DERLEME REVIEW

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Streptococcus pneumoniae Infections in Cancer Patients and the Role of the Pharmacist in Pneumococcal Vaccination: Traditional Review

Kanser Hastalarında *Streptococcus pneumoniae* Enfeksiyonları ve Eczacının Pnömokok Aşılamasındaki Rolü: Geleneksel Derleme

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ABSTRACT Cancer patients are one of the susceptible populations at risk of infections due to intensive and immune response-altering treatments. Among the infections, *Streptococcus pneumoniae*-related infections have a significant impact on cancer patients. These infections can be seen as mild or invasive type which varies in severity according to the type of cancer. Invasive pneumococcal disease is a serious infection that increases morbidity and mortality in cancer patients. Ensuring the integrity of patients' immunity is essential in order to maintain safe and effective cancer treatment processes. International guidelines and health authorities recommend that cancer patients should receive pneumococcal vaccines against pneumococcal diseases. The administration of vaccines in cancer patients is more complicated than in any other patient groups due to ongoing immunosuppressive treatments, which results in not achieved desired rates in pneumococcal vaccination. The vaccination process requires comprehensive assessment of the factors directly related with cancer, such as cancer type/diagnosis, cancer stage, type of treatment and scheduled treatment along with other patient-related factors. Sustainability of immunization in adult population can be achieved by implementation of vaccination programs, although logistics, economic, social, and epidemiological factors hinder its implementation. In order to increase the vaccination rates, health professionals should work in cooperation with the patient. Pharmacists, as healthcare professionals, have contributed to increased vaccination rates in cancer patients by providing vaccine consultancy and as vaccine practitioners in some countries. This review focuses on pneumococcal infections observed in cancer patients, vaccination process, and pharmacist's role in vaccination.

Keywords: Cancer survivors; *Streptococcus pneumoniae* infections; pharmacist; vaccination

ÖZET Kanser hastaları, almış oldukları yoğun ve bağışıklık yanıtını değiştiren tedaviler nedeniyle enfeksiyon riski altındaki duyarlı popülasyonlardan biridir. Bu enfeksiyonlar arasında *Streptococcus pneumoniae* enfeksiyonları kanser hastalarında önemli bir etkiye sahiptir. Bu enfeksiyonlar, kanserin tipine göre şiddeti değişen hafif veya invaziv tipte görülebilmektedir. İnvaziv pnömokok hastalığı, kanser hastalarında morbidite ve mortaliteyi artıran ciddi bir enfeksiyondur. Güvenli ve etkili kanser tedavi süreçlerini sürdürmek için hastaların bağışıklığının bütünlüğünü sağlamak çok önemlidir. Uluslararası kılavuzlar ve sağlık otoriteleri, kanser hastalarının pnömokok hastalıklarına karşı pnömokok aşısı ile aşılanmalarını önermektedir. Kanser hastalarında aşıların uygulanması, devam eden immünsupresif tedaviler nedeniyle diğer hasta gruplarına göre daha karmaşıktır ve bu da pnömokok aşısıyla aşılamada istenilen oranlara ulaşılamaması ile sonuçlanmaktadır. Aşılama süreci, kanser türü, kanser tanısı, kanser evresi, tedavi türü ve planlanan tedavi süreci gibi kanserle doğrudan ilişkili faktörlerin ve hastayla ilgili diğer faktörlerin kapsamlı bir değerlendirmesini gerektirmektedir. Lojistik, ekonomik, sosyal ve epidemiyolojik faktörler aşı uygulanması önündeki bariyerler olsa da erişkin popülasyonda bağışıklamanın sürdürülebilirliği, aşılama programlarının uygulanmasıyla sağlanabilmektedir. Aşılanma oranlarının artması için sağlık profesyonellerinin hasta ile iş birliği içerisinde çalışması gerekmektedir. Eczacılar, sağlık profesyonelleri olarak, aşı danışmanlığı yaparak ve bazı ülkelerde aşı uygulayıcısı olarak kanser hastalarında aşı oranlarının artmasına katkıda bulunmaktadır. Bu derleme, kanser hastalarında gözlenen pnömokok enfeksiyonları, aşılama süreci ve eczacının aşılamadaki rolüne odaklanmaktadır.

