

Review Article

Impact of Hygiene on the Survival of Cancer Patients with Infection: A Narrative Review

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Abstract

Given the high prevalence of cancer and its significant consequences on patients' health, it is essential to examine supportive and preventive interventions alongside mainstream treatments. Thus, this structured narrative review aimed to investigate the effectiveness and mechanism of various interventions related to hand hygiene, health education, lifestyle, vaccination, and environmental hygiene in patients with cancer who have infections. These interventions focus on promoting self-efficacy, improving the quality of life (QoL), and supporting the recovery process of patients while reducing the risk of infection. Additionally, analysis of the biochemical, cellular, and behavioral mechanisms of these interventions forms part of this methodology. In the context of cancer patients with infections, vaccination and hand hygiene have the greatest direct impact on decreasing the risk and severity of infections while increasing the chances of survival. Lifestyle and environmental hygiene play an important supporting and reinforcing role in increasing the body's resistance. Moreover, health education indirectly affects survival by improving QoL and empowering the patient. Our findings confirmed the importance of a comprehensive, multifaceted approach to cancer care. Improving hand hygiene, providing effective health education, encouraging healthy lifestyles, implementing appropriate vaccination programs, and maintaining environmental hygiene all play a critical role in reducing infections while promoting health, improving QoL, and increasing survival in cancer patients. Nonetheless, the sustained success of these interventions requires simultaneous attention to individual needs assessment, self-efficacy enhancement, practical and communication skills training, and integration into the standard care process.

Keywords: Infection, Cancer, Survival, Hygiene



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Introduction

Cancer has been a major threat to public health, and the global burden of cancer is expected to steadily increase for at least the next twenty years. Nonetheless, the risk of cancer-related mortality has decreased with the development of early detection strategies, supportive care, and clinical treatment (1). It is estimated that by 2040, there will be more than twenty-eight million new cases of cancer worldwide (2). Patients with cancer are frequently at increased risk of infection, and infections are more fatal in people with cancer. In addition, infectious diseases complicate cancer treatment, directly endanger the health of individuals with cancer, and ultimately contribute to a poor prognosis (3). Fortunately, many risk factors for cancer, including infection, tobacco use, alcohol, and obesity, are largely preventable (4). Public health is defined as the science and art of preventing disease, promoting health, and increasing longevity through informed choices by communities and

individuals. Moreover, it plays a vital role in moving society toward achieving its goals of improving the health and QoL of cancer patients (5, 6). Although extensive studies have evaluated the causes of cancer death, the issue of patient survival has received less attention. Dramatic advances in diagnostic and therapeutic methods have significantly increased the life expectancy of cancer patients. However, patient survival depends on several factors, such as the type of cancer and individual characteristics. Accordingly, examining survival rates not only provides us with valuable information about the natural course of the disease, but also demonstrates the impact of new treatment methods and screening programs (7).

Most research has focused on the clinical management of infection after it occurs, and there is limited research on the impact of proactive and proactive public health interventions on survival outcomes. It should be noted that public health, with a focus on prevention, vaccination,



education, and community surveillance, has the unique potential to create a safer environment for this most vulnerable population.

Procedure

The method of selecting and screening the articles and is shown in Figure 1.

Hand Hygiene

Hand hygiene is one of the most effective and cost-effective interventions to reduce the transmission of infectious agents. Randomized and systematic evidence shows that both proper hand washing with soap and the use of alcohol-based hand rubs can significantly decrease the microbial load on hands. Cancer patients are at high risk of viral infections, including coronavirus disease 2019 (COVID-19), as well as opportunistic infections due to immunosuppressive treatments (e.g., chemotherapy). Hand hygiene, as one of the most important preventive measures, plays a vital role in controlling the source of infection. Guidelines require patients, caregivers, and families to wash their hands frequently with soap and water for at least 20 seconds or use hand sanitizers containing at least 70% alcohol, especially before eating, after using the toilet, after touching suspicious surfaces, and after coughing or sneezing; in healthcare facilities, staff should also disinfect their hands after each patient contact and clean high-touch surfaces several times a day (8). Studies indicate that patients with hematological malignancies undergoing chemotherapy have less contamination of their hands, which is attributed to high awareness and ability to take care of themselves, and proper implementation of hand hygiene significantly reduces this contamination. These findings emphasize the special importance of

hand hygiene in cancer patients, where its observance by medical staff in outpatient oncology centers is considered the most effective way to interrupt the chain of pathogen transmission, reduce nosocomial infections, and alleviate infectious complications, length of stay, and treatment outcomes (9, 10).

