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Current Vaccination Principles and Practices in Adult Cancer Patients

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ABSTRACT

Adults with cancer are at a substantially increased risk of infectious complications due to malignancy-related immune dysregulation and the immunosuppressive effects of anticancer therapies. Vaccine-preventable infections remain a significant cause of morbidity and mortality despite advances in oncologic care. This review summarizes current evidence and international guideline recommendations on vaccination strategies in adult patients with solid tumors. Inactivated and recombinant vaccines are generally safe and should be administered according to standard schedules, preferably before the initiation of immunosuppressive therapy. Although immune responses may be attenuated during treatment, available data support a meaningful clinical benefit in reducing severe infections and hospitalizations. Live attenuated vaccines are contraindicated during significant immunosuppression and should be considered only after documented immune reconstitution. Optimizing vaccination outcomes requires individualized scheduling, attention to treatment-related immune effects, and immunization of household contacts. Proactive, guideline-based vaccination should be integrated into routine oncology care to reduce infection-related complications and support treatment continuity.

Keywords: Adult cancer patients, immunization, immunosuppression, preventive care, vaccination.

INTRODUCTION

Adult cancer patients are at a markedly increased risk of infections due to malignancy-associated immune dysregulation and the immunosuppressive effects of chemotherapy, radiotherapy, immunotherapy, and targeted agents. Impairment of cellular immunity, disruption of mucosal

barriers, functional asplenia, and reduced B-cell–mediated responses contribute to significantly higher infection-related morbidity and mortality from bacterial and viral pathogens compared with the general population.[1] Despite substantial advances in oncologic therapies and supportive care measures, vaccine-preventable diseases remain a significant clinical burden in this vulnerable group.[2,3] Moreover, immune responses are frequently diminished during active treatment, and vaccine immunogenicity varies considerably according to treatment modality, timing of administration, and the degree of immune recovery achieved.

The intersection of cancer treatment and vaccine-preventable infections presents unique clinical challenges. Cancer itself can compromise immune function through various mechanisms, including bone marrow infiltration, malnutrition, and the production of immunosuppressive cytokines. When combined with the effects of modern anticancer therapies, which may include intensive chemotherapy regimens, prolonged corticosteroid use, B-cell–depleting monoclonal antibodies, and novel immunotherapeutic agents, the cumulative impact on immune competence can be profound and prolonged.[4,5]

This narrative review summarizes current evidence, international guideline recommendations, and practical considerations regarding vaccination strategies in adult cancer patients with solid tumors. Patients with hematologic malignancies and hematopoietic stem cell transplant recipients were excluded from this review because of their distinct and more complex immune reconstitution profiles. A structured literature search was conducted using PubMed/MEDLINE, Embase, and the Cochrane Library for English-language publications up to 2026. International guidelines and consensus documents were also reviewed. Original studies, randomized controlled trials, observational studies, systematic reviews, and meta-analyses addressing vaccine safety, immunogenicity, efficacy, and timing in adults with solid tumors were included. The findings were synthesized qualitatively to inform practical, guideline-aligned recommendations. We confirm that the study was conducted in accordance with the Declaration of Helsinki.

CLINICAL AND RESEARCH CONSEQUENCES

General Principles of Vaccination

Vaccination is a cornerstone of preventive care in adult cancer patients and aims to reduce infection risk and treatment-related complications that may interrupt or compromise oncologic therapy. Standard adult immunization schedules published by organizations such as the Centers for Disease Control and Prevention should be followed whenever feasible; however, vaccination strategies require careful individualization based on multiple factors, including vaccine type, timing relative to cancer treatment, degree of immunosuppression, and treatment-related immunologic effects.[6]

Vaccines used in oncology practice can be broadly categorized as inactivated vaccines and live attenuated vaccines.[7] Inactivated vaccines contain killed pathogens or purified components and cannot cause infection, even in profoundly immunosuppressed individuals. This category includes subunit vaccines, toxoid vaccines, recombinant vaccines, and conjugate vaccines. In contrast, live attenuated vaccines contain weakened but viable microorganisms capable of replication and, although generally safe in immunocompetent individuals, they pose a risk of disseminated infection in patients with significant immunosuppression. Understanding this fundamental distinction is critical for safe vaccination practices in the oncology setting.