Anahtar Kelimeler: Kanser survivorları; *Streptococcus pneumoniae* enfeksiyonları; eczacılar; aşılama

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CANCER

Cancer is a disease that can start in almost any organ or tissue of the body and occurs when cells multiply and uncontrollably invade surrounding tissues, go beyond their normal limits, and/or spread to other organs.[1] The disease begins when a cell frees itself from the normal restrictions on cell division and follows its own proliferation process.[2] This process is manifested by altered expression and/or activity of cell cycle-related proteins.[3] These cells may proliferate inappropriately and become a tumor or mass; the tumor or mass may persist within the tissue from which it originated or invade nearby tissues and spread.[4] Lung, breast, colorectal, prostate, skin, and stomach cancers are among the most common types of cancer, and mortality rates are higher in lung, colorectal, stomach, liver, and breast cancers.[5]

Cancer is the 2nd leading cause of death globally and it caused an estimated of 9.6 million deaths in 2018.[5] In 2018, 210,537 new cancer cases were detected in Türkiye, and 116.710 people died due to cancer in the same year.[6] Along with an expansion of new treatment regimens that have emerged by developing technology, the survival rates in cancer patients have increased considerably, although they differ according to the cancer type. Considering the 5-year relative survival rate by cancer type, the highest survival rates are seen in prostate cancer (95.5%), melanoma (91.4%), and breast cancer (91%); the lowest rates are seen in pancreatic cancer (10.4%), lung cancer (17.8%), liver cancer (19.4%), esophageal cancer (23.1%) and brain cancer (23.1%).[7]

INFECTIONS IN CANCER PATIENTS

The incidence of bacterial, viral, and fungal infections increases in immunocompromised patients compared to healthy individuals, which varies according to underlying cancer disease.[8] In a study by Pagano et al. the incidence of bacterial infections in individuals with newly diagnosed hematological cancers was 10.3%, bacteremia was 85%, fungal infection was 3%, and the rate of viral infection was 1.8%.[9] In a study by Blimark et al., it was found that bacterial infections are 7-fold and viral infections are 10-fold more common in multiple myeloma patients compared to general population.[8] On the other hand, the incidence of infections in patients with solid cancers is lower than in patients with hematological cancers.[10] Considering compromised immune system in cancer patients, the possibility of infection poses a high risk for increasing morbidity and mortality.

There are 3 main reasons that lead to development of infections in cancer patients.

1. Impairment of cellular and humoral immunity resulted by the use of cytotoxic chemotherapy and/or immunosuppressants such as glucocorticoids:

The neutralization of bacterial toxins decreases due to impaired function of B and T cells, which act as a defense against microorganisms. As a result, the risk of infection increases, especially in patients with hematological cancer or bone marrow transplant, even if they are not neutropenic.

2. Neutropenia:

Neutropenia, defined as the condition where the absolute neutrophil count is less than 500/mm³ or is predicted to be <500/mm³ within 48 hours, is an important and severe side effect caused by chemotherapy, myelosuppressive agent and radiotherapy. It occurs due to disease itself (such as leukemia, lymphoma, solid tumors that have metastasized to the bone marrow) or cancer treatment (chemotherapy, use of glucocorticoids), and the risk of infection increases as its severity increases.[11]

3. Disruption of skin and mucosal barriers:

Pathogens entering the respiratory tract in a healthy individual are expelled by the activity of cilia cells that cover the upper and lower respiratory tracts and form a structural barrier against pathogens and mucociliary layer on the surface of these cells.[12] Pathogens are inactivated through antimicrobial peptides, free oxygen radicals, surfactant proteins, and phagocytes expressed by epithelial cells.[13]

These defense mechanisms afore mentioned in cancer patients are damaged due to disease itself and ongoing treatments; since the defense function is not entirely fulfilled, the occurrence of infections in these patients becomes common. In addition to these mechanisms, malnutrition in patients also increases susceptibility to infections.[12]

Catheter used for administration of drugs and blood products during cancer treatment is the leading factor that disrupts the skin barriers and creates an entrance for infectious agents. Colonization occurs in the catheter due to microorganisms located on patient's skin surface or contamination from the person touching the catheter, which causes infections. These infections may remain as local or become systemic infections by passing through bloodstream that lead to severe morbidity and mortality.[14]

