Revista ARACÊ
ISSN: 2358-2472

ADVANCES IN IMMUNE THERAPY: REDEFINING THE FUTURE OF CANCER CARE

https://doi.org/10.56238/arev7n3-160

Submitted on: 02/17/2025 **Publication date:** 03/17/2025

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Revista ARACÊ
ISSN: 2358-2472

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ABSTRACT

Cancer is one of the leading causes of global morbidity and mortality, making primary and secondary prevention essential strategies to reduce its incidence and impact on public health. This study aims to analyze the effects of preventive actions on reducing the burden of cancer, highlighting challenges and opportunities to improve cancer control policies. This is an integrative literature review, with a search for articles published between 2018 and 2025 in the PubMed, SciELO, Web of Science, and Google Scholar databases, using controlled descriptors. The results show that primary prevention, through vaccination, tobacco control, and promotion of healthy habits, significantly reduces the risk of cancer, but faces barriers such as behavioral resistance and misinformation. Secondary prevention, focused on screening and early diagnosis, improved survival rates, but eliminated inequality of access and limited infrastructure of health services. It is concluded that the integration between both strategies, combined with investments in technology and health education, is essential to improve early detection and minimize the impacts of cancer on the population.

Keywords: Immunotherapy. Cancer. Biological Therapies. Therapeutic Advances.

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Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

Cancer represents one of the main challenges today, being one of the main causes of morbidity and mortality in the world. The biological complexity of tumors and their ability to evade immune make cancer treatment a field in constant evolution. Conventional therapies, such as surgery, chemotherapy, and radiation therapy, have significant limitations, including high toxicity and the development of therapeutic resistance. In this context, immunotherapy has emerged as an innovative paradigm, redirecting the focus to strengthening the immune system in the fight against tumor cells (Lutosa *et al.,* 2024)

Immunotherapy is based on the immune system's ability to recognize and eliminate malignant cells. Unlike traditional approaches, which act directly on the tumor, immunotherapy seeks to enhance the patient's immune response, offering a long-lasting and, in many cases, less aggressive effect. This strategy has shown great clinical impact, particularly in neoplasms previously considered to have an unfavorable prognosis (Lutosa *et al.,* 2024)

Among the most studied immunotherapeutic approaches, immune checkpoint inhibitors stand out, which block inhibitory signals from tumor cells, allowing a more effective response of T lymphocytes. Drugs such as pembrolizumab and nivolumab, which act on the PD-1/PD-L1 pathway, have revolutionized the treatment of tumors such as melanoma and non-small cell lung cancer, substantially improving patient survival (Evangelista; Silva; Loureiro 2023).

Another relevant innovation is the therapy with genetically modified T cells, known as CAR-T cells. This strategy consists of the ex vivo manipulation of the patient's T lymphocytes, giving them the ability to recognize specific tumor antigens. The use of CAR-T cells has shown great efficacy in the treatment of hematological malignancies, such as leukemia and lