen; CDC, Centers for Disease Control and Prevention; CAR-T, chimeric antigen receptor T-cell; GVHD, graft-versus-host disease.

(4) What are vaccination recommendations for household and close contacts of adults with cancer?

METHODS

Guideline Development Process

This systematic review-based guideline was developed by a volunteer, multidisciplinary Expert Panel, which included a patient representative and an ASCO guidelines staff member with health research methodology expertise ([Appendix Table A1](#)).

The recommendations were developed using a systematic review of evidence identified through online searches of PubMed and the Cochrane Library from January 1, 2013, to February 16, 2023. This systematic review builds upon the 2013 Infectious Disease Society of America (IDSA) guideline on Vaccination of the Immunocompromised Host⁵ and may cite previous literature that provides the evidence base for the recommendation and for which no updates have

been published. Eligible publication types were systematic reviews, randomized controlled trials (RCTs), and non-randomized studies (for questions not addressed by systematic reviews or RCTs). Articles were selected for inclusion in the systematic review on the basis of the following criteria:

- Population: Adults with solid tumors or hematologic malignancies, including long-term survivors and those who received HSCT.
- Interventions: Routine vaccines listed on the CDC immunization schedules and travel vaccines.
- Comparisons: Placebo, different vaccines, or different strategies for vaccination (eg, different vaccine timings).
- Outcomes: Risk of infection, disease severity, mortality, cellular and humoral immune responses, and vaccine safety.

Articles were excluded from the systematic review if they were (1) meeting abstracts not subsequently published in peer-reviewed journals; (2) editorials, commentaries, letters, news articles, case reports, and narrative reviews; and (3) published in a non-English language.

TABLE 2. Recommended Immunizations for Adults With Cancer

Vaccine	Recommended Age	Schedule
Influenza ^a	All ages	Annually
RSV	60 years and older	Once
COVID-19	All ages	As per the latest CDC schedule for immunocompromised ¹⁷
Tdap or Td ^b	19 years and older	One dose of Tdap, followed by Td or Tdap booster every 10 years
Hepatitis B	19-59 years: eligible 60 years and older: immunize those with other risk factors ^c	For adults 20 years and older, use high antigen (40 µg) and administer as a three-dose Recombivax HB series (0, 1, 6 months) or four-dose Engerix-B series (0, 1, 2, 6 months) ¹⁸
Recombinant zoster vaccine	19 years and older	Two doses at least 4 weeks apart
Pneumococcal vaccine	19 years and older	One dose PCV15 followed by PPSV23 8 weeks later OR One dose PCV20 ^d
HPV	19-26 years: eligible 27-45 years: <i>shared decision making</i>	Three doses, 0, 1–2, 6-months

NOTE. Adapted from CDC Adult Immunization Schedule By Medical Condition and Other Indication.¹⁵ Information linking to US trade names for each vaccine is available and routinely updated at the CDC's website on vaccines.¹⁶ Coadministration of two or more of the recommended nonlive vaccines is acceptable per CDC guidelines. When given on separate days, there is no recommended waiting period. Note, PCV-15 and PPSV-23 should be separated by at least 8 weeks as noted in the table.

Abbreviations: CDC, Centers for Disease Control and Prevention; HPV, human papillomavirus; PCV, pneumococcal conjugate vaccine; PPSV-23, 23 valent Pneumococcal polysaccharide vaccine; RSV, respiratory syncytial virus; Td, tetanus and diphtheria; Tdap, tetanus, diphtheria and pertussis.

^aLive attenuated influenza vaccine, which is administered as a nasal spray, cannot be given to patients with cancer.

^bTdap has lower amounts of diphtheria and pertussis toxoid and is only used for those 7 years and older. DTaP, the pediatric vaccine for prevention of tetanus, diphtheria, and pertussis, is only for children younger than 7 years.

^cHIV, chronic liver diseases, intravenous drug use, sexual risk factors, incarcerated individuals.

^dPatients who have previously received PCV13 only can receive one dose of PCV 20 after an interval of 1 year.

Three full panel meetings were held, and members were asked to provide ongoing input on the guideline development protocol, quality and assessment of the evidence, and generation of recommendations; draft content; and review and approve drafts during the entire development of the guideline. ASCO staff met routinely with the Expert Panel cochairs and corresponded with the panel via e-mail to coordinate the process to completion. Ratings for the strength of the recommendation and evidence quality are provided with each recommendation, defined in Appendix Table A2. The quality of the evidence for each outcome was assessed using the Cochrane Risk of Bias tool and elements of the GRADE quality assessment and recommendation development process.^{19,20} GRADE quality assessment labels (ie, high, moderate, low, very low) were assigned for each outcome by the project methodologist in collaboration with the Expert Panel cochairs and reviewed by the full Expert Panel.

Guideline Review and Approval

The draft recommendations were released to the public for open comment from July 28 to August 11, 2023. Response categories of “Agree as written,” “Agree with suggested modifications,” and “Disagree. See comments” were captured for every proposed recommendation, with 47 written comments received. For each recommendation, the

proportion of respondents who agreed or agreed with slight modifications ranged from 88% to 100%. Expert Panel members reviewed comments from all sources and determined whether to maintain the original draft recommendations, revise with minor language changes, or consider major recommendation revisions. In addition, a guideline implementability review was conducted. On the basis of this review, revisions were made to the draft to clarify the recommended actions for clinical practice.

All changes were incorporated into the final manuscript before ASCO Evidence-Based Medicine Committee (EBMC) review and approval. All ASCO guidelines are ultimately reviewed and approved by the Expert Panel and the ASCO EBMC before submission to the *Journal of Clinical Oncology* for editorial review and consideration for publication.

Guideline Updating

The ASCO Expert Panel and guideline staff will work with cochairs to keep abreast of any substantive updates to the guideline. On the basis of a formal review of the emerging literature, ASCO will determine the need to update. The ASCO Guidelines Methodology Manual (available at www.asco.org/guideline-methodology) provides additional information about the guideline update process. This is the most recent information as of the publication date.

TABLE 3. Recommendations for Other Vaccines That May be Indicated for Adults With Cancer and Coexisting Health Conditions

Vaccine	Type	Other Risk Factor	Recommendation
Haemophilus influenzae type b vaccination (Hib)	Nonlive	Anatomic asplenia	For elective splenectomy: one dose at least 14 days before splenectomy (preferred)
		Functional asplenia	One dose if previously did not receive Hib
Hepatitis A vaccination	Nonlive	Chronic liver disease, HIV, MSM, homelessness, injection or noninjection drug use, occupational exposure, travel	Two-dose series HepA or three-dose series HepA-HepB
Meningococcal vaccination ^a	Men ACWY (nonlive)	Anatomic or functional asplenia, complement component deficiency, complement inhibitor (eg, eculizumab, ravulizumab), Travel, Occupational, Military recruits, Residential living for college students	Two-dose series MenACWY-D Frequency: 8 weeks apart Revaccinate every 5 years if risk remains
	Men B (nonlive)	Anatomic or functional asplenia (including sickle cell disease), persistent complement component deficiency, complement inhibitor (eg, eculizumab, ravulizumab) use, occupational (microbiologists), pregnancy, MSM outbreak setting	Two-dose primary series MenB-4C at least 1 month apart Or three-dose primary series MenB-FHbp at 0, 1-2, 6 months Revaccinate every 2-3 years if risk remains
IPV	Nonlive	Travel Community risk (eg, wastewater detection of vDPV)	Single booster
MMR	Live	No evidence of immunity: HIV (CD4 >200 for 6 months), HCP, outbreak setting, travel	Contraindicated with cancer treatment and other immunocompromising conditions
Varicella	Live	Postexposure	Contraindicated with cancer treatment and other immunocompromising conditions
MVA (Monkeypox)	Live (replication-deficient)	Postexposure, Occupational exposure (laboratory worker), high risk	Safe to administer in persons with HIV or those on immunosuppressive therapies
Monkeypox and smallpox (ACAM2000)	Live		Contraindicated with cancer treatment and other immunocompromising conditions

NOTE. Adapted from CDC Adult Immunization Schedule By Medical Condition and Other Indication (<https://www.cdc.gov/vaccines/schedules/hcp/imz/adult-conditions.html>).¹⁵

Abbreviations: HCP, health care personnel; Hib, Haemophilus influenzae type b; IPV, inactivated poliovirus vaccine; Men, meningococcal; MMR, measles, mumps, and rubella; MSM, men who have sex with men; MVA, modified Vaccina Ankara; vDPV, vaccine-derived poliovirus.

^aPatients eligible for both meningococcal vaccines can receive the new Men ABCWY.

RESULTS

Characteristics of Studies Identified in the Literature Search

A total of 1,596 publications were identified in the literature search. After applying the eligibility criteria, 102 studies remained, forming the evidentiary basis for the guideline recommendations: 24 systematic reviews,^{11,21-43} 14 RCTs,^{6,44-56} and 64 nonrandomized studies.^{57-84,85-104,105-120}

The identified trials were published between 2013 and 2023. The largest body of evidence focused on the immunogenicity of COVID-19 vaccines and how this may vary by type of cancer and cancer therapy. Nonrandomized studies have also evaluated the association between COVID-19 vaccination status and COVID-19 infections and hospitalizations in patients with cancer. For influenza vaccines, RCTs considered whether variations in the timing of administration, vaccine type, or number of doses affect immunogenicity or influenza outcomes. For both COVID-19 and influenza vaccines, systematic reviews have explored whether vaccination affects the frequency of immune-related adverse

events. Smaller numbers of studies addressed other routine adult vaccines. Characteristics and results of the systematic reviews and RCTs are provided in the Data Supplement. Nonrandomized studies are listed by topic in the Supplement, but data were not extracted in full.