The use of antiseptic soaps (e.g., Dettol, Savlon, and Lifebuoy Plus) and herbal soaps (e.g., Neem, Aloe Vera, and Haldi Chandan) shows the highest susceptibility to *Staphylococcus aureus*, while the resistant bacteria *Pseudomonas aeruginosa* is less affected. The mechanism of action of these soaps includes reduction of the surface tension of cell membrane by anionic surfactants, extraction of phospholipid lipids, and creation of hydrophobic pores, leading to the destruction of peptidoglycan wall, denaturation of membrane proteins, and cell lysis (11). In addition to its antimicrobial activity in soap, chloroxylenol specifically inhibits the Wnt/ β -catenin signaling pathway in colorectal cancer cells; this compound inhibits the survival, proliferation, migration, invasion, spheroid formation, and stemness properties of cancer cells and induces apoptosis by reducing β -catenin nuclear translocation, disrupting the β -catenin/TCF4 complex, and repressing Wnt target genes (*Axin2*, *Survivin*, and *LGR5*). Moreover, it reduces tumor growth in the MC38 xenograft model (12). Neem leaf ethanol extract, which contains active compounds 2',3'-dehydrosolanol, 6-desacetyl nimbinene, and nimolinone, inhibits tumor growth and induces apoptosis in animal models by suppressing the proliferation of prostate cancer cells and causing genomic changes, such as an increase in cell death and drug metabolism genes, along with a decrease in cell cycle and DNA repair genes. Similarly, herbal soaps containing neem exert strong antimicrobial effects, especially against *S. aureus*, by