Timing of Immunization

Vaccination timing is a key determinant of immunogenicity in adults with cancer. Optimal immune responses are achieved when vaccines are administered before the initiation of immunosuppressive therapy. Accordingly, inactivated vaccines should be administered at least 2 weeks before chemotherapy or immunomodulatory treatment, whereas live attenuated vaccines should be administered at least 4 weeks in advance.[4]

Inactivated vaccines can be safely administered during or after cancer treatment, although antibody responses are often attenuated. Therefore, vaccination should preferably be scheduled during periods of relative immune recovery within chemotherapy cycles. Immune reconstitution typically occurs within 3–6 months after chemotherapy, whereas recovery may be delayed for up to 6–12 months following B-cell–depleting therapies, such as anti-CD20 monoclonal antibodies.[8] Live attenuated vaccines remain contraindicated during active immunosuppression and should be considered only after adequate immune recovery.

INACTIVATED VACCINES

Seasonal Influenza Vaccine

Seasonal influenza is a major cause of respiratory illness in adults with cancer and is associated with a substantial risk of severe complications and mortality. Influenza-related hospitalization rates are approximately fourfold higher, and mortality rates are nearly tenfold higher, in adults with cancer than in the general population.[9] Consequently, international guidelines uniformly recommend annual administration of the inactivated influenza vaccine for all patients with cancer, with optimal vaccination ideally performed at least 2 weeks before the initiation of immunosuppressive therapies.

Table 1. Recommended pneumococcal vaccination schedule for immunocompromised patients aged 19 years and older

Vaccination status	Recommendation
Unvaccinated	One dose of PCV20, or one dose of PCV13 or PCV15 followed by PPSV23 after 8 weeks
History of receiving one dose of PPSV23	PCV20, PCV15, or PCV13 after 1 year
If a booster dose of PPSV23 is required	The first booster dose of PPSV23 should be administered at least 8 weeks after the last PCV13 dose and at least 5 years after the last PPSV23 dose.
History of receiving one dose of PCV13	One dose of PCV20 after 1 year, or PPSV23 after 8 weeks

PCV13: 13-valent pneumococcal conjugate vaccine; PCV15: 15-valent pneumococcal conjugate vaccine; PCV20: 20-valent pneumococcal conjugate vaccine; PPSV23: 23-valent pneumococcal polysaccharide vaccine.

Immune responses to influenza vaccination vary according to tumor type, chemotherapy intensity, and immunomodulatory treatments. Seroprotection rates are generally preserved in patients with solid tumors, particularly breast, lung, and gastrointestinal cancers, but are significantly reduced in those receiving B-cell–depleting therapies or regimens that cause profound humoral immunosuppression.[10]

When influenza vaccination is required during chemotherapy, available evidence suggests that early administration within the chemotherapy cycle is safe and immunogenic. In adults receiving cytotoxic chemotherapy every 3 weeks, vaccination administered on day 1 or day 11 resulted in comparable seroprotection rates, whereas vaccination on day 1 was associated with fewer adverse events (13% vs. 32%, p=0.04).[11] Similarly, higher serologic response rates were reported with early postchemotherapy vaccination (day 5) than with late postchemotherapy vaccination (day 16) in patients with breast cancer.[12] These findings support vaccination during treatment when necessary, preferably avoiding periods of profound neutropenia.

Strategies to enhance immunogenicity, including high-dose inactivated influenza vaccines and 2-dose vaccination schedules, have been investigated. Although some studies have reported improved antibody responses with these approaches, current evidence remains limited and insufficient to support their routine implementation. Nevertheless, even in the presence of reduced serologic responses, influenza vaccination has been shown to reduce influenza-related complications, hospitalizations, and mortality in patients with cancer.