Evidence Quality Assessment

The quality of evidence was assessed for each outcome of interest. This rating includes factors such as study design, consistency of results, directness of evidence, precision, publication bias, and magnitude of effect, assessed by one reviewer. Evidence quality was rated as moderate with one exception: very little evidence is available regarding the optimal timing of vaccination after CAR-T therapy. The moderate rating for remaining settings was due to the relatively small number of RCTs in patients with cancer, but a consistent body of evidence from nonrandomized studies. Refer to Appendix [Table A2](#) for definitions of the quality of the evidence, and the Methodology Manual for more information.

RECOMMENDATIONS

All recommendations are available in [Table 1](#).

TABLE 4. Other Vaccine Recommendations for Previously Unimmunized Adults With Cancer

Vaccine	Recommended doses ^a
IPV	Complete three-dose series
Tdap	One dose of Tdap followed by one dose of Td or Tdap at least 4 weeks later, and a third dose of Td or Tdap 6-12 months later
Hepatitis A	Perform serologic assessment for past infection. If negative, vaccinate as per Table 3
Hepatitis B	Perform serologic assessment for past infection. If HBsAg is negative, vaccinate as per Table 2
Varicella	Cannot be given to immunocompromised patients. Patients with solid tumors receiving chemotherapy, immunotherapy, or radiation should be assumed to be immunocompromised
MMR	For solid tumors, vaccines may be considered at least 4 weeks before cancer treatment initiation and wait at least 3 months after completion

NOTE. Adapted from CDC Adult Immunization Schedule By Medical Condition and Other Indication.¹⁵

Abbreviations: HBsAg, Hepatitis B surface antigen; IPV, inactivated poliovirus vaccine; MMR, measles, mumps, and rubella; Td, tetanus and diphtheria; Tdap, tetanus, diphtheria and pertussis.

^aTiming of recommended doses: Start immunization before chemotherapy when possible. Measurement of the immune response to decide on repeating doses after treatment completion can be considered. Delay vaccination for 6 months after B-cell depletion for indicated vaccines. See separate recommendations for patients undergoing stem-cell transplant or chimeric antigen receptor T-cell therapy.

CLINICAL QUESTION 1: WHAT ARE THE RECOMMENDED ROUTINE PREVENTATIVE VACCINATIONS FOR ADULTS WITH CANCER?

Studies conducted since the 2013 IDSA guideline⁵ have addressed new vaccines and the vaccination of patients receiving new types of cancer therapies. Researchers have continued to investigate the safety, immunogenicity, and optimal timing of vaccinations during cancer treatment. The recommended vaccines from ACIP for adults with cancer are summarized in [Table 2](#). The literature review and analysis primarily focus on new evidence regarding recommended uses of these vaccines. Additional information for each vaccine, including side effects, is available from CDC.¹²¹ The approach to immunization and reimmunization after procedures such as HSCT, CAR-T therapy, and treatments involving specific B-cell depletion necessitates unique considerations. These are addressed separately under Clinical Question 2.

Advances in treatment, including the presence of multiple lines of effective systemic therapy, have resulted in improved survival for patients with cancer. However, cancer therapies may also render individuals at higher risk for some infections. Patients with certain types of cancer, as well as those receiving certain cancer therapies, may have lower seroconversion rates after vaccination. Thus, when feasible, it is of paramount importance that patients with cancer receive up-to-date seasonal vaccines as well as age- and risk-based vaccines (preferably 2-4 weeks) prior to the initiation of treatment, allowing them to mount an adequate response. This approach also applies to under- or unvaccinated adults for whom the role of vaccination catch-up becomes more pronounced. Even if the vaccines cannot be given within the recommended time frame due to the urgency or ongoing nature of the cancer treatment, vaccine administration should still be strongly advised early in the

treatment journey acknowledging more flexible intercalation of nonlive vaccines during cancer therapy.

COVID-19 Vaccines

Literature Review and Analysis

A large body of evidence has addressed serologic response to COVID-19 vaccination among patients with cancer. In adults with solid tumors, seroconversion rates tend to be lower than in patients without cancer, with meta-analyses reporting relative risks ranging from 0.90 to 0.95.^{22,31,36} Seroconversion rates may vary by the duration of cancer and treatment modality, with lower rates observed among recently diagnosed patients and those receiving cytotoxic treatments. Humoral responses are only minimally diminished in patients with solid tumors who are receiving immune checkpoint inhibitors (ICIs) or targeted therapy.¹¹

Seroconversion rates are heterogeneous and overall lower among patients with hematologic cancer than patients with solid tumors.^{22,30,31,34,37,40} In a 2022 meta-analysis, seroconversion after two vaccine doses was 95% among patients with solid tumors, 64% among patients with hematologic cancers, and 42% in patients with chronic lymphocytic leukemia (CLL).⁴⁰ Treatments associated with reduced seroconversion rates included anti-CD20 agents and other B-cell-directed therapies, Janus kinase (JAK) inhibitors, high-dose corticosteroids, and CAR-T therapy.^{37,40} Lack of serological responses after specific B-cell-targeted therapies can extend for up to a year after treatment completion and may warrant revaccination. The panel addresses the approach in these situations in Clinical Question 2.

Five nonrandomized studies support the benefit of vaccination in reducing the risk of severe COVID-19 illness in patients with cancer.^{62,67,71,75,112} One study of 1,610 patients

with cancer and a positive COVID-19 test reported that vaccinated individuals were significantly less likely to experience hospitalization for COVID-19 or death within 30 days, compared with unvaccinated individuals (odds ratio, 0.44 [95% CI, 0.28 to 0.72]).⁶² The remaining studies also report reduced rates of hospitalization and mortality^{67,75,112} or reduced COVID-19 sequelae⁷¹ in vaccinated versus unvaccinated adults with cancer.

The vast majority of adverse events after COVID-19 vaccination are mild to moderate (grade 1 or 2), with the most common side effects being injection site pain, fatigue, myalgia, headache, and fever.⁴¹ Vaccination has been associated with transient axillary adenopathy, and the Society of Breast Imaging has provided guidance on this topic.¹²²

Clinical Interpretation

COVID-19 resulted in many more hospitalizations and deaths among immunocompromised patients with cancer prior to COVID-19 vaccine availability.⁷¹ The COVID-19 vaccines protect patients with cancer, reducing the risk of severe COVID-19 illness and hospitalization.^{62,67,71,75,112} The most current recommendation for previously COVID-19–vaccinated individuals is to receive at least one dose of the updated 2023–2024 COVID-19 vaccine (any authorized formulation).¹⁷ There is no recommended optimal timing during treatment cycles. Providers should strongly recommend additional vaccine doses after a 2-month interval for patients receiving therapies known to weaken vaccine responses. It is recommended to postpone immunization for 2–3 months for individuals who have recently had a COVID-19 infection.

Influenza Vaccines

Literature Review and Analysis

Nine RCTs have evaluated questions such as high-dose and adjuvanted influenza vaccines, as well as vaccine timing, and second vaccine doses with the goal of increasing response to vaccination among patients with cancer.^{6,44–51} High-dose trivalent influenza vaccine was compared with standard-dose trivalent influenza vaccine in a 2016 pilot RCT that enrolled 100 adults under the age of 65 who were receiving chemotherapy with curative intent.⁴⁸ Local site pain was more common in the high-dose group. There were no serious adverse events. Seroconversion rates for all three influenza antigens were higher in the high-dose group. Seroprotection did not differ significantly by vaccine group. Although evidence is limited, RCTs of influenza vaccine timing during chemotherapy report that earlier vaccination is safe and may provide benefits. Vaccination on day 1 or day 11 of chemotherapy resulted in similar rates of seroprotection in adults with solid tumors (primarily breast or lung) undergoing 3-week cytotoxic chemotherapy, but day 1 vaccination was associated with a reduced risk of adverse effects (13% v 32%, $P = .04$; most adverse effects were

mild).⁴⁹ Early (day 5 after chemotherapy) and later (day 16 after chemotherapy) influenza vaccinations were also assessed in a trial of patients undergoing chemotherapy for breast or colorectal cancer; higher serologic response was observed with early vaccination in patients with breast cancer only.⁶

Clinical Interpretation

Influenza vaccines improve infection-related outcomes in patients with cancer and are recommended annually, ideally to be received by early fall²³ in the Northern Hemisphere. Earlier vaccination can be associated with waning immunity later in the season. Patients aged 65 years and older should receive one of the preferentially recommended high-dose or adjuvanted vaccine formulations (high-dose Quadrivalent vaccine, Quadrivalent recombinant flu vaccine, and Quadrivalent adjuvanted flu vaccine) licensed for patients in this age group.^{123–125}

Studies examining the optimal timing for administering the inactivated influenza vaccine (IIV) during cancer treatment are limited and have yielded varied conclusions when comparing responses to vaccines administered concurrently with chemotherapy, at initiation, a few days later, or between treatment cycles.^{6,49}

Furthermore, several investigations have explored different strategies to enhance the immunogenicity of IIV. Notably, the high-dose IIV has demonstrated safety and superior immunogenicity in adults aged 65 years and younger with cancer.⁴⁸ In the general adult population 50–64 years of age, a recent study shows modest relative vaccine effectiveness of the high-dose recombinant vaccine against influenza infection compared to standard-dose (15.3% [95% CI, 5.9 to 23.8]), without significant differences in the risk of influenza-related or all-cause hospitalizations and deaths.¹²⁶ Nevertheless, evidence remains limited regarding the immunogenicity and clinical benefit of high dose versus standard dose, making it difficult to preferentially recommend the high-dose vaccine for adults with cancer who are below 65 years of age. Similarly, the evidence for adjuvanted formulation⁵⁰ or a two-dose vaccine series⁴⁵ does not show clear benefit. In general, individuals should receive the vaccine when possible, with whichever formulation is locally available. The COVID-19 vaccine can be coadministered with the influenza vaccine, and it is safe to vaccinate concurrently with cytotoxic chemotherapy or during the cytopenic period. Finally, the live attenuated influenza vaccine, given as a nasal spray and approved for use in nonpregnant individuals 2–49 years of age, should not be administered to patients with cancer.