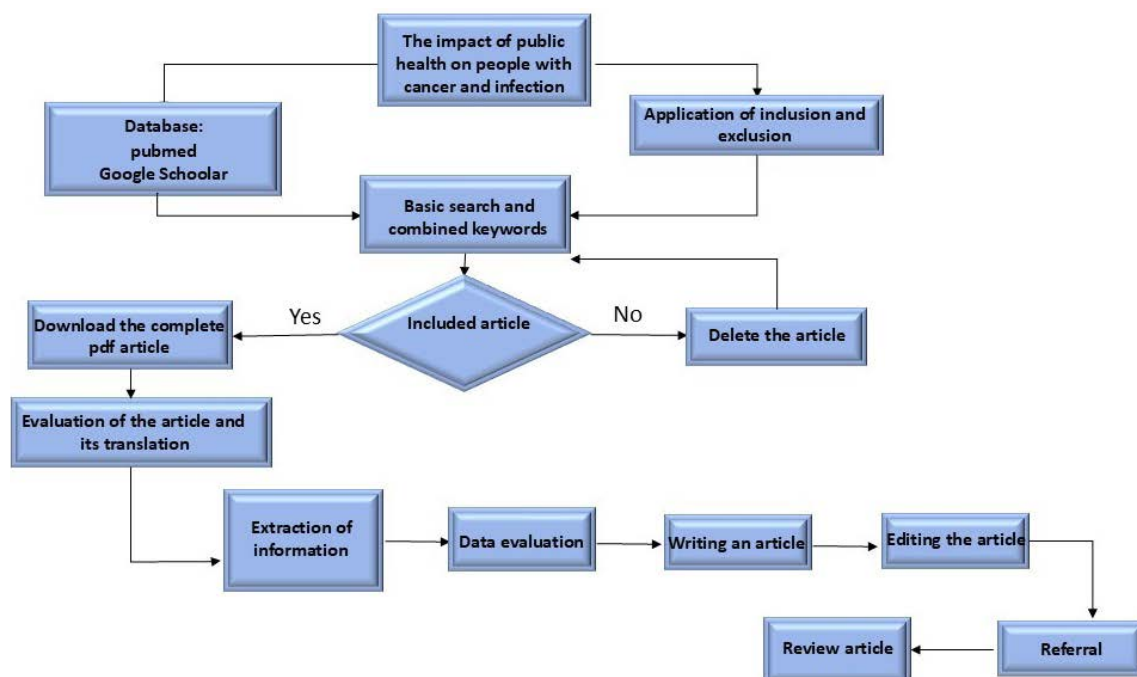


Figure 1. Flowchart of Selected Articles

destroying the peptidoglycan wall, denaturing membrane proteins, and reducing membrane surface tension (11, 13). Medicinal and traditional soaps perform better against *S. aureus* and cause membrane destruction and cell swelling by acting on phospholipids and affecting membrane potential; nonetheless, cosmetic and laundry soaps are weaker, and *Candida albicans* shows high resistance due to its thick chitin wall. Liquid hand soap formulated with vegetable oils and aloe vera extract has alkaline pH, favorable foaming, and appropriate antimicrobial activity against bacteria and fungi and maintains long-term stability (14). Additionally, alcohol-based hand sanitizers with concentrations of 60–95% are effective against a wide range of enveloped bacteria, fungi, and viruses without the need for water, but are less effective against spores and non-enveloped viruses. These products are available in a variety of forms, including gels, foams, and liquids, each with different skin feel and drying time. Likewise, additives such as glycerol and hydrogen peroxide are used to improve skin tolerance and enhance the effectiveness of the formulation. Nevertheless, repeated use of these hand sanitizers can cause dryness and contact dermatitis, while ingredients such as benzalkonium chloride and triclosan may cause systemic side effects; thus, their use should be limited to minimize potential adverse effects. To develop natural and safer products, herbal formulas based on extracts such as *Calotropis gigantea* have been able to display the potential to replace alcoholic products with suitable physicochemical properties and significant antimicrobial activity (15, 16). In addition, the dichloromethane extract of the stem bark of this plant, *Calotropis gigantea*, containing significant amounts of cardenolides and triterpenoids, has a strong cytotoxic effect on colon cancer cells and. Furthermore, in combination with the chemotherapy drug 5-fluorouracil, it increases mitochondrial-dependent apoptosis by reducing adenosine triphosphate production, increasing the production of reactive oxygen species, and disrupting the mitochondrial membrane. In contrast to its strong effect on cancer cells, this extract does not have significant toxicity on normal cells, indicating its selectivity (17).

In addition, alcohol-free gels containing aloe vera and clove oil with an acidic pH and broad antimicrobial spectrum, high skin acceptance and proven safety are a logical alternative (18). Similarly, compounds such as luteolin provide targeted antibacterial effects by increasing cell membrane permeability and causing the leakage of intracellular materials (19). Laboratory studies have shown that different brands of alcohol-based hand sanitizers have different performance against common bacteria; for instance, Y-Senses and Lovillea have broader inhibition zones and more effective spectrum, while others have lower or limited performance (20). Likewise, clinical trials have shown the effectiveness of rubbing alcohol-based hand solutions to be significantly better than washing with soap; however, a combination of the two methods has the best results. These natural substances, as compounds in detergents and drugs, with their mechanisms, can control infections and directly target tumors in oncological patients

while inhibiting the growth of microbes and their effect on cancer cells. Thus, while improving hand hygiene, they increase the quality of care and safety in these patients and prevent the negative consequences of opportunistic infections. This multifunctional integration provides new horizons for the use of safe and effective natural products in cancer treatment and infection control (21, 22).

Therefore, integrating these programs into infection control, along with mask use and social distancing, improves the quality of care while minimizing the exposure of vulnerable oncological patients, thereby positively impacting their survival rates.