In cancer patients, infections often occur on the skin, circulatory system, lungs, hepatobiliary system, intestinal tract, and urinary system.[15] Infections due to chemotherapy are common in solid cancers. The incidence of neutropenia is lower, and the duration of neutropenia is shorter in solid cancers than in hematological cancers; however, there is an increased risk of infection in these individuals due to damaged anatomical barriers by surgical procedures, chemotherapy, radiotherapy, or medical devices (such as catheter, shunt, stent) or having other clinical conditions such as malnutrition.[16]

Bloodstream infections are a significant complication in cancer patients, which disrupt patient's treatment process, increases the length of hospital stay, morbidity, mortality and financial costs.[17] By considering the cancer types, the incidence of bloodstream infections (mainly gram-negative bacteria with multi-drug resistance) is found as 18% in colon cancer and 27% (bacteremia) in Non-Hodgkin lymphoma.[15]

PNEUMOCOCCAL INFECTIONS IN CANCER PATIENTS

Streptococcus pneumoniae is a gram-positive, encapsulated diplococci extracellular pathogen that causes infections such as otitis, community-acquired pneumonia, bacteremia, and meningitis.[18,19] This pathogen is a member of upper respiratory tract flora, colonizes in nasopharynx and transmitted to people by droplets or aerosols.[19] Bacteria that enter nasal cavity attach to nasopharyngeal epithelial cells, then colonize in or spread to ears (otitis), sinus (sinusitis), or lungs (pneumonia). They can penetrate into mucosal barriers and enter bloodstream (septicemia) or cross blood-brain barrier (meningitis), finally cause infections in these areas.[18] Bacteria that pass into the bloodstream can move into the heart (peritonitis) or and settle in the joints, causing infections that require long-term treatment, such as arthritis and osteomyelitis.[20]

Asymptomatic nasopharyngeal carriage, which varies according to age, immune system, and region of residence, plays a vital role in disease transmission. Carriage rates are higher in young children and elderly compared to other age groups.[21] Pneumococcal carriage rates vary between 20-65% in children, 5-10% in adults and >10% in elderly.[19,21,22]

Pneumococcal diseases are significant causes of morbidity and mortality worldwide.[23] There are more than 90 pneumococcal serotypes identified, but only 25 percent of them cause infection. Infections can occur as otitis, sinusitis, and bronchiolitis with mild mucosal infections or as community-acquired pneumonia, meningitis, and other invasive pneumococcal diseases accompanied by much more severe clinical findings.[24] Although the infections can be treated with antibiotics, *S. pneumoniae* species that develop penicillin or multi-drug resistance have increased in recent years due to unnecessary or inappropriate antibiotic usage.

Infections caused by *S. pneumoniae* are categorized as noninvasive (such as otitis, sinusitis, and pneumonia) and invasive (bacteremia, meningitis, and some types of pneumonia infections) infections. Pneumonia causes hospitalization in approximately 10% of cancer patients, and it is known that the rate of developing pneumonia during treatment in hematological cancers exceeds 30%.[12]

Cancer patients are particularly prone to development of severe pneumococcal infections. Invasive pneumococcal diseases increase morbidity and mortality in cancer patients, and the incidence is particularly high in immunocompromised patients. The incidence of infections varies according to the type of cancer (higher in Hodgkin lymphoma and multiple myeloma), where large amount of cases are aged 50 years and over.[15,25] In particular, the incidence of pneumonia remains high for a long time after surgical procedures, which is one factor that increases sus-

ceptibility to infection in cancer treatment. Although the 1-year cumulative incidence of pneumonia after surgery is higher in lung cancer (2.1-10.7%), the rates can also be considered clinically significant in other solid cancers (stomach cancer 1.8-4.3%; colorectal cancer 1-6.2%; hepatocellular carcinoma 0.7%; breast cancer 0.4%).[25,26]

In hematological cancers, pneumococcal infections are usually seen in neutropenic episodes, whereas infections may be tumor-induced or develop due to treatment-induced neutropenia in solid cancers.[15]

PREVENTION OF PNEUMOCOCCAL INFECTIONS

Pneumococcal infections that occur as a combination of viral and bacterial infections have higher disease severity than other bacterial types of pneumonia and usually require patients to be hospitalized.[27] These type of severe pneumonias require long-term treatment and caused increased hospital costs and mortality, therefore prevention of infections is essential for improving health-related outcomes in individuals and in community. While influenza viruses (A and B) are the most common pathogens in viral pneumonia, *S. pneumoniae* is the most common pathogen in bacterial pneumonia, and these infections can be prevented by influenza and pneumococcal vaccinations.[28] There are 2 types of vaccines used against pneumococcal infections. Influenza and pneumococcal vaccines are recommended for children and adults to prevent influenza and common community-acquired pneumonia, and these vaccines are administered free of charge for children and adults with risk factors within the scope of vaccination programs.[29]