Hepatitis B Vaccine

Literature Review and Analysis

No eligible studies were identified by the systematic review.

Clinical Interpretation

In oncology settings, many individuals are screened for hepatitis B before initiating certain anticancer therapies due to the risk of reactivation in those with occult hepatitis B infection.¹²⁷ Although testing is not specifically required prior to hepatitis B vaccination, this screening practice offers a unique opportunity to assess immunity to hepatitis B, previous vaccination status, and to immunize individuals who have never been vaccinated before.

Hepatitis B surface antibody concentrations can be lower in patients who receive hepatitis B vaccine during chemotherapy.¹²⁸ Accelerated vaccination schedules for hepatitis B and newer two-dose and adjuvanted vaccine formulations have not been thoroughly evaluated in patients with cancer or other immunocompromising conditions. ACIP recommends that immunocompromised patients receive a higher antigen dose as shown in Table 2.¹²⁹ Administration of a second complete series has been shown to improve the seroprotection rates in nonresponders. Consequently, postvaccination antisurface antibody titers should be checked 1–2 months after the last dose, and the vaccine series should be repeated if hepatitis B surface antibody concentrations >10 mIU/mL are not achieved.

Human Papillomavirus Vaccine

Literature Review and Analysis

No eligible studies were identified by the systematic review.

Clinical Interpretation

Young cancer survivors have a higher incidence of secondary human papillomavirus (HPV)-associated malignancies when compared to the general population.¹³⁰ A significant factor contributing to this is underimmunization.¹³¹ Studies have revealed that HPV vaccines are as immunogenic in young cancer survivors as they are in the general population. When to administer the vaccine should be based on individual risks.^{132,133} It is important to note that HPV testing or cytology screening is not required before vaccination.

Pneumococcal Vaccines

Literature Review and Analysis

In a small RCT of patients with gastric and colon cancer, vaccination on the day of chemotherapy or 2 weeks before initiation showed comparable immune responses.⁵³

Clinical Interpretation

Patients with cancer undergoing treatment face a significantly higher risk of invasive pneumococcal disease (IPD) compared to the general population. Those diagnosed with hematologic malignancies have a 50-fold elevated risk.¹³⁴

Pneumococcal vaccination improves patient outcomes by reducing the incidence of pneumonia and the need for hospitalization in this patient population.⁶⁶

Notably, patients who have traditionally exhibited poor responses to polysaccharide vaccines, such as those with CLL, demonstrate improved antibody levels with the polysaccharide protein-conjugated vaccines. Still, humoral responses are subdued in patients treated with anti-CD20 therapies and Bruton Tyrosine Kinase (BTK) inhibitors. The most robust immune responses are achieved when the vaccine is administered before starting treatment or before the onset of hypogammaglobulinemia, underscoring the importance of early vaccination.^{52,88,135–138}

Initial priming with a conjugate vaccine enhances the antibody response to subsequently administered vaccines, informing the currently recommended approach. In the United States, two conjugate vaccines are available: pneumococcal conjugate vaccine (PCV)-15 and PCV-20. Vaccine-naïve adult patients with cancer can receive either one dose of PCV-20 only or a dose of PCV-15 followed by a dose of PPSV23, with at least 8 weeks between administrations.

Recombinant Zoster Vaccine

Literature Review and Analysis

The adjuvanted, recombinant zoster vaccine (RZV) was approved by the US Food and Drug Administration (FDA) in 2017. It is a nonlive, adjuvanted recombinant subunit (surface glycoprotein E) vaccine. Two doses of the vaccine are immunogenic in patients with solid tumors⁵⁶ and hematologic malignancies.⁵⁵ Humoral responses tended to be higher when the vaccine was given before or after immunosuppressive therapy, rather than during therapy. Adverse events were common with RZV. Grade 3 local adverse events, such as injection-site pain, were reported in 12%–13% of patients in the vaccine arms and no one in the placebo arms.^{55,56} Grade 3, solicited general adverse events were reported by patients in both the vaccine and placebo arms but were more common in the vaccine arms (22% v 16%⁵⁶ and 16% v 6%⁵⁵). As is the case for COVID-19 vaccines, response to the RZV was lower in patients treated with BTK inhibitors.¹⁰³

Clinical Interpretation

The incidence of herpes zoster is particularly high in the first 2 years following a cancer diagnosis, with the greatest risk observed in patients with hematologic malignancies, particularly multiple myeloma. Furthermore, cancer-related herpes zoster risk elevation is greater in younger patients (those below 50 years of age) compared with older adults.¹³⁹ Complications of herpes zoster, such as postherpetic neuralgia, can significantly diminish quality of life.

The approval of the adjuvanted, RZV by the US FDA in 2017 marked a significant scientific advancement, especially since

the previous vaccine, a live attenuated formulation, was not recommended for patients with cancer. RZV should be made available to all adults with cancer. The vaccine remains immunogenic even after cancer treatment has begun. However, the most optimal humoral and cellular responses are expected when the vaccine is administered immediately after a cancer diagnosis and before the initiation of immunosuppressive treatments. The interval between the two RZV doses can be reduced to 4 weeks to achieve early protection.

The RZV has not been studied in patients with cancer who do not have a history of primary varicella (chickenpox). Patients who have experienced herpes zoster should receive the vaccine to prevent future episodes. There is no specific waiting period before immunization, as long as the acute episode has resolved. Patients who may have previously received the live zoster vaccine before cancer diagnosis are eligible to be immunized with the RZV. Finally, the duration of clinical protection from RZV is unclear at this time and vaccination should not influence the duration of antiviral prophylaxis with certain therapies (eg, proteasome inhibitors).

Respiratory Syncytial Virus Vaccines

Literature Review and Analysis

No eligible studies were identified by the systematic review.

Clinical Interpretation

Patients aged 60 years and older with cancer are eligible to receive the respiratory syncytial virus (RSV) vaccine (Table 2). According to the CDC, the RSV vaccine can be coadministered with other seasonal immunizations. There are no data to guide the use of RSV vaccines in patients with cancer younger than 60. No specific recommendation can be made for this age group.

Tetanus, Diphtheria, and Acellular Pertussis Vaccine

Literature Review and Analysis

No eligible studies were identified by the systematic review.

Clinical Interpretation

Immunity to tetanus, diphtheria, and acellular pertussis (Tdap) tends to decrease with age, and this decline may be accelerated after cancer treatment.¹⁴⁰ It is strongly recommended that individuals diagnosed with cancer receive the Tdap vaccine if they have not been vaccinated as adults (Table 2).

Vaccination of Adults Receiving ICI Therapy

The question of whether vaccination affects the risk of immune-related adverse events in patients receiving checkpoint inhibitor therapy has been evaluated for both influenza and COVID-19 vaccines. A 2023 meta-analysis of COVID-19

vaccination (primarily mRNA vaccines) found that rates of seroconversion were similar in patients receiving ICIs and in a control group of patients without cancer (relative risk, 0.97 [95% CI, 0.92 to 1.03]³⁹). Vaccine side effects tended to be mild or moderate, with the most common being local pain and fatigue. Retrospective studies comparing vaccinated with unvaccinated individuals or historical cohorts have not found an increased risk of immune-related adverse events associated with the COVID-19 vaccines.¹⁴¹⁻¹⁴³ Nonsignificant differences in the frequency of immune-related adverse events by vaccination status were also reported in two systematic reviews of patients who received influenza vaccines during ICI therapy.^{33,42}

CLINICAL QUESTION 2: WHAT ADDITIONAL VACCINATIONS AND REVACCINATIONS ARE RECOMMENDED FOR ADULTS UNDERGOING HSCT, CD19 CAR-T TREATMENT, OR B-CELL-DEPLETING THERAPY?

HSCT Recipients

Numerous studies have shown that adult HSCT recipients lose immunity from childhood immunizations and are vulnerable to vaccine-preventable illnesses, particularly in the first year after transplant. Revaccination is essential to restore this immunity, and the optimal vaccine timing is based on adequate B- and T-cell recovery. Various disease, transplant, and recipient factors influence the immunologic recovery and responses to the vaccine, including recipient age, donor source, vaccine type, timing from transplant, graft-versus-host disease (GVHD) prophylaxis, ongoing immunosuppression, GVHD severity, and vaccine antigens. Understanding the influence of these factors has become particularly important given the increasing use of haploidentical donors and in vivo T-cell depletion to increase donor availability and decrease GVHD incidence and severity, as both have been associated with increased infectious complications including viral reactivation.

The IDSA, CDC, the American Society for Transplantation and Cellular Therapy, European Society for Blood and Marrow Transplantation (EBMT), and European Conference on Infections in Leukemia have existing guidelines on the approach to vaccination in HSCT recipients.^{5,144-147} Immunologic parameters such as CD19⁺ and CD27⁺ B-cell (memory B-cells) count, immunoglobulin G levels, and CD4 count could be used to guide timing. Still, there is no standardized approach for applying these immune predictors, nor is there consensus on whether immune predictor-guided vaccination schedules are more likely to induce a protective immune response than a standardized schedule based on the time elapsed after transplantation. Furthermore, the durability of protection attained by post-transplant vaccination needs to be better understood.