Vaccination

Vaccination is a fundamental and life-saving intervention in the care of cancer patients. The goal is not only to prevent infection, but also to reduce disease severity, hospitalization, and mortality from vaccine-preventable diseases, and indeed plays a vital role in improving survival in this vulnerable group. The vaccination of cancer patients should include non-live vaccines, such as seasonal respiratory vaccines, pneumococcal conjugate vaccine (PCV15/PCV20) instead of the polysaccharide type, recombinant zoster (RZV) for all adults 19 years and older, high-dose hepatitis B, and human papillomavirus vaccine for eligible adults up to 45 years of age (23, 24).

The response to vaccination in cancer patients varies depending on the type of cancer and the treatment. More precisely, patients with solid tumors produce lower levels of antibodies after the COVID-19 vaccine than healthy individuals, but this reduction is much smaller in those treated with immune checkpoint inhibitors (ICIs) or targeted therapies. Moreover, patients with blood cancers have a poorer response to the vaccine, especially those treated with drugs that disrupt B lymphocytes (e.g., anti-CD20, Bruton's tyrosine kinase inhibitors, chimeric antigen receptor T-cell therapy) or high-dose corticosteroids. It should be noted that the COVID-19 vaccine has significantly reduced hospitalizations and deaths in cancer patients (23, 24).

Cancer patients demonstrate a better immune response to high-dose influenza vaccine than the standard dose. Influenza vaccination (including seasonal and pandemic H1N1) even during chemotherapy, monoclonal antibodies, or tyrosine kinase inhibitors, provides high seroprotection after two doses and enhances the activation of memory B and T cells. In patients receiving hematopoietic stem cell transplantation, factors such as graft-versus-host disease and immunosuppressive drugs decrease the response to vaccines, but COVID-19, high-dose influenza, and RZV vaccines are safe and effective in this group (25). In children a booster dose of the vaccine can significantly restore protective immunity after completing chemotherapy. Seasonal influenza vaccination is associated with a significant decline in mortality in cancer patients, although it does not substantially reduce hospitalizations and infectious complications (26). Furthermore, vaccination is safe, even in patients with a weak immune response,

such as those treated with rituximab or splenectomy, and is recommended despite a limited immune response (27). Patients treated with immunosuppressive agents (ICIs) display a good immune response to COVID-19 and influenza vaccines without an increased risk of treatment-related immune complications; recent research has also confirmed that influenza vaccination in patients treated with immunosuppressive agents (ICIs) is not only not ineffective but also increases overall survival (27 months vs. 20.9) and disease control (28).

Pneumococcal conjugate vaccines (e.g., PCV13) elicit higher antibody levels than the polysaccharide variant, particularly in patients with poor responses, such as chronic lymphocytic leukemia, and are generally safe and effective in cancer patients, especially lung, lymphoma, and breast cancer. RZV provides good protection, especially if given before or after immunosuppressive therapies (29, 30).

The timing of vaccination in cancer patients varies depending on the type of treatment and the target population, with the main goal being to achieve a maximal immune response before the start of immunosuppressive therapies; in general, the best time to vaccinate is 2–4 weeks before the start of immunosuppressive therapies. It should be noted that patients undergoing B-cell-depleting therapies require a specific schedule and occasionally an additional dose. Stem cell transplant recipients should resume their vaccination schedule 3–6 months after transplantation (29, 30).

Despite scientific support, vaccination rates in cancer patients are still low. Only about 37% of general practitioners vaccinate all patients as recommended, and the main barriers include lack of training and information, patient concerns about complications, and the perception that vaccination is unnecessary. Continuous training for physicians, practical guidelines, and patient awareness are necessary. Studies have shown that oncologists are the most likely to recommend vaccination for influenza (87%), pneumococcus (73%), and hepatitis B (67%), and vaccination is a higher priority for patients with lung, lymphoma, and breast cancer. However, only a quarter of physicians believe that their recommendations are adequate and effective. Lack of time and knowledge related to vaccination and high patient numbers in different units reduce recommendations. In terms of safety and efficacy, influenza and pneumococcal vaccines have been shown to be well tolerated in patients undergoing chemotherapy (31, 32). Additionally, serologic responses to influenza vaccine are accepted in patients with solid tumors; early vaccination (especially in breast cancer) elicits a stronger response. A large prospective study revealed that these vaccines enhance both anti-infective and anti-tumor immunity without negatively interfering with immunotherapy. In conclusion, vaccination in cancer patients is a safe, cost-effective, and effective intervention. More precisely, regular and timely vaccination significantly reduces the burden of disease and mortality in these patients. However, translating this evidence into routine clinical practice requires overcoming structural and educational barriers.