Overall, the safety profile of inactivated influenza vaccines in adults with cancer is favorable, and the clinical benefits of vaccination clearly outweigh concerns regarding reduced immunogenicity. Annual influenza vaccination is therefore strongly recommended for patients with cancer and their household contacts.

Pneumococcal Vaccine

Invasive pneumococcal disease is a major cause of morbidity and mortality among adults with cancer, driven by malignancy-associated immune dysfunction, treatment-related neutropenia, mucosal barrier disruption, and impaired humoral immunity.[13] Currently available pneumococcal vaccines include conjugate vaccines (PCV13, PCV15, PCV20, and PCV21) and the polysaccharide vaccine (PPSV23). Conjugate vaccines induce T-cell–dependent immune responses, leading to immunologic memory, higher antibody avidity, and more durable protection. Consequently, they demonstrate superior immunogenicity compared with polysaccharide vaccines in immunocompromised adults. Historically, this supported a strategy of primary conjugate vaccination followed by PPSV23 boosting. The expanded serotype coverage of newer conjugate vaccines, particularly PCV20, has simplified adult vaccination schedules (Table 1). Current guidelines recommend either a single dose of PCV20 or sequential vaccination with PPSV23 administered at least 8 weeks after PCV15 or PCV13 in adults with cancer.[4] Both approaches provide broad serotype coverage and effective protection, whereas the single-dose PCV20 regimen offers practical advantages in oncology settings. PCV21 has also recently been licensed, further expanding the available options.[14]

Pneumococcal vaccination is ideally administered before the initiation of anticancer therapy, when immunogenicity is highest. If vaccination is required during treatment, periods of neutropenia should be avoided whenever possible. Although immune responses may be attenuated during active therapy, vaccination should not be deferred, particularly in patients with anatomic or functional asplenia, who are at high risk for rapidly progressive and life-threatening pneumococcal infections.[4] When splenectomy is planned, vaccination should be administered at least 2 weeks before surgery; if this is not feasible, postoperative vaccination is acceptable. Pneumococcal vaccines are generally well tolerated in adults

with cancer. Adverse events are usually limited to mild local reactions, whereas systemic effects and serious vaccine-related complications are rare.[8,15]

Tetanus, Diphtheria, and Acellular Pertussis Vaccination

Tetanus, diphtheria, and pertussis are vaccine-preventable infections that may cause severe disease in adults.[16] Although data on their incidence in adults with cancer are limited, immunosuppressive cancer therapies impair both cellular and humoral immunity, resulting in reduced protective antibody levels. Therefore, maintaining immunity against these infections is an important component of preventive care in oncology practice.[4] Tetanus–diphtheria–acellular pertussis (Tdap) and tetanus–diphtheria (Td) vaccines, which contain inactivated toxoids and subunit antigens, can be safely administered even in patients with significant immunosuppression. Adults who have not completed a primary immunization series should receive 3 doses administered at 0, 1, and 6–12 months.[17] Individuals who have never received Tdap should receive a single lifetime dose, followed by Td or Tdap booster doses every 10 years.

Hepatitis B Vaccine

Hepatitis B virus (HBV) infection poses a significant clinical risk in patients with cancer, primarily because of potential viral reactivation during immunosuppressive therapies. This risk is particularly pronounced in patients receiving anti-CD20 monoclonal antibodies, high-dose corticosteroids, or intensive chemotherapy.[18] HBV reactivation can lead to fulminant hepatitis and treatment interruption. Comprehensive baseline serologic screening, including HBsAg, anti-HBc, and anti-HBs, is essential before anticancer treatment.[19] Because seroconversion rates after hepatitis B vaccination are substantially reduced during active cancer therapy, vaccination should preferably be completed before treatment whenever possible. For immunocompromised adults aged 20 years and older, standard Recombivax HB consists of 3 20-µg doses administered at 0, 1, and 6 months. When Engerix-B is used, a high-dose schedule of 4 40-µg doses administered at 0, 1, 2, and 6 months is recommended.[4] High-dose vaccination is also standard practice in patients undergoing chronic hemodialysis, and combined hepatitis A–B vaccine formulations may be safely used in adults with cancer. Postvaccination assessment of anti-HBs titers is recommended, as additional doses may be required when antibody levels remain below the protective threshold of 10 IU/L. Hepatitis B vaccines have an excellent safety profile. However, vaccine-induced responses are markedly attenuated during B-cell–depleting therapies; therefore, vaccination may be more effective when deferred until approximately 6–12 months after treatment completion.

Hepatitis A Vaccine

Hepatitis A virus (HAV) may cause symptomatic and occasionally severe infection in adults. Although the overall incidence in patients with cancer does not appear to be higher than that in the general population, the risk of severe disease may be increased because of immunosuppressive therapies, comorbidities, and reduced hepatic reserve. Hepatitis A vaccination is recommended for adults with chronic liver disease, individuals traveling to regions with high HAV endemicity, household contacts of acute cases, men who have sex with men, individuals with substance use disorders, and those living in high-endemicity areas. Malignancy alone does not constitute an indication; however, vaccination should be strongly considered in patients who meet these risk criteria.[20] It is particularly important in liver transplant candidates and recipients. The inactivated vaccine is administered as a 2-dose series at 0 and 6 months. Data on immunogenicity in patients with cancer are limited, and seroconversion rates are reduced in immunosuppressed populations. Vaccination should ideally be administered before anticancer therapy. Hepatitis A vaccines are generally well tolerated, with rare serious adverse events.

Meningococcal Vaccination

Neisseria meningitidis can cause rapidly progressive, life-threatening conditions, including meningitis and septicemia. Although the incidence is not higher in adults with cancer, immunosuppressive therapies and, particularly, anatomic or functional asplenia substantially increase the risk of severe invasive disease. Meningococcal vaccination is not routinely recommended for all patients with cancer but is strongly indicated in high-risk settings, including anatomic or functional asplenia, congenital complement deficiencies, and the use of complement pathway inhibitors such as eculizumab.[21] Additional indications include travel to endemic regions, close contact with infected individuals, occupational exposure, congregate living environments, and outbreaks.

Available vaccines include conjugate quadrivalent MenACWY and recombinant serogroup B (MenB) vaccines. In adults at increased risk, a 2-dose primary MenACWY series administered approximately 8 weeks apart is recommended, with boosters every 5 years if the risk persists. MenB provides protection exclusively against serogroup B and is complementary to MenACWY. These vaccines demonstrate robust immune responses in high-risk populations and have a favorable safety profile, with mild local reactions being the most common adverse events.[22]

Haemophilus influenzae Type b (Hib) Vaccine

Haemophilus influenzae type b can cause severe invasive infections, particularly in individuals with anatomic or

functional asplenia. Patients who have undergone splenectomy or have functional asplenia are at a substantially increased risk. Hib vaccination is important in oncology patients at risk of anatomic or functional asplenia. Routine vaccination is not recommended for adult patients with cancer in the absence of these risk factors.[23] Conjugate Hib vaccines elicit robust T-cell–dependent immune responses, enabling adequate antibody responses even during immunosuppressive therapy. In adults, Hib vaccination is administered as a single dose that confers long-term protection.

Human Papillomavirus (HPV) Vaccine

Human papillomavirus is responsible for anogenital warts and malignancies of the cervix, vagina, vulva, anus, penis, and oropharynx. HPV-16 and HPV-18 account for more than 70% of cervical cancer cases.[24] HPV vaccines are virus-like particle vaccines produced using recombinant technology without live virus; therefore, they can be safely administered to immunocompromised individuals. The 9-valent vaccine provides broad protection and has demonstrated high efficacy. The Advisory Committee on Immunization Practices (ACIP) recommends routine vaccination at ages 9–14 years, with catch-up vaccination through age 26 years. Vaccination in adults aged 27–45 years may be considered based on shared decision-making. HPV vaccination may still benefit individuals with prior exposure by providing protection against other types. In immunocompromised individuals, a 3-dose schedule at 0, 2, and 6 months is recommended.[25] HPV vaccines are generally well tolerated, with rare serious adverse events.[25,26]

Recombinant Zoster Vaccine

Herpes zoster is clinically significant in adults with cancer, with a markedly increased incidence and a higher risk of complications. The risk is approximately 2- to 3-fold higher in patients with solid tumors and up to 10-fold higher in those with hematologic malignancies.[27] Complications such as postherpetic neuralgia and disseminated zoster occur more frequently, particularly during the first 2 years after diagnosis. Because the live attenuated zoster vaccine is contraindicated in immunosuppressed patients, the recombinant zoster vaccine (RZV) is the preferred strategy. RZV is indicated for adults aged 50 years and older and immunocompromised individuals aged 18 years and older. The strongest immune response is achieved before immunosuppressive therapy. The standard schedule consists of 2 doses at 0 and 2–6 months; in patients requiring rapid protection, the interval may be shortened to 4 weeks.[4] In solid organ transplant candidates, RZV should be administered before transplantation when feasible or 6–12 months after transplantation during clinical stability. Patients with prior herpes zoster may be vaccinated after resolution. Revaccination is appropriate for those who previously received live attenuated vaccines. Vaccine immunogenicity is reduced with B-cell–depleting therapies. In patients undergoing such treatment, a single RZV dose approximately 4 weeks before the next chemotherapy cycle may be considered. RZV has a favorable safety profile, with generally mild to moderate self-limited reactions and rare serious events.[28]

Respiratory Syncytial Virus (RSV) Vaccines

Respiratory syncytial virus can cause severe lower respiratory tract infections in older adults and immunocompromised individuals. In adults with cancer, RSV infection is associated with an increased risk of pneumonia, hospitalization, and adverse outcomes. In 2023, 2 vaccines containing recombinant prefusion F protein (Arexvy® and Abrysvo®) were approved for adults aged 60 years and older. As non-live vaccines, they are appropriate for immunocompromised populations. Clinical trials demonstrated vaccine efficacy of 66%–83% in preventing RSV-associated lower respiratory tract disease and 85%–94% in preventing severe disease; however, data specific to patients with cancer remain limited.[29,30] The American Society of Clinical Oncology (ASCO) recommends a single dose of RSV vaccine in patients with cancer aged 60 years and older.[4] Optimal timing is at least 2 weeks before immunosuppressive therapy. During active treatment, administration should avoid periods of severe neutropenia. In transplant candidates, vaccination is preferably administered at least 2 weeks before or at least 6 months after transplantation.[31] RSV vaccines are generally well tolerated, with mild local reactions and transient systemic symptoms.

COVID-19 Vaccines

COVID-19 is associated with a substantially increased risk of severe illness and mortality in adults with cancer, and vaccination remains the cornerstone of prevention. All currently authorized COVID-19 vaccines are non-live platforms and can be safely administered during cancer treatment. Guidelines recommend completing the primary vaccination series and receiving boosters according to standard schedules. Although humoral responses may be attenuated by immunosuppressive therapies, mRNA vaccines retain clinically meaningful effectiveness. In individuals receiving immune checkpoint inhibitors, COVID-19 vaccination has not been associated with reduced efficacy or a clinically significant increase in immune-related adverse events.[32] Although vaccination should ideally be administered before therapy, it may be safely given during treatment, while avoiding periods of profound neutropenia. COVID-19 vaccines are generally well tolerated, with rare serious adverse events. Given the potential for waning immunity and reduced antibody responses under certain regimens, adherence to recommended boosters is essential.

LIVE ATTENUATED VACCINE APPLICATIONS

Live attenuated vaccines constitute an important category of immunizations but carry a risk of disseminated infection in immunosuppressed adults because they contain replication-competent microorganisms with reduced virulence. In adults with cancer, malignancy-associated immune dysfunction, together with treatment-related cellular and humoral immunosuppression induced by chemotherapy, immunotherapy, targeted therapies, anti-CD20 monoclonal antibodies, and high-dose corticosteroids, substantially limits the safe use of live vaccines.[4,8,15] Accordingly, live attenuated vaccines, including measles–mumps–rubella (MMR), varicella, live attenuated zoster vaccine, intranasal live attenuated influenza vaccine (LAIV), yellow fever vaccine, and oral typhoid vaccine, are contraindicated during active cancer treatment.[4] Administration of live vaccines may be considered only if they are given at least 4 weeks before the initiation of immunosuppressive therapy. In the posttreatment setting, vaccination decisions should be individualized and based on the degree and durability of immune reconstitution.

In general, a minimum interval of 3 months after completion of cytotoxic chemotherapy is recommended before live vaccination is considered; however, longer delays may be necessary depending on the intensity and immunosuppressive profile of the therapeutic agents used. After B-cell–depleting therapies, such as anti-CD20 antibodies, restoration of B-cell function is required before live vaccines can be administered, and an interval of at least 6–12 months is typically recommended.

Vaccination in Patients Receiving Immunotherapy

Vaccination in patients treated with immune checkpoint inhibitors (ICIs) warrants particular attention because of theoretical concerns regarding a potential increase in immune-related adverse events (irAEs). However, current evidence indicates that inactivated influenza and mRNA-based COVID-19 vaccines are generally safe in this population. In one study, irAE rates after influenza vaccination were reported to be approximately 20%–30%, comparable to those observed in unvaccinated ICI-treated cohorts.[33] Similarly, several series have demonstrated that grade≥3 irAEs remained within the range of 5%–10% without a significant increase, although a small study reported a higher incidence of adverse events.[34,35]

Data on COVID-19 vaccines are consistent with these findings. In patients receiving ICIs, overall adverse event rates after mRNA vaccination range from 30% to 50%, whereas serious adverse events occur in fewer than 5% of cases, with no significant increase in immune-related toxicities.[36] Seroconversion rates in patients with solid tumors receiving ICIs range from 70% to 90%, exceeding those observed in patients undergoing cytotoxic chemotherapy.[37] Compared with B-cell–depleting therapies, such as anti-CD20 agents, immune responses appear to be better preserved.

The impact of vaccination on immunotherapy efficacy remains unclear. Retrospective analyses have reported median progression-free survival (PFS) of 8–12 months in vaccinated patients, with outcomes comparable to those of unvaccinated cohorts.[38] However, these studies are limited by small sample sizes and heterogeneity, and randomized controlled data are lacking. In addition, direct comparative evidence regarding vaccine responses across different ICI classes, including PD-1/PD-L1 and CTLA-4 inhibitors, remains insufficient.

In conclusion, current evidence supports the safety and feasibility of inactivated and mRNA vaccines during ICI therapy. However, their effects on survival, tumor response, and long-term immunologic outcomes remain uncertain, highlighting the need for well-designed prospective studies.

Vaccination of Household Contacts

An essential component of vaccination strategies in adult cancer patients is ensuring the appropriate immunization of household contacts. Vaccination of close contacts is a critical element of infection prevention and control in this population and is as important as vaccination of the patients themselves. There are no restrictions on the administration of inactivated vaccines to household contacts, and these vaccines can be safely administered without concern.

Live attenuated vaccines, however, require special consideration when administered to close contacts of immunosuppressed individuals. In the event of a postvaccination rash, which may rarely occur after varicella vaccination, close contact with severely immunosuppressed patients should be temporarily avoided. Similarly, although the intranasal live attenuated influenza vaccine may be administered to contacts, its use is not recommended in households that include individuals with profound immunosuppression; in such settings, the inactivated influenza vaccine should be preferred whenever possible. In addition, oral live vaccines, such as rotavirus and oral poliovirus vaccines, pose a potential transmission risk because of viral shedding in stool and are therefore contraindicated for close contacts of immunosuppressed patients. Immunocompromised individuals should avoid contact with soiled diapers of infants who have received oral poliovirus or rotavirus vaccines for 4–6 weeks after vaccination.[4,15] This precaution should be explicitly included in patient education materials and discharge instructions to ensure adequate awareness and adherence in clinical practice.