COVID-19 Vaccines

Literature review and analysis. Assessments of primary mRNA vaccines among HSCT recipients demonstrate

vaccines elicit an immune response in these individuals; however, the overall humoral response is lower compared to other groups, with studies showing a range of 79.6%–86.1% for both allogeneic (allo) and autologous (auto) HSCT. COVID-19 antibody and cellular responses are lower in patients undergoing HSCT than healthy volunteers and patients with solid tumors. Humoral responses are subdued in the first year after HSCT, and this effect is more pronounced with advanced age, concurrent lymphopenia, GVHD, underlying non-Hodgkin lymphoma, and ongoing immunosuppressive or corticosteroid use.^{57,95,99} Evidence also indicates that seroconversion is improved with additional primary and booster doses to address poor initial response and accelerated antibody decay in HSCT recipients.¹⁴⁸

A substantial subset of humoral nonresponders can mount virus-specific cellular immune responses after vaccination. A single multicenter prospective study of allo HSCT supports early COVID-19 vaccination before 4 months with comparable humoral and cellular responses to those starting vaccination between 4 and 12 months, including among those with GVHD and ongoing immunosuppression.⁷⁷ Reports of GVHD flares after COVID-19 vaccination are inconclusive for a causal association, and no other significant safety concerns have emerged.^{57,77,80}

Clinical interpretation. COVID-19–related mortality in HSCT has improved with the availability of vaccines, antivirals, and immunotherapeutics to treat and prevent COVID-19. Vaccine effectiveness is lower in HSCT recipients when compared to immunocompetent individuals and wanes more rapidly, particularly in the first year after HSCT. Studies have consistently shown that mRNA vaccines are immunogenic in HSCT recipients. Still, a two-dose series elicits lower responses when compared to the general population and patients undergoing treatment for solid tumors. Other factors adversely influencing vaccine immunogenicity are older age, lymphopenia, corticosteroid use, and chronic GVHD. Lymphoid malignancies, especially for which anti-CD20 therapies precede HSCT, are another critical determinant of a less robust humoral response. Overall, responses after autologous transplant, especially among those with multiple myeloma, are higher than those observed after allogeneic HSCT.

T-cell responses are elicited in a subset of HSCT patients despite a lack of seroconversion and may play an essential role in protection against severe disease, especially when humoral defenses are impaired. A third vaccine dose in the primary series can boost cell-mediated responses and antibody titers and is therefore the currently recommended approach for revaccination after HSCT. Vaccination earlier after transplant is desirable, as a shorter time interval from transplant correlates with worse COVID-19 outcomes. At least one study of allogeneic HSCT recipients showed good immune responses, including among patients with acute GVHD,⁷⁷ lending support to the current recommendations by

leading US and European transplant professional societies to start vaccination at 3 months after HSCT. Vaccination should be completed with the most updated formulation recommended by public health agencies.

Donor vaccination is neither practical nor advantageous over current approaches, and ethical considerations add further complexity. The data on mRNA vaccines as a trigger for GVHD have led to different conclusions. Accelerated immune decay in HSCT is an area of ongoing investigation to optimize the timing and number of booster doses.

Influenza Vaccines

Literature review and analysis. Studies have shown that IIVs offer significant clinical protection, despite low serological responses among HSCT recipients.^{87,100} Influenza vaccine is generally administered 6 months post-HSCT, but due to the seasonal nature of the infection, can be given earlier, between 3–6 months post–auto- or allo-HSCT during periods when high community transmission is expected. RCTs have compared the seroconversion rates with adjuvanted and nonadjuvanted influenza vaccines in adult allogeneic HSCT recipients demonstrating similar immunogenicity.⁵⁰ Two RCTs in adult allogeneic HSCT recipients comparing single and two high-dose versus standard-dose formulations show higher antibody titers after the high-dose influenza vaccine compared to the standard dose to H3N2 and H1N1 antigens and H3N2 and B Victoria antigens, respectively.^{47,149} Auto-HSCT patients vaccinated at a median of 2.3 months after transplant achieved a high seroprotection rate for all influenza antigens using a two-dose approach with an initial high-dose or standard dose followed by a second SD in both arms, ranging from 75.8% to 97.1%.⁵¹ In contrast, no significant increase in seroprotection or seroconversion for all influenza antigens occurred in allo-HSCT recipients after two doses of standard-dose IIV, especially in those vaccinated within the first year of HSCT.⁴⁴ Two high-dose IIV doses were safe and showed superior immunogenicity for influenza A antigens compared to standard dose in pediatric HSCT recipients ages 3–17 years.¹⁵⁰

Clinical interpretation. The high-dose influenza vaccine is safe and has improved immunogenicity compared to the standard-dose vaccine. Thus, high-dose IIV is preferred in adult HSCT recipients regardless of age. The data supporting the superiority of a two-dose regimen of standard or high doses are less robust.

Pneumococcal Vaccines

Literature review and analysis. HSCT recipients are at exceptionally high risk for infections with encapsulated bacteria early after transplant and have among the highest incidence of IPD, especially in the first year after HSCT.¹⁰⁹ Introduction of the PCV has significantly reduced IPD in

HSCT recipients.¹⁰⁶ Post-transplant studies show that 64%–98% of recipients develop antibody responses against covered serotypes, varying by vaccine type, time from transplant, and GVHD-associated immunosuppression. To mitigate the risk of early IPD, a pneumococcal 13-valent conjugate vaccine (PCV-13) schedule beginning at 3 months post-transplant revealed a comparable level of functional antibodies to late immunization beginning at 9 months.⁷⁰ However, earlier vaccination was associated with waning protection and lower responses in patients with GVHD.⁷⁰ Overall, studies that have compared early versus late pneumococcal immunization show similar initial antibody responses but a significant decline by 24 months in the early group.⁸²

Although no studies are available with the pneumococcal 20-valent conjugate vaccine (PCV-20) in HSCT recipients and the practical experience with this approach is limited, the current US recommendation is to revaccinate all HSCT recipients with the first dose of PCV-20 at 4–6 months after transplant since this adds coverage for additional pneumococcal serotypes.^{74,151} The subsequent two doses are given at 1-month intervals, followed by the fourth dose administered 6 months later. Patients who have started revaccination with PCV-15 can complete subsequent doses with PCV-20. However, for the PCV-15 series, PPSV-23, a pneumococcal polysaccharide vaccine, can be administered 2 months after the fourth PCV-15 dose. The long-term immunity from conjugated vaccines in HSCT survivors with and without GVHD remains undetermined.

Clinical interpretation. Earlier revaccination of HSCT recipients starting after 3 months is the preferred approach in combination with a fourth conjugate vaccine dose administered at 1 year. Improved immunogenicity of the conjugated vaccine and the expanding serotype coverage have led to preference for the PCV-20 vaccine, although evidence remains limited. Surveillance of circulating pneumococcal serotypes in the community and review of timely national guidelines will help determine whether a PPSV-23 boost is necessary after the pneumococcal 20-valent conjugate vaccine to cover the additional serotypes. The benefit of administering additional doses needs to be defined in the future.⁶⁹

RZV

Literature review and analysis. The pivotal Zoster Efficacy in HSCT trial demonstrated robust antiglycoprotein antibody and cellular responses in vaccine recipients. In auto HSCT recipients who received the vaccine between 50 and 70 days after transplant, the overall clinical efficacy was 68.2% (95% CI, 56 to 78) for herpes zoster prevention at a median of 21 months.^{54,152} Follow-up evaluations showed sustained clinical vaccine effectiveness at 2 years after vaccination, including 72% for patients with multiple myeloma and 61% for those with non-Hodgkin's lymphoma, without significant difference in patients 18–49 years old and those 50 and older.¹⁵³ Humoral responses declined significantly at 2 years

after vaccination and were overall lower in patients with non-Hodgkin's lymphoma; however, robust cell-mediated immune responses were retained and comparable across both age groups and disease type,¹⁵³ suggesting vaccine-generated polyfunctional T-cell immunity renders primary immune protection against herpes zoster. The RZV assessments in allogeneic HSCT are limited to small studies with incomplete immunologic measurements, but the vaccine is safe without the risk of GVHD exacerbation.⁵⁹ Finally, while the RZV is not approved for the prevention of primary varicella, the evidence reports this as a safe and effective strategy.

Clinical interpretation. Although no data are available to guide the use of RZV in allo-HSCT, the vaccine may be administered after the end of antiviral prophylaxis, usually 12–18 months after an allogeneic and 3–12 months after an autologous HSCT. Antiviral prophylaxis should be continued longer if there is an indication, such as chronic GVHD or ongoing immunosuppression related to transplant or other comorbidities.

Hepatitis B Vaccine

Literature review and analysis. Vaccination with three or four doses of the recombinant hepatitis B vaccine (Table 2) is recommended between 6 and 12 months after HSCT. Seroreversion rates with revaccination in the first year after auto- and allo-HSCT have ranged from 64% to 100% and are lower among older individuals and those with GVHD.¹⁵⁴ Reactivation after post-transplant immunization of recipients with resolved hepatitis B infection (core antibody positive; surface antigen negative) can happen irrespective of anti-hepatitis B surface antibody levels and with a cumulative 3-year risk of 29%.^{94,113,155}

Clinical interpretation. Hepatitis B vaccines are safe and immunogenic in HSCT patients. Hepatitis B surface antibody titers should be routinely checked 6 months post-immunization, especially for those vaccinated within 12 months of transplant, and a three-dose series repeated for levels below the protective threshold (hepatitis B surface antibody <10 mIU/mL).