It is noteworthy that integrating systematic vaccine counseling and administration into the standard of care for cancer patients, as part of a comprehensive approach, could make a significant contribution to maintaining health and improving treatment outcomes for these patients (28).

Life Style

Lifestyle interventions, including adequate sleep, regular exercise, a balanced diet, and vitamin supplements, can strengthen the immune system, control inflammation, and reduce the risk of opportunistic infections. Extensive research has examined the role of these factors in the management of cancer patients, each of which is complementary in improving QoL and prognosis for patients. Likewise, several studies have investigated the role of vitamins in helping to treat cancer and reduce the side effects of chemotherapy. The simultaneous administration of vitamins C and E in breast cancer patients undergoing chemotherapy regimens could improve the impaired antioxidant status caused by the disease and treatment. These supplements significantly increased the activities of protective enzymes, such as superoxide dismutase, catalase, glutathione S-transferase, glutathione reductase, and reduced glutathione, while significantly decreasing lipid peroxidation (malondialdehyde) and DNA damage, indicating the protection of these vitamins against the oxidative side effects of chemotherapy. In addition, another study reported that taking vitamin C and E supplements along with chemotherapy improved antioxidant status and reduced oxidative stress, thereby helping to minimize cell damage while improving patients' biochemical status (28). Similarly, *in vitro* studies have shown the synergistic effect of vitamin C in combination with chemotherapy drugs, such as mitoxantrone and methotrexate. For example, adding vitamin C to mitoxantrone allows for a reduction in the drug dose and increases the apoptosis of cancer cells. Moreover, combining low-dose vitamin C with methotrexate in the treatment of breast cancer activates caspase-3 and p38 protein kinase-dependent death pathways, although this effect is reduced in some resistant lines, implying the complexity of the mechanisms (33, 34). In other types of cancer, vitamin intake has a different effect on survival; for instance, high intake of vitamin A increases the risk of death, while moderate intake of vitamins B1 and B2 is associated with a reduced risk of death. The relationship between vitamin C and survival is more complex, with moderate intake having a protective effect, but extremely high intake increasing the risk. Therefore, careful adjustment of vitamins in patients' diets is of great importance (35). Further, vitamin B12 plays an important role in the prevention and treatment of chemotherapy-induced peripheral neuropathy; although supplements cannot completely prevent its occurrence, they provide significant improvements in symptoms and QoL for patients. In this context, there is a need for more detailed evaluation and investigation of B vitamins. Regarding vitamin D, a systematic review up to 2010 demonstrated that there is no convincing evidence for

the effect of vitamin D supplementation on the prognosis of cancer patients; hence, more research is needed in this regard (36). Finally, the intravenous injection of high-dose vitamin C in cancer patients reduces inflammation, C-reactive protein, and inflammatory cytokines, which has been associated with improvements in tumor markers in some patients; however, the response to treatment varies and is less observed in advanced cases (37).