PNEUMOCOCCAL VACCINES

The polysaccharide chain is a substance with strong immunogenic properties found in the structure of the cell wall is responsible for the virulence and colonization of *S. pneumoniae*. Therefore, purified capsular polysaccharide antigen is used in the production of vaccines.[30]

There are 92 different capsular polysaccharide serotypes of *S. pneumoniae* identified, and the serotypes causing severe infections in adults are known as 14, 3, 9, 19, 1, 6, 23, and 7.[31,32] Pneumococcal vaccines are inactivated vaccines containing serotypes that cause serious infections and are categorized as polysaccharide and conjugate vaccines.

PNEUMOCOCCAL POLYSACCHARIDE VACCINE (PPSV23)

Twenty-three different serotypes (1, 2, 3, 4, 5, 6B, 7F, 8, 9N, 9V, 10A, 11A, 12F, 14, 15B, 17F, 18C, 19A, 19F, 20, 22F, 23F, 33F) that consist 90% of the serotypes responsible for invasive infections.[32] In the production of polysaccharide vaccine, capsule polysaccharide is purified, but not many changes applied/modifications have been made. Therefore, antigens do not generate T cell response, but create a temporary memory only through B cells, which lead requirement of repeated doses for long-term maintenance of antibody response.[33]

PNEUMOCOCCAL CONJUGATE VACCINE (PCV13)

This vaccine contains 13 different serotypes (1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F, 23F) responsible for the infections.[32] Pneumococcal conjugate vaccines are produced by binding a bacterial polysaccharide to a carrier protein, such as diphtheria or tetanus toxoid. The carrier protein in the PCV13 vaccine is the CRM197 protein, a non-toxic mutant of diphtheria toxin.[33] The carrier protein provides formation of memory cells that ensure long-term immune response (T-cell-dependent immune response).[34]

PNEUMOCOCCAL VACCINATION IN CANCER PATIENTS

Vaccination is the most convenient and cost-effective treatment option in control of vaccine-preventable diseases in individuals whose immune system is suppressed or weakened, such as cancer patients.[35] However, the desired adult vaccination rates in cancer patients have not yet been reached worldwide, as it happened in general adult vaccination rates.[36]

Immunization process in cancer patients is more complicated compare to other patient populations.[37] This process requires comprehensive assessment of the factors directly related with cancer, such as can-

cer type/diagnosis, cancer stage, type of treatment and scheduled treatment along with other patient-related factors.[38]

The recovery time of prolonged suppressed immune system varies according to treatment received and types of cancer. Immune recovery is delayed in patients receiving chemotherapy or chemo-radiotherapy. It is reported that in breast cancer patients, who received chemotherapy or radiotherapy, 6-76% improvements in various immune-related parameters have occurred 12 months after the treatment.[39]

Due to impaired immune system, high titers of antibody response cannot occur in cancer patients as it observed in healthy individuals. Therefore, response to the vaccine decreases as the degree of suppression of the immune system increases. In a study examined the antibody titers in cancer patients against vaccine-preventable diseases (such as measles-mumps-rubella, varicella, Zoster, diphtheria-tetanus-pertussis, hepatitis A and B), antibody levels were found lower in cancer patients than in healthy individuals.[40] It has been emphasized that inadequate antibody response is related with the type of cancer or immunosuppressive effect of cancer treatment.

Vaccination recommendations for cancer patients are summarized by the Infectious Diseases Society of America and the Advisory Committee on Immunization Practices under the following headings;[38,41]

1. Patients ≥6 months with hematologic or solid cancer should receive annual influenza vaccination, except for patients receiving anti-B cell antibody therapy or intensive chemotherapy, such as induction or consolidation for acute leukemia.

2. PCV13 should be administered in adult patients with newly diagnosed hematologic or solid cancer. PPSV23 should be administered in patients at least 8 weeks after the indicated PCV13 doses.

3. Live viral vaccines should not be administered during chemotherapy.

4. Patients should be vaccinated three months after chemotherapy with inactivated or live vaccines. In regimens containing anti-B cell antibodies, vaccinations should be delayed for at least 6 months.