Viral reactivation, in patients with occult hepatitis B infection (core antibody-positive, surface antigen-negative), can be a late complication after antiviral cessation, with a 2-year cumulative risk of up to 40%.^{156–158} Although high surface antibody levels correlate with a lower risk of reactivation,¹⁵⁹ it remains unclear whether immunization of HSCT donors and recipients to increase antibody levels confers durable clinical protection against reactivation in HSCT recipients with occult hepatitis B infection.¹⁵⁷

Diphtheria, Tetanus, Pertussis, Polio, and Haemophilus B Influenza

Literature review and analysis. Generally, revaccination with these childhood immunizations is recommended

starting 6–12 months after transplant regardless of ongoing immunosuppression. A report of 84 allo-HSCT recipients immunized with Diphtheria, Tetanus, Pertussis, Polio, Haemophilus B Influenza (DTaP-IPV-Hib) at a median of 369 days (86% between 100 and 500 days), including 13% with active GVHD, reported serological responses as follows: Haemophilus B Influenza 97.4%; diphtheria 88%; tetanus 95.2%; and pertussis 68.3%.¹⁰⁷ Most pertussis vaccine responders had protective antibodies to all other vaccine antigens (96.4%–100%). Prior GVHD was present in 88.9% of the nonresponders, and only 54.7% of the responders.¹⁰⁷ A recent study evaluated combined pediatric formulations of diphtheria, tetanus, acellular pertussis, hepatitis B, inactivated poliovirus, and Hemophilus influenzae (DTaP-HB-IPV-Hib) in adults who underwent allo-HSCT, including a third of the participants with chronic GVHD and were reimmunized at a median of 12 months after transplant. Results showed >90% serological responses sustained through 2 years after transplant for all antigens except hepatitis B.⁶⁸ Existing data support that high antigen dose-containing vaccines give superior immune responses and are safe. In the United States, adult HSCT recipients can receive either three doses of DTaP or Tdap followed by two doses of Diphtheria and Tetanus vaccine (DT or Td). Routine revaccination of adult transplant recipients with DTaP is standard practice at European transplant centers.¹⁰⁷

Clinical interpretation. Booster doses are likely to be needed in transplant recipients since patients lose protective antibody levels over time, especially against diphtheria.¹⁶⁰

Meningococcal Conjugate Vaccine

Literature review and analysis. A study of 67 auto- and allo-HSCT recipients vaccinated with the meningococcal conjugate vaccine, of whom 59% had GVHD, demonstrated serogroup-specific responses in those without pre-existing immunity of 77% (serogroup A); 65.5% (serogroup C); 52% (serogroup W-135); and 65% (serogroup Y).^{60,64}

Clinical interpretation. Two doses of quadrivalent meningococcal vaccine 2 months apart are recommended 6–12 months after transplant for recipients with risk factors. Meningococcal B vaccines should also be offered to HSCT recipients with high-risk conditions or young adults (16–23 years old) who are eligible to receive the vaccine. Booster doses are likely to be needed in transplant recipients since patients lose protective antibody levels over time.

HPV Vaccine

Literature review and analysis. HPV-associated cancers often occur among HSCT survivors.^{161,162} The combination of HPV infection prior to transplant and development of GVHD are associated with a high burden of post-transplant multifocal HPV-associated epithelial hyperplasia, with a 5- and 10-year cumulative risk of 28.1% and 36.7%, respectively.¹⁶¹ The quadrivalent HPV vaccine, when given at a median of

2.5 years from transplant, induced antibody responses comparable to healthy controls in a study of 44 women who had undergone allo-HSCT, wherein half of the patients were receiving systemic immunosuppression. The vaccine was well tolerated with mild side effects and without GVHD exacerbation.¹¹¹

Clinical interpretation. Immunogenicity of HPV vaccines has not been well studied in HSCT recipients. It is especially important to revaccinate young (age 19–45 years) transplant recipients who are not only at heightened risk of HPV exposure but are also at a greater risk of developing HPV-related cancers compared to the general population. The HPV 9-valent vaccine is broadly recommended for adults up to age 45 years.¹⁶³ Whether older already-HPV-infected individuals will have a reduced risk of HPV-associated cancers from post-transplant vaccination is currently unknown and an area for study. The optimal timing for HPV vaccination after HSCT is not established and can be initiated around 9–12 months.

RSV Vaccines

Literature review and analysis. No eligible studies were identified by the systematic review.

Clinical interpretation. Two RSV vaccines were recently licensed in multiple countries for adults aged 60 and older who are at high risk for RSV lower respiratory tract infection. Pivotal trials did not include immunocompromised patients and there are no data available on immunogenicity in HSCT, or to guide the timing or doses of RSV vaccines after cellular therapies.

Live Vaccines: MMR and Varicella

MMR. MMR antibody levels wane significantly after transplant, especially among those with vaccine-induced immunity.¹⁶⁴ MMR is a routinely recommended live vaccine for seronegative transplant recipients. The vaccine should be given no sooner than 2 years after HSCT, provided there is no occurrence of GVHD. Individual assessment should be made to determine the timing for patients with resolving GVHD. Additionally, the patient should not have received systemic immunosuppressives or intravenous immunoglobulin (IVIG) for 8–11 months prior to vaccine administration.

Varicella. A two-dose series of varicella vaccines administered 1 month apart may be given to varicella-seronegative patients without a history of primary varicella, no sooner than 2 years after HSCT and in the absence of GVHD, no systemic immunosuppressive use for least a year, and no receipt of IVIG for 8–11 months. There are currently no data regarding the efficacy of RZV for protection against varicella in seronegative HSCT patients although it was shown that vaccination could induce both humoral and cellular immune responses after solid organ transplantation in seronegative patients.¹⁶⁵

Chimeric Antigen Receptor T-Cell Therapy Recipients

Chimeric antigen receptor (CAR) T-cell therapy is a form of immunotherapy that involves adoptive cell transfer. Currently approved for treating B-cell leukemias, non-Hodgkin lymphoma (NHL), and multiple myeloma, this treatment is associated with lymphodepletion and long-lasting B-cell aplasia.

Literature Review and Analysis

The frequency of developing humoral responses to COVID-19 vaccines ranges from 28.2% to 35.9%, with similar response rates when vaccinated before and 6 months after CAR-T treatment.^{28,166,167} Up to 72.2% of recipients develop cellular responses that can confer protective immunity.⁶² As observed with other vaccines, responses are better in post-CAR-T patients with myeloma compared to those with NHL. Additional vaccine doses are safe but have a modest effect on antibody levels in those with long-lasting B-cell aplasia. Similarly, 31% of CAR-T recipients in remission vaccinated against influenza 13–57 months after treatment had at least fourfold increases in antibody titers for ≥ 1 vaccine antigens.¹¹⁶

Walti et al¹⁶⁸ evaluated 54 CAR-T recipients, most of whom had non-Hodgkin's lymphoma. These patients had undergone a median of five prior lines of therapy, 58% had previously undergone HSCT, and 54% had received recent IVIG. Measured antibody levels against vaccine antigens at a median of 20 months post-CAR-T treatment were comparable to the US adult population, even for patients without recent IVIG. Antibody levels were lowest for pneumococcus, Hib, pertussis (0%–15%), and hepatitis B (39%). Responses to the PCV were found to be suboptimal within 6 months of CAR-T.¹⁶⁹

Clinical Interpretation

Studies are limited from which to define vaccination metrics for patients receiving CAR-T therapy for hematologic malignancies. Thus, administration of nonlive vaccines preferably should occur before CAR-T treatment or at least 6–12 months thereafter. Influenza and COVID-19 vaccines ideally should be given 2 weeks before lymphodepletion or follow the same timing as recommended for HSCT patients (≥ 3 months post-CAR-T treatment). There are no data to guide the safety and timing of administration of live vaccines. The need for revaccination and the timing of other vaccines in CAR-T recipients remains poorly defined. The current literature is limited and mostly derived from CD19-targeted treatments and is emerging from B-cell maturation antigen CAR-T-treated individuals. There is considerable heterogeneity in vaccine responses which is primarily influenced by the therapeutic target antigen construct and the stage of differentiation at which it is expressed on the B cells. In addition to host-related factors (advanced age, prior lines of therapy), prolonged treatment-related B-cell

aplasia, cytopenia, and hypogammaglobulinemia lead to diminished vaccine humoral responses.

Patients Receiving B-Cell–Depleting Therapies and Those on Chronic Maintenance Treatment

Literature Review and Analysis

It was observed that patients with certain B-cell malignancies, especially those receiving anti-CD20 antibodies, had worse COVID-19–related outcomes and were unable to mount an effective humoral response to the COVID-19 vaccines in the first 6–12 months after treatment.^{37,41,76,170} However, cellular immune responses were observed in a substantial proportion of patients. COVID-19 revaccination should be considered at least 6–12 months after completion of B-cell–depleting treatments.

Clinical Interpretation

Understanding the dynamics of B-cell recovery and serological responses to COVID-19 vaccination following B cell–depleting therapy is important in determining the optimal timing of vaccination against COVID-19 infection. It is important to consider that B-cell recovery may be delayed for a variety of reasons including number and type of prior treatments, tumor histology, and comorbidities. Patients undergoing repetitive exposure to anti-CD20 therapies may have progressively attenuated B-cell reconstitution with each successive exposure. Vaccination is still strongly recommended as cellular immune responses appear to remain at least partly intact. Patients should receive seasonal influenza vaccine despite attenuated responses.¹⁷¹ These vaccines can be timed 4 weeks from the most recent treatment dose for patients on chronic anti-CD20-directed therapy. For other nonseasonal immunizations, vaccines ideally should be given 2–4 weeks before commencing anti-CD20 therapy or delayed until 6–12 months after completion, except for RZV, which can be given 1 month after the most recent dose of B-cell–depleting therapy.^{102,103,172} Serological assessment of B-cell reconstitution may help determine the optimal vaccination timing.

The risk of hypogammaglobulinemia following individual monoclonal antibodies against CD20, alone or in combination with other therapies, has been relatively well studied; however, there is a paucity of data for newer monoclonal antibodies and strategies that can deplete B cells, such as bispecific antibodies targeting CD20 and CD3.¹⁷³

Other Patients With Untreated or Controlled Hematologic Malignancies, Including Long-Term Survivors

Survivors of hematologic malignancies are not routinely tested for persistent immune defects that can impact vaccine responses such as hypogammaglobulinemia. However, a subset of patients with hematologic malignancies have an

inherent immune defect regardless of treatment (eg, CLL, small lymphocytic lymphoma, indolent lymphomas) or have been exposed to B-cell–directed therapies that predispose to transient or persistent hypogammaglobulinemia, and administration of nonlive vaccines should be instituted at a low threshold.