For optimal protection, vaccination status should be systematically assessed in both patients with cancer and

Table 2. Recommended immunizations for adults with cancer

Vaccine	Recommended age	Schedule
Influenza, inactivated	All ages	Annually
RSV	60 years and older	Once
COVID-19	All ages	According to the latest CDC schedule for immunocompromised individuals
Tdap/Td	19 years and older	One dose of Tdap, followed by a Td or Tdap booster every 10 years
Hepatitis B	19–59 years: eligible; 60 years and older: immunize those with other risk factors*	For adults aged 20 years and older, use a high-antigen-dose formulation (40 µg) and administer as a 3-dose Recombivax HB series at 0, 1, and 6 months or a 4-dose Engerix-B series at 0, 1, 2, and 6 months
Recombinant zoster vaccine	19 years and older	Two doses at least 4 weeks apart
Pneumococcal vaccine	19 years and older	One dose of PCV15 followed by PPSV23 8 weeks later, or one dose of PCV20**
HPV	19–26 years: eligible; 27–45 years: shared decision-making	Three doses at 0, 1–2, and 6 months

CDC: Centers for Disease Control and Prevention; HPV: human papillomavirus; PCV13: 13-valent pneumococcal conjugate vaccine; PCV15: 15-valent pneumococcal conjugate vaccine; PCV20: 20-valent pneumococcal conjugate vaccine; PPSV23: 23-valent pneumococcal polysaccharide vaccine; RSV: respiratory syncytial virus; Td: tetanus–diphtheria; Tdap: tetanus–diphtheria–acellular pertussis. *: HIV, chronic liver disease, intravenous drug use, sexual risk factors, and incarceration; **: Patients who have previously received PCV13 only can receive one dose of PCV20 after an interval of 1 year.

their close contacts. Completion of missing immunizations and implementation of appropriate precautions to mitigate transient transmission risks associated with live vaccines in contacts are essential components of a comprehensive vaccination strategy in this setting.

ARTIFICIAL INTELLIGENCE APPLICATIONS IN VACCINATION STRATEGIES

Artificial intelligence (AI) is increasingly being used to personalize vaccination strategies in oncology patients. Machine learning algorithms can analyze multiple variables, including age, tumor type, treatment modality (e.g., chemotherapy or immunotherapy), lymphocyte counts, and comorbidities, to predict vaccine responsiveness and determine the optimal timing of immunization.[39] In addition, these models may help identify patients at high risk of infection, thereby supporting vaccination prioritization.[39,40] Integration with electronic health records enables the automated identification of missing vaccinations and facilitates clinical decision support through reminder systems.[40] Notably, predictive models developed during the COVID-19 pandemic have shown promising results in estimating immune responses and seroconversion after vaccination.[40] However, most available data are derived from retrospective studies, and further prospective validation is required before widespread implementation in routine clinical practice.

CONCLUSION

This clinical guide provides an overview of current evidence and guideline-based recommendations. It emphasizes the substantially increased risk of severe infections during active treatment and immunosuppression. Although vaccine-induced responses may be attenuated, the clinical benefits outweigh these limitations.

In conclusion, many infections in adults with cancer are preventable through vaccination (Table 2). Malignancy-related immune impairment and treatment-related immunosuppression significantly increase the risk of infection, making vaccination a key component of supportive oncology care. Although inactivated and recombinant vaccines can be safely administered, live attenuated vaccines are contraindicated during active treatment and should be considered only after adequate immune reconstitution. Optimal protection is achieved through vaccination before treatment initiation whenever possible, individualized timing according to immune status and treatment regimens, and comprehensive vaccination of household members. An integrated and patient-centered vaccination strategy is essential to reduce infection-related morbidity and support the continuity and success of cancer treatment.

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