In line with these trends, exercise interventions play a vital role in improving physical function and QoL in cancer patients, although their effects on fatigue are variable. Exercise programs combining aerobic and resistance training have been shown to maintain or increase muscle strength, aerobic capacity, improve QoL, and accelerate return to daily activities in patients undergoing palliative care, as well as in survivors of various types of cancer (patients who have recovered from cancer), including breast, testicular, and colon. These interventions are safe and feasible and have no negative impact on chemotherapy doses; although there are challenges such as patient dropout due to disease progression. Moreover, regular exercise reduces cancer-related pain, psychological symptoms, insomnia, and shortness of breath; however, it has no significant effect on nausea, anorexia, or gastrointestinal problems. In prostate patients, exercise improved QoL but had no marked effect on fatigue and some functional tests (38, 39). Studies have reported that regular exercise, especially at moderate or vigorous intensity, improves aerobic capacity and survival in different types of cancer while reducing the risk of cancer-related and total mortality; these effects are particularly potent after diagnosis and with a combination of aerobic and resistance training. From a cardiovascular perspective, exercise is protective and significantly reduces the rate of cardiac events, failure, and death, even during systemic treatments, including chemotherapy and radiotherapy (40, 41). Furthermore, in patients recovering from cancer, combined exercise programs have been shown to increase bone density, improve indices of bone formation and resorption, and increase muscle mass without increasing fat. It should be noted that exercise prescription should be personalized and based on age, medications, medical history, and cardiopulmonary function testing. Likewise, it should be included as a core part of cancer rehabilitation in comprehensive care (41, 42).

Additionally, malnutrition and loss of muscle mass are prevalent and serious problems in cancer patients, which are associated with increased treatment complications, poor drug tolerance, and reduced patient survival. Regular nutritional screening with standard tools (e.g., Malnutrition Universal screening Tool, Nutritional Risk Screening 2002, and Patient-Generated Subjective Global Assessment) is recommended from the time of diagnosis until the end of treatment (43). Nutritional interventions, including individualized nutritional counseling, oral supplements, enteral nutrition, and, if necessary, parenteral nutrition, also help maintain nutritional status. In addition, immunonutrition enriched with arginine, nucleotides, and

omega-3 has a significant effect on reducing postoperative infectious complications and shortening hospital stay, especially in patients undergoing upper gastrointestinal surgery, although no significant effect on overall mortality has been observed so far. In advanced patients, malnutrition and cachexia are negative predictors of poorer treatment and survival; a high-energy (25–30 kcal/kg) and high-protein diet, combined with anti-inflammatory supplements (e.g., omega-3 and early palliative care) can improve nutritional indices, QoL, and survival. The ultimate goal of this approach is to counteract treatment-induced catabolic crises and increase recovery periods at a lower cost than new drugs (44, 45).

Environmental Health

As a preventive branch of biomedicine, environmental health plays a pivotal role in reducing hospital-acquired infections and improving the survival of cancer patients by controlling the interaction of biological, physical, chemical, and social environmental factors on human health (46).

Several studies have indicated that the hospital environment is a major reservoir of opportunistic pathogens, such as Gram-negative bacteria (*Proteus* spp., *Escherichia coli*, *P. aeruginosa*), Gram-positive bacteria (*S. aureus* and *Bacillus* spp.) and fungi (*Candida* spp. and *Aspergillus*); about 30% of high-touch surfaces (bed rails, sinks, and bathroom handles) are contaminated, and the antibiotic resistance pattern (extended-spectrum beta-lactamase and multidrug-resistant) between clinical and environmental isolates is similar (47–49). This contamination is prevalent even in non-room spaces (e.g., corridors, waiting rooms, toilets, and outpatient centers) and is influenced by complex factors, such as surface type, season, ward type (general medicine > intensive care unit) and isolation status (non-isolated > isolated), while the quality of routine cleaning is often inadequate (50).

Complementary surface measures are effective, including daily chlorhexidine baths (reduction of multidrug-resistant organisms), a low-microbial diet (avoidance of raw foods), and meticulous oral hygiene with regular rinsing (4–6 times daily with sterile water or normal saline). Other measures are catheter management (aseptic packaging), and surface disinfection with probiotics (*Bacillus: mecA-MRSA* gene reduction in sinks), human papillomavirus steam, UV-C, or self-disinfecting surfaces (copper and silver). In the intensive care unit, high-touch surfaces are contaminated within 24 hours and harbor methicillin-resistant *S. aureus* /vancomycin-resistant enterococci /*Pseudomonas* (relative risk: 2.8) (51). In oncology palliative care, continued COVID measures (hand hygiene, mandatory masking, screening, and rapid isolation) reduced healthcare-associated infection without increasing antibiotic resistance (52).