The recent literature surrounding COVID-19 vaccinations demonstrates that the immune response to vaccination in this group of patients is better in treatment-naïve compared to recently treated individuals, especially those who have received B-cell–directed therapies (eg, anti-CD 20 monoclonal antibodies, BTK inhibitors, B-cell lymphoma-2 inhibitor).¹⁷⁴ However, T- and B-cell activation is required for most optimal vaccine responses,¹⁰³ and a subset of patients with persistent functional B-cell disruption may retain or recover T-cell function, allowing cellular immune response to vaccines and providing some protection that complements the passive immunity provided by IVIG, which is routinely used as a prevention measure in many patients. There is no concern for immune interference with inactivated vaccines with administration of IVIG; thus, coadministration or proximate administration of vaccine and IVIG can occur.

Individuals with treated or untreated hematologic malignancies should follow the vaccination schedule outlined in Table 2. Providers should address the issue of live vaccine safety on a case-by-case basis in consultation with an infectious diseases expert. It is worth noting that untreated patients with hematologic malignancies may have subtle dysfunctions of T-cell subsets and antigen-presenting cells. Therefore, immunization with a live vaccine is unsafe.

CLINICAL QUESTION 3: WHAT ADDITIONAL VACCINATIONS ARE RECOMMENDED FOR ADULTS WITH CANCER WHO ARE TRAVELING OUTSIDE THE UNITED STATES?

Literature Review and Analysis

The 2013 IDSA guideline notes that nonlive vaccines indicated for travel based on the CDC annual schedule for immunocompetent adults and children may be administered to immunosuppressed individuals, and that live agent vaccines generally should not be given to patients who are immunosuppressed.⁵ An updated literature review did not identify publications that would change these recommendations. The 2024 CDC Yellow Book: Health Information for International Travel provides additional details for immunocompromised travelers.¹⁷⁵ The Yellow Book states that HSCT recipients should ideally delay travel for at least 2 years after transplant, noting the need for complete revaccination of HSCT recipients.

Clinical Interpretation

Per the 2024 CDC Yellow Book: Health Information for International Travel information for immunocompromised travelers, travel vaccinations should in general be delayed

until at least 3 months from last chemotherapy exposure and with disease in remission for patients with solid tumors.¹⁷⁵ Patients with active, untreated solid malignant neoplasm under observation only, should discuss travel timing and the degree of immunosuppression with their healthcare provider before consideration of receipt of live virus vaccines. Some chemotherapeutic and targeted agents are less immunosuppressive than others, including demonstrated safety with ICIs; however, there are limited clinical data regarding safety with live agent vaccines.

Due to immunogenicity and safety concerns, MMR, varicella vaccines, and other live virus vaccines should not be administered to HSCT recipients for at least 24 months post-transplant and only if the recipient is at that time judged immunocompetent. For this reason, HSCT recipients ideally should delay travel ≥ 2 years after transplant to allow for full revaccination. This recommendation also extends to CAR-T-cell recipients, though data are sparse. For other patients with hematologic malignancies in remission, the safety of live vaccines should be carefully assessed on a case-by-case basis in conjunction with an infectious disease or travel medicine expert.³² In all cases of travel, discussion of travel timing with the patient's oncologic and general health care team is indicated before travel vaccination. Additionally, attention should be paid to the regional seasonality of infections (eg, influenza timing in the Southern Hemisphere) and outbreaks that may be occurring globally.

CLINICAL QUESTION 4: WHAT ARE VACCINATION RECOMMENDATIONS FOR HOUSEHOLD AND CLOSE CONTACTS OF ADULTS WITH CANCER?

Literature Review and Analysis

The 2013 IDSA guideline states that immunocompetent individuals who live in a household with immunocompromised patients can safely receive all recommended live and nonlive vaccines, with certain exceptions and precautions.⁵ The IDSA guideline⁵ recommends against oral polio vaccine for household contacts of immunocompromised patients, and also recommends against live-attenuated influenza vaccine in household contacts of patients who have recently received an HSCT or have GVHD. An updated literature review did not identify publications that would change these recommendations.

Clinical Interpretation

All vaccines recommended by the ACIP for both adults and children, including live vaccines such as varicella and MMR, can be safely administered to household contacts of patients undergoing cancer treatment except for live attenuated influenza vaccine use in close contacts of HSCT recipients. Additionally, close contacts should remain up to date with seasonal vaccines.

An incompletely attenuated live vaccine formulation can occasionally revert to wild type or effectively transmit to a susceptible close contact. Observed transmission events with unintended clinical consequences have fortunately been rare, except for oral poliovirus and smallpox vaccines, which should not be given to family members of immunocompromised persons.¹⁷⁶⁻¹⁷⁸ The bivalent oral poliovirus vaccine is only used in a few countries, and the smallpox (live vaccinia) vaccine is indicated for select situations.

Specific considerations regarding live vaccine use in household contacts:

- Live vaccines for routine childhood and adult immunization of household contacts: Viable virus can be recovered from nasal swabs after intranasally administered influenza vaccine.^{179,180} No confirmed cases of live attenuated influenza vaccine virus transmission to severely immunocompromised contacts have been described. The evidence indicates that live attenuated influenza vaccine is generally safe for family members and other contacts of patients with cancer who have mild to moderate immunosuppression. Contacts of patients who receive HSCT should preferably receive the inactivated vaccine. MMR and varicella vaccines are both safe to administer to close contacts. Vaccine strain transmission to immunocompromised hosts is not associated with MMR use in family members. Eleven cases of varicella (vOka) vaccine strain transmission are described in the published literature, but none occurred in immunocompromised patients.¹⁸¹ Because vaccine strain can cause severe and fatal varicella in profoundly immunocompromised patients,¹⁸²⁻¹⁸⁶ precautions are advised to avoid close contact with a person with vaccine-induced rash. The rash site should be covered, and intimate skin-to-skin contact should be avoided with the immunocompromised household member until healed. Vaccine strain rotavirus is shed in the stool after the first vaccine dose, with reports of gastroenteritis in close contacts.^{187,188} Practice of good hand hygiene and avoidance of diaper changes for up to 2 weeks after the last vaccine dose is recommended to reduce the risk of transmission.
- Live vaccines for household contact travelers: The use of MMR and yellow fever vaccines is safe. Oral typhoid vaccine (Live Oral Ty21a) use is also acceptable, although live organisms have been detected in the stool post-immunization, albeit without onward transmission. In 2016, the oral cholera vaccine was licensed for US travelers. Approximately 11% of healthy vaccine recipients excrete the vaccine strain bacteria in their stool for up to 7 days. Although the transmission potential appears to be low overall, available data are limited and do not extend beyond 7 days. Therefore, the oral cholera vaccine should not be given to household contacts of immunocompromised patients.
- Live vaccines for other risk-based indications: A second-generation smallpox vaccine containing the vaccinia virus grown in cell culture (ACAM2000), is used for certain

military personnel, laboratory and research workers, and for monkeypox prevention in the United States. The risk of unintentional vaccinia transmission after ACAM 2000 is similar to the first-generation smallpox vaccine (Dryvax) and is estimated at around 5.4 events per 100,000 vaccinations.^{189,190} Therefore, ACAM-2000 should not be used in household members of immunocompromised patients. In contrast, a live replication-deficient modified vaccinia Ankara vaccine (Jynneos) to prevent monkeypox is safe for household contacts of immunocompromised patients.¹⁹¹ Finally, a subcutaneously administered live dengue vaccine was recently licensed in the United States. Although this vaccine cannot be given to patients with cancer, eligible children who reside in the household of an immunocompromised person can receive this vaccine.¹⁹²

DISCUSSION

Infections are the second most common cause of non-cancer-related mortality within the first year after a cancer diagnosis, with most of these deaths attributed to influenza and pneumonia, deaths that can be prevented through immunization.^{9,193} While patients with cancer have lower immune responses to influenza and pneumococcal vaccines, evidence supports the safety and benefits of vaccinations in reducing the severity of infections and associated hospitalizations.

Furthermore, newer vaccines, such as COVID-19 mRNA vaccines and the RZV, demonstrate only slightly lower efficacy in many patients with cancer when compared with the general population. The COVID-19 vaccine experience emphasizes the important role of cell-mediated immunity in preventing severe disease. It underscores that many patients with cancer benefit from vaccination, including those with blunted antibody production.

The common perception of weakened vaccine responses and inadequate protection of vaccines in patients with cancer should evolve to emphasize the importance of preventing severe disease and the critical role of vaccines in enhancing cancer-related outcomes by reducing infection-related complications.

A cancer diagnosis can be overwhelming, and vaccination may not be an immediate priority in the treatment plan. However, numerous studies consistently highlight the best protection when vaccines are administered before starting cancer treatment, emphasizing the need for early vaccination.

To achieve this goal, optimizing vaccination status should be considered a key element in the care of patients with cancer, through multidisciplinary approaches and dedicated resources, following Standards for Adult Immunization Practices.¹⁴ Implementation considerations include the following:

1. Documentation of vaccination status at the time of the first patient visit will help identify patients who need their

- vaccinations brought up to date or for whom seasonal vaccinations are required.
- 2. Alignment of revaccination after HCST, CAR-T therapy, or B-cell-depleting treatments with the expected time of immune reconstitution.
- 3. Active partnerships with patients' primary care providers, pharmacists, and nursing colleagues to collect and respond to vaccination data.
- 4. Provider endorsement and patient education are essential to overcome vaccine hesitancy and common misconceptions related to vaccine use for patients undergoing cancer treatment.
- 5. Emphasis on vaccination of household contacts and caregivers to protect patients.