The algorithm for adult vaccination scheme in cancer patients is shown in Table 1, and the pneumococcal vaccination scheme is shown in Table 2.

After chemotherapy Live and inactivated vaccines can be administered in patients with leukemia, lymphoma, and other cancers in remission (not receiving a regimen containing anti-B cell antibodies) at least 3 months after the last chemotherapy doseAdministration of live and inactivated vaccines in patients receiving regimens containing anti-B cell

TABLE 1: Adult vaccination scheme in cancer patients.[38,42]

	Inactivated vaccines	Live vaccines
Before chemotherapy	It is recommended to administer at least 2 weeks before chemotherapy/radiotherapy	It is recommended to administer at least 4 weeks before chemotherapy/radiotherapy
During chemotherapy	It is NOT recommended to administer inactivated vaccines in patients while receiving chemotherapy Inactivated influenza vaccine can be administered as needed If one of the inactivated vaccines are administered during chemotherapy, the vaccine should not be considered protective unless the level of antibodies has been demonstrated to be adequate. Once the patient becomes immune sufficient, the vaccine may need to be repeated	It is NOT recommended to administer live vaccines in patients while receiving chemotherapy
After chemotherapy	Live and inactivated vaccines can be administered in patients with leukemia, lymphoma, and other cancers in remission (not receiving a regimen containing anti-B cell antibodies) at least 3 months after the last chemotherapy dose Administration of live and inactivated vaccines in patients receiving regimens containing anti-B cell antibodies should be delayed for at least 6 months after the last chemotherapy dose	

TABLE 2: Pneumococcal vaccination scheme in cancer patients.[38,42]

Patients	Recommendation
Patients who have not been vaccinated previously with PCV13 or PPSV23	A single dose of PCV13 vaccine should be given and a dose of PPSV23 vaccine should be given at least 8 weeks later
Patients who have received one or more previous doses of PPSV23 vaccine	A dose of PCV13 should be given ≥1 year after the last dose of PPSV23
Patients requiring additional doses of PPSV23 vaccine	PPSV23 should be given at least 8 weeks after the first dose of PCV13 and at least 5 years after the last dose of PPSV23

antibodies should be delayed for at least 6 months after the last chemotherapy dose

THE ROLE OF PHARMACISTS IN VACCINATION OF CANCER PATIENTS

Pharmacists, as a professional responsible in provision of public health, can contribute vaccination programs for patients with complex treatment processes, such as cancer patients. Within the scope of immunization programs, nurses and physicians are acknowledged professions with authority to vaccinate worldwide. Although pharmacists have limited responsibilities in provision of preventive health services, they are still easily accessible healthcare professional in the health system for the patients. There are regions, such as America, Australia, and some European countries, where pharmacists have the authority to vaccinate and also take active roles in supplying vaccines, counseling services, and administering the vaccines.[43-46] These countries mentioned in the 2020 report of The International Pharmaceutical Federation (FIP) are United States of America, the United Kingdom, Canada, Portugal, Ireland, New Zealand, Argentina, Bolivia, Congo, Costa Rica, Denmark, Finland, Iceland, Lebanon, Netherlands, Philippines, South Africa, and Switzerland. Pharmacists are permitted to administer vaccines in counties including Brazil, Chad, Estonia, France, Greece, Hong Kong/China, Indonesia, Israel, Kenya, Malta, Nepal, Norway, Paraguay, Sierra Leone, Sweden, and Venezuela after the coronavirus disease-2019 pandemic, which begins in early 2020.[47] However, counseling and patient education about the vaccines are prominent services that pharmacist provided among the studies in the literature.

Sustainability of immunization in adult population can be achieved by implementation of vaccination programs, although logistics, economic, social, and epidemiological factors hinder its implementation. These barriers can be originated from the patient, the producer, and the system itself, but can be overcome by collaboration between healthcare professionals. Pharmacists are also in the position both at primary and secondary healthcare settings, who can maintain continuation of immunization programs by actively participating in all stages of immunisation process. The studies demonstrate that vaccine is procured, stored and delivered to the users at appropriate conditions through pharmacies and vaccination consultation given by a pharmacist can reduce vaccine refusals or hesitations of the patient.[48,49] It is also one of the services provided by pharmacists to inform and remind patients who need to be vaccinated, but cannot be reached or overlooked within the scope of vaccination programs, and to direct them to the vaccination units.