Waste management is a major challenge that requires special attention; incorrect segregation (73% pharmaceutical errors, 36% cytotoxic agents, 65% physicians' accuracy, and 70% cleaners') leads to inappropriate treatment, occupational hazards (needlesticks), and nosocomial

transmission (*P. aeruginosa*, *K. pneumoniae*, *S. aureus*, and extended-spectrum beta-lactamase) (53).

Ultimately, combined interventions (hand hygiene, visitor restrictions, sanitation, and disinfection of the hospital environment) reduce the prevalence of healthcare-associated infection in cancer patients while improving survival; challenges include emerging pathogens (*C. auris*), human factors, and costs requiring ongoing education, fluorescent/adenosine triphosphate monitoring, and standardization (53).

Health Education

Based on existing research in the field of health education for cancer patients, strong evidence has been reported of the positive and multidimensional effects of these interventions.

A large systematic review suggests that self-management education as part of health education leads to significant improvements in reducing fatigue, relieving symptoms of depression and anxiety, and improving QoL. However, the impact of this education on pain management has been less conclusive (54). Of note in this review is the high variability in intervention design and the relative neglect of a crucial component such as training in communication skills with the treatment team. It should be noted that the success of health education depends on the use of a variety of strategies. According to another systematic review, face-to-face, one-on-one education, especially when combined with a “teach-back” approach, has the greatest impact on improving psychological well-being, increasing knowledge, and managing symptoms such as pain. In contrast, group education, while effective in reducing anxiety and depression, is less effective in improving physical symptoms, such as fatigue. Further, the use of customized written resources, educational videos, and digital platforms can increase knowledge and adherence to treatment when tailored to patients’ needs and health literacy levels (55).

Moreover, new digital interventions have gained prominence. According to evidence, structured psychoeducational interventions delivered via the Internet can significantly reduce cancer-associated depression and fatigue. Similarly, a study of an online support community on social media revealed that education in this way increased patients’ awareness of the disease and treatment options and reduced anxiety levels (56).

In addition, the effectiveness of these trainings in specific populations and different clinical settings has undergone investigation. In pediatric cancer survivors, participation in integrated combined programs incorporating practical adventure activities and health education has been associated with increased levels of physical activity and enhanced self-esteem (57). In patients with lung cancer undergoing major surgery, the provision of a structured educational booklet in the preoperative period improved postoperative respiratory indices while significantly reducing pain and anxiety (58). Additionally, a structured group training program for cancer survivors with fatigue resulted in reduced persistence of fatigue but improved

QoL, self-efficacy, and physical activity. In women with breast cancer, a nursing-centered “self-care” educational program led to remarkable improvements in QoL across all physical, psychological, social, and spiritual dimensions. Overall, the findings emphasized the usefulness of structured, multimodal health education in empowering cancer patients. However, the long-term effectiveness of these interventions depends on a comprehensive approach that focuses on individual needs, promotes self-efficacy, develops communication and practical skills, and incorporates these strategies into standard clinical care (59, 60).

Conclusion and Future Perspectives

Infection is a prevalent complication among patients with cancer and may result from cancer treatments or healthcare-associated infections. Its occurrence can adversely affect survival outcomes and lead to increased mortality. Effective infection prevention and control protocols can have a significant impact on improving survival outcomes among patients with cancer. The use of protocols. In addition, the implementation of infection prevention and control protocols may vary depending on the patient’s clinical condition and the type of infections. Adherence to evidence-based protocols can facilitate effective infection control and reduce the burden of infection among patients. In future studies, it would be valuable to evaluate the combined effect of these protocols on infection control in patients. On the other hand, the identification of microorganisms resistant to certain protocols and the characterization of their underlying molecular pathways may help inform the development of more effective health and infection-control protocols.

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Competing Interests

The authors declare that they have no conflict of interest.

Consent for Publication

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Data Availability Statement

This is a review study, and it is not an original.

Ethical Approval

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