CURRENT GAPS AND FUTURE DIRECTIONS

Continuous research into the mechanisms and remedies for acute and chronic immunocompromise in patients with cancer and long-term cancer survivors and into how the immune system processes and responds to vaccine and disease exposure will advance knowledge well beyond the direct implications for patient care. Enhancing vaccine uptake against preventable illnesses will help the community and improve the quality of care for patients with cancer. Unmet needs that require continuous research and other dedicated efforts include the following:

- Participation of patients with cancer with varied types of immunocompromise in vaccine trials is imperative. To ensure meaningful representation, actively or recently treated patients with cancer should be recruited actively to vaccine trials. Where vaccine trials for only patients with cancer are not feasible, pre-existing cancer should not preclude eligibility and inclusion of cohorts of patients receiving anticancer treatment(s) should be incorporated prospectively.
- The quest for more immunogenic vaccines and research to optimize vaccination approaches in patients receiving novel therapies is vital. There is a critical need to expand the understanding of vaccine responses after CAR-T, newer B-cell-directed therapies, and bispecific antibodies that target immune modulators as one epitope. These populations might have unique needs because of the underlying effect of disease and previous therapy on immune function, the potential for loss of immunity to childhood immunizations, and impairment of future vaccine responses.
- Mechanisms to help successful institutional commitment to integrate and sustain immunization best practices for patients with cancer through multidisciplinary team-based approaches, protocol-based vaccination standing orders, and leveraging data sharing to implement standardized processes for finding and recording a patient's vaccination status and needs.
- Evidence-based decision-making tools emphasizing preventative care through immunization. Provide educational resources and training to address commonly asked questions and misperceptions.

- Strategies for addressing the unique challenges and factors contributing to vaccine hesitancy during cancer treatment.

PROVIDER TEAM-BASED PROTOCOLS TO IMPROVE VACCINE UPTAKE

Implementation of a vaccination protocol has been shown to improve influenza and pneumococcal vaccination rates in the hematology and oncology and other specialty settings. Wong et al¹⁹⁴ implemented a vaccination protocol as a quality initiative, increasing vaccination rates from below 70% to 89% and higher. A nurse-led protocol described by Rodriguez et al¹⁹⁵ increased the number of influenza vaccinations by 97% and the number of pneumococcal vaccinations by 684%. Developed through a collaborative multidisciplinary approach, effective vaccination protocols are best integrated into the clinic's workflow processes. A successful example of this approach begins on the patient's arrival at the clinic. An electronic reminder or best practice alert generated in the electronic medical record will prompt patient screening for eligibility by the clinic or nursing staff. If applicable, the nurse activates a standing order set or initiates draft orders for vaccination to be signed and activated by the provider, and the patient receives the applicable vaccine(s) before leaving the health care facility.¹⁹⁴⁻¹⁹⁷ Nursing assessment and engagement provide the opportunity for patient and caregiver education, support, and reinforcement of the safety and efficacy of vaccinations during cancer treatment.

PATIENT AND CLINICIAN COMMUNICATION

Clinicians are seen as the vaccine resource for their patients, providing guidance on the safety and efficacy of vaccines before, during, and after cancer treatment. Assessment of a patient's need for vaccination, attitudes and beliefs around vaccination, and potential barriers (eg, access, cost, risks) to vaccination are critical when engaging in shared decision making and developing individualized approaches to care. Vaccines should be included as one aspect of overall health and disease prevention.

Open communication between the clinician and the patient around the topic of vaccines is essential and can be hampered by vaccine hesitancy and misinformation. Active listening lets the clinician understand the concerns of patients around vaccines and address their individual needs. Clinicians play a critical role in helping the patient and caregiver to understand the potential benefits and risks of recommended vaccination(s). In addition, clinicians should provide authoritative resources, such as fact-based vaccine informational handouts and internet sites, to help patients and caregivers learn more about the topic. Through assessment, active listening, and education, clinicians can help patients feel more informed and empowered to participate in their care.

For recommendations and strategies to optimize patient-clinician communication, see Patient-Clinician Communication: American Society of Clinical Oncology Consensus Guideline.¹⁹⁸

HEALTH EQUITY CONSIDERATIONS

The COVID-19 pandemic has highlighted the extent to which vaccine access, vaccine uptake, and serious illness disproportionately affect certain populations. As detailed in a 2021 WHO report, groups that have experienced increased rates of COVID morbidity and mortality include those who are poor, marginalized ethnic minorities, low-paid essential workers, the homeless, and those who are incarcerated.¹⁹⁹ Furthermore, the excess burden of disease borne by these and other vulnerable populations can exacerbate existing health inequities, through factors such as job loss or disruption of health insurance and education.

In the United States, vaccine coverage among adults remains low for many recommended vaccines and varies by race and ethnicity. Data from the National Health Interview Survey for the 2017–2018 season show that receipt of influenza vaccination among patients with high-risk conditions was lower among Black and Hispanic adults (53% and 55%, respectively) than among White and Asian adults (63% and 76%, respectively).²⁰⁰ Vaccine coverage is also significantly lower among adults who lack health insurance. Strategies under discussion to improve vaccine access in this population include a federal Vaccines for Adults program, which would build on the success of the Vaccines for Children program.²⁰¹

CONSIDERATIONS FOR LOW- AND MIDDLE-INCOME REGIONS

The availability, accessibility, and use of vaccines among patients with cancer in low- and middle-income countries (LMICs) are significant challenges. Limited resources and infrastructure, coupled with logistical barriers, often restrict the availability and distribution of vaccines in these regions. This situation can be further exacerbated by the high cost of vaccines, making them financially unattainable for the majority of LMICs. The Ministry of Health, as the primary authority responsible for vaccine policies, procurement, and distribution, plays a significant role in shaping the availability and accessibility of vaccines. However, this centralized approach can lead to a limited selection of vaccines and prioritized distribution to select populations. As a result, the lack of access to vaccines leaves patients with cancer vulnerable to potentially serious infections, which can have detrimental effects on their health outcomes.

Improving the availability, accessibility, and use of vaccines among patients with cancer in LMICs requires multifaceted efforts. Strengthening health care systems and infrastructure is essential to ensure the efficient delivery and

distribution of vaccines. This approach includes establishing vaccination programs that target patients with cancer specifically, providing them with necessary information and resources. Furthermore, raising awareness among health care providers and patients with cancer about the importance of vaccination and its potential benefits in preventing infections is crucial for increasing vaccine uptake and ensuring its optimal use among this vulnerable population.

COST IMPLICATIONS

Discussion of cost can be an important part of shared decision-making.²⁰² Standard adult vaccines for most patients are generally covered by third-party payers, without cost-sharing; this includes patients covered by Medicare and Medicaid. Some vaccines, such as COVID-19, influenza, and RSV, may be obtained through local pharmacies, and uninsured patients are encouraged to ask about cost. Additional resources regarding vaccination programs for minimally or uninsured patients can be found at the CDC Bridge Program for COVID-19 (<https://www.cdc.gov/vaccines/programs/bridge/index.html>)²⁰³ and by contacting local health departments regarding access to standard vaccines.

GUIDELINE IMPLEMENTATION

ASCO guidelines are developed for implementation across health settings. Each ASCO guideline includes a member from ASCO's Practice Guideline Implementation Network (PGIN) on the panel. The additional role of this PGIN representative in the guideline panel is to assess the suitability of the recommendations for implementation in the community setting and to identify any other barrier to implementation a reader should be aware of. Barriers to implementation include the need to increase awareness of the guideline recommendations among frontline practitioners and survivors of cancer and caregivers and provide adequate services in the face of limited resources. The guideline recommendation table and accompanying tools (available at www.asco.org/supportive-care-guidelines) were designed to facilitate implementation of recommendations. This guideline will be distributed widely through the ASCO PGIN. ASCO guidelines are posted on the ASCO website and most often published in the *Journal of Clinical Oncology*.

ADDITIONAL RESOURCES

For current information, including selected updates, supplements, slide sets, and clinical tools and resources, visit www.asco.org/supportive-care-guidelines. The Data Supplement for this guideline includes evidence tables and information regarding the literature search. Guideline recommendations and algorithms are also available in the free ASCO Guidelines app (available for download in the Apple [App Store](#) and [Google Play Store](#)). Listen to key

recommendations and insights from panel members on the [ASCO Guidelines podcast](#). The Methodology Manual (available at www.asco.org/guideline-methodology) provides additional information about the methods used to develop this guideline. Patient information is available at www.cancer.net.

ASCO welcomes your comments on this guideline, including implementation challenges, new evidence, and how this guideline affects you. To provide feedback, contact us at guidelines@asco.org. Comments may be incorporated into a future guideline update. To submit new evidence or suggest a topic for guideline development, complete the [online form](#).

GENDER-INCLUSIVE LANGUAGE

ASCO is committed to promoting the health and well-being of individuals regardless of sexual orientation or gender identity.²⁰⁶ Transgender and nonbinary patients, in particular, may face multiple barriers to oncology care including stigmatization, invisibility, and exclusiveness. One way exclusiveness or lack of accessibility may be communicated is through gendered language that makes presumptive links between sex and anatomy.^{207–210} With the acknowledgment that ASCO guidelines may affect the language used in clinical and research settings, ASCO is committed to creating gender-inclusive guidelines. For this reason, guideline

RELATED ASCO GUIDELINES

- Integration of Palliative Care into Standard Oncology Care²⁰⁴ (<http://ascopubs.org/doi/10.1200/JCO.2016.70.1474>)
- Patient-Clinician Communication¹⁹⁸ (<http://ascopubs.org/doi/10.1200/JCO.2017.75.2311>)
- Antimicrobial Prophylaxis for Adult Patients with Cancer-Related Immunosuppression²⁰⁵ (<https://ascopubs.org/doi/10.1200/JCO.18.00374>)
- Hepatitis B Virus Screening and Management for Patients With Cancer Prior to Therapy¹²⁷ (<https://ascopubs.org/doi/10.1200/JCO.20.01757>)

authors use gender-inclusive language whenever possible throughout the guidelines. In instances in which the guideline draws upon data on the basis of gendered research (eg, studies regarding women with ovarian cancer), the guideline authors describe the characteristics and results of the research as reported.