Unfortunately, there are limited studies on increasing vaccination rates in cancer patients.[50-54] Those studies have assessed the impact of physician-led interventions or the adoption of vaccination recommendations on the rates of pneumococcal and influenza vaccination in patients with specific malignancies. Studies conducted by pharmacists to increase vaccination rates were generally carried out in adult population, where attitudes and behaviors towards influenza and pneumococcal vaccines stand out compared to other adult vaccines. In a study conducted among patients in primary care settings in whom counseled about PPSV23 vaccine by the pharmacist, 38.9% of patients accepted vaccination recommendations and 66.5% confirmed that they are

vaccinated at 6 months follow-up.[55] The vaccination rates in periods of before- and after- the pharmacist consultation were found to be significantly different (54.1% vs 60.5%, p<0.001).

In a randomized controlled study evaluating community pharmacist-led intervention on the rates of influenza and pneumococcal vaccination, was found that pneumococcal vaccination rate was 1.91 times higher in the intervention group (95% confidence interval, 1.26-2.87).[56]

In another study conducted in Israel, in which vaccination rates among 916 elderly people were evaluated, has shown that 3.9% of participants had ever heard about pneumococcal disease and only 0.5% had vaccination.[57] Two months after the provision of educational by a pharmacist, 30.5% of participants had a positive attitude towards the vaccine, 36% consulted with their physician regarding the vaccine and 1.9% became vaccinated (p=0.008).

Pharmacists can contribute to increase vaccination rates not only by providing patient counseling but also by training healthcare professionals to increase their knowledge about vaccines. In a study conducted by Caffrey et al., an educational campaign on pneumococcal immunization was organized and provided for immunization providers in community pharmacies and acute care hospitals.[58] According to the survey findings at the study, 92% of participants stated that their knowledge about the vaccine was increased; and by implementation of the campaign, their pneumococcal immunization practice (vaccination rates) has increased significantly which has resulted in significantly decreased in the rate of pneumococcal diseases in community.

In the view of these studies, it has been acknowledged that positive attitudes and behavior change can be achieved among different patient population towards influenza and pneumococcal vaccines by contribution of pharmacists in public health issues through various ways.

Pharmacists can also take an active role in monitoring and recording the vaccine-related side effects/adverse effects that may occur after vaccination.[46] Overall, it has been shown that vaccination rates have increased in the health systems where pharmacists are actively included in vaccination programs.[44]

FIP has set targets for pharmacists to take an active role in vaccination and encouraged to take initiatives in this perspective. The program outlined in 2020 by the FIP has evolved to the digital platform in 2021 as “Transforming Vaccination Globally, Regionally, Nationally”.[59,60] In order to accelerate vaccine equity, access, and sustainability among community, the FIP has committed to change vaccination.

The FIP has suggested to implement strategies in order to achieve these targets such as involvement of pharmacies and pharmacists in the system while developing vaccination-related policies, providing delivery of vaccines for all age groups through pharmacies, giving importance to gender equality in order to make access to the vaccine fair, and preventing vaccine rejection by contributing to the development of health literacy by pharmacists. Another goal is to carry out all these activities through a multidisciplinary team. The targets set by FIP show that there are areas where the pharmacist can contribute much more to vaccination in specific patient groups, such as cancer patients. It can be concluded that pharmacists will become more influential healthcare professional in vaccination in the countries’ health policies in the coming periods.

CONCLUSION

Cancer patients are one of the patient groups at risk of developing infections due to intensive and immune response-altering treatments. It is the main focus of healthcare in cancer patients to ensure and protect the patients’ immunity in order to control the disease progress and to maintain treatment continuity without experiencing with problems.

Several international associations and immunization committees emphasize the importance and necessity of vaccination in cancer patients and therefore recommend certain vaccinations for these patients. The pneumococcal vaccine is one of the recommended vaccines by clinical experts and has shown effective in preventing invasive pneumococcal disease, especially in cancer patients.

The Center for Disease Control and Prevention emphasizes the importance of cooperation between healthcare professionals in order to increase adult vaccination rates. Pharmacists, one of the profession that frequently and closely communicate with patients, have crucial role in identifying susceptible patient population for the risk of infections and verifying patients' needs in preventive healthcare. Pharmacists can supply the vaccine, provide information about vaccines/vaccination and take responsibility in administration of vaccine in order to increase vaccination rates among adult population, particularly in cancer patients.

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