AFFILIATIONS

¹Memorial Sloan Kettering Cancer Center, Weill Cornell Medical College, New York, NY

²American Society of Clinical Oncology, Alexandria, VA

³American Cancer Society, Atlanta, GA

⁴MedStar Georgetown University Hospital, Georgetown Lombardi Comprehensive Cancer Center, Washington, DC

⁵The Leukemia and Lymphoma Society, Rye Brook, NY

⁶Fight Colorectal Cancer, Arlington, VA

⁷Harvard Medical School, Dana Farber Cancer Institute, Boston, MA

⁸Kaiser Permanente, Roseville, CA

⁹Oncology Nursing Society, Pittsburgh, PA

¹⁰Karolinska Comprehensive Cancer Center, Karolinska University Hospital Huddinge, Karolinska Institutet, Stockholm, Sweden

¹¹The Ohio State University Comprehensive Cancer Center, Columbus, OH

¹²The University of Texas MD Anderson Cancer Center, Houston, TX

¹³Duke University Medical Center, Durham, NC

¹⁴Huntsman Cancer Institute at the University of Utah, Salt Lake City, UT

¹⁵City of Hope Comprehensive Cancer Center, Duarte, CA

¹⁶Addis Ababa University, Addis Ababa, Ethiopia

¹⁷Cancer Therapy Evaluation Program, National Cancer Institute, Rockville, MD

CORRESPONDING AUTHOR

American Society of Clinical Oncology, 2318 Mill Rd, Ste 800, Alexandria, VA 22314; e-mail: guidelines@asco.org.

EQUAL CONTRIBUTION

M.K. and E.C.K. were Expert Panel Cochairs.

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EDITOR'S NOTE

This ASCO Clinical Practice Guideline provides recommendations, with a comprehensive review and analyses of the relevant literature for each recommendation. Additional information, including a supplement with additional evidence tables, slide sets, clinical tools and resources, and links to patient information at www.cancer.net, is available at www.asco.org/supportive-care-guidelines.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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AUTHOR CONTRIBUTIONS

Conception and design: Kari Bohlke, Deana M. Baptiste, Abbey Fueger, Lee Jones, Amar H. Kelkar, Lisa Y. Law, Per Ljungman, Heather N. Moore, Heloisa P. Soares, Randy A. Taplitz, Elise C. Kohn

Collection and assembly of data: Mini Kamboj, Kari Bohlke, Kieron Dunleavy, Amar H. Kelkar, Heather N. Moore

Data analysis and interpretation: Mini Kamboj, Kari Bohlke, Kieron Dunleavy, Amar H. Kelkar, Lisa Y. Law, Kristine B. LeFebvre, Per

Ljungman, Eric D. Miller, Heather N. Moore, Heloisa P. Soares, Randy A.

Taplitz, Edom S. Woldetsadik, Elise C. Kohn

Manuscript writing: All authors

Final approval of manuscript: All authors

Accountable for all aspects of the work: All authors

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Vaccination of Adults With Cancer: ASCO Guideline

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Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians ([Open Payments](http://OpenPayments.gov)).

Mini Kamboj

Consulting or Advisory Role: Medscape, MJHlife sciences, Regeneron

Kieron Dunleavy

Honoraria: AbbVie, AstraZeneca, Amgen, BeiGene, Genmab, Regeneron, Autolus, Cellectar, ADC Therapeutics, Kite/Gilead, Ono Pharmaceutical

Consulting or Advisory Role: AbbVie, AstraZeneca, Amgen, BeiGene, Genmab, Regeneron, Autolus, Cellectar, ADC Therapeutics, Kite, a Gilead company, Ono Pharmaceutical

Research Funding: Genentech (Inst), Kite/Gilead (Inst), Kymera (Inst), Ono Pharmaceutical (Inst)

Abbey Fueger

Consulting or Advisory Role: Protomer Technologies

Lee Jones

Consulting or Advisory Role: Bayer, Genmab, Evidera/PPD

Uncompensated Relationships: Eisai

Amar H. Kelkar

Stock and Other Ownership Interests: Iovance Biotherapeutics, Amgen

Research Funding: CareDX

Kristine B. LeFebvre

Employment: Oncology Nursing Society, American Nurses Credentialing Center (ANCC)

Per Ljungman

Honoraria: MSD, OctaPharma Europe, Blueprint Medicines, Enanta

Consulting or Advisory Role: Takeda (Inst), Gilead Sciences, Moderna Therapeutics (Inst), SymBio Pharmaceuticals (Inst)

Research Funding: MSD (Inst), AlloVir (Inst), Takeda (Inst), Astellas Pharma (Inst)

Travel, Accommodations, Expenses: MSD K.K

Other Relationship: MSD (Inst), Gilead Sweden (Inst), Moderna Therapeutics (Inst)

Eric D. Miller

Other Relationship: NCCN

Open Payments Link: <https://openpaymentsdata.cms.gov/physician/3591064>

Larissa A. Meyer

Employment: Gulf Coast Vascular Partners

Stock and Other Ownership Interests: crispr therapeutics, Bristol Myers Squibb, InVita, Johnson & Johnson, Denali Therapeutics

Research Funding: AstraZeneca, Merck

Other Relationship: Bristol Myers Squibb/Medarex

Heather N. Moore

Consulting or Advisory Role: Novartis, Lilly, AstraZeneca/Daiichi Sankyo, Pfizer, Race Oncology

Heloisa P. Soares

Honoraria: TM Isotope Technologies Munich SE

Consulting or Advisory Role: Ipsen, TerSera, AstraZeneca, Pfizer, Novartis

Uncompensated Relationships: North American Neuroendocrine Tumor Society, National Comprehensive Cancer Network, Healing NET Foundation

Randy A. Taplitz

Consulting or Advisory Role: Merck, Karius

Research Funding: Allovir, Geovax

Travel, Accommodations, Expenses: Karius

Edom S. Woldetsadik

Honoraria: MSD Oncology

Speakers' Bureau: AstraZeneca

Research Funding: Pfizer/EMD Serono

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APPENDIX 1. GUIDELINE DISCLAIMER

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APPENDIX 2. GUIDELINE AND CONFLICTS OF INTEREST

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TABLE A1. Vaccination of Adults with Cancer Expert Panel Membership

Name	Affiliation	Role or Area of Expertise
Mini Kamboj, MD (cochair)	Memorial Sloan Kettering Cancer Center, Weill Cornell Medical College, New York, NY	Infectious Disease
Elise C. Kohn, MD (cochair)	Cancer Therapy Evaluation Program, National Cancer Institute, Rockville, MD	Gynecologic Oncology
Deana M. Baptiste, PhD, MPH	American Cancer Society, Atlanta, GA	Epidemiology and Guideline Development
Kieron Dunleavy, MD	MedStar Georgetown University Hospital, Georgetown Lombardi Comprehensive Cancer Center, Washington, DC	Medical Oncology, Hematology
Abbey Fueger, BA, BSN, RN	The Leukemia and Lymphoma Society, Rye Brook, NY	Oncology Nursing
Lee Jones, MBA	Fight Colorectal Cancer, Arlington, VA	Patient/Advocacy Representative
Amar H. Kelkar, MD, MPH	Harvard Medical School, Dana Farber Cancer Institute, Boston, MA	Stem-Cell Transplantation, Hematology
Lisa Y. Law, MD	Kaiser Permanente, Roseville, CA	Hematology, Medical Oncology
Kristine B. LeFebvre, DNP, RN, NPD-BC, AOCN	Oncology Nursing Society, Pittsburgh, PA	Oncology Nursing
Per Ljungman, MD, PhD	Karolinska University Hospital and Karolinska Institutet, Stockholm, Sweden	Hematology
Eric D. Miller, MD, PhD	The Ohio State University Comprehensive Cancer Center, Columbus, OH	Radiation Oncology
Larissa A. Meyer, MD, MPH	The University of Texas MD Anderson Cancer Center, Houston, TX	Gynecologic Oncology
Heather N. Moore, CPP, PharmD	Duke University Medical Center, Durham, NC	Pharmacy
Heloisa P. Soares, MD, PhD	Huntsman Cancer Institute at the University of Utah, Salt Lake City, UT	Medical Oncology, ASCO Practice Guidelines Implementation Network
Randy A. Taplitz, MD	City of Hope Comprehensive Cancer Center, Duarte, CA	Infectious Disease
Edom S. Woldetsadik, MD	Addis Ababa University, Addis Ababa, Ethiopia	Clinical Oncology
Kari Bohlke, ScD	American Society of Clinical Oncology, Alexandria, VA	ASCO Practice Guideline Staff (Health Research Methods)

TABLE A2. Recommendation Rating Definitions²¹¹

Term	Definitions
Quality of evidence	
High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very Low	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect
Strength of recommendation	
Strong	In recommendations for an intervention, the desirable effects of an intervention outweigh its undesirable effects In recommendations against an intervention, the undesirable effects of an intervention outweigh its desirable effects All or almost all informed people would make the recommended choice for or against an intervention
Weak	In recommendations for an intervention, the desirable effects probably outweigh the undesirable effects, but appreciable uncertainty exists In recommendations against an intervention, the undesirable effects probably outweigh the desirable effects, but appreciable uncertainty exists Most informed people would choose the recommended course of action, but a substantial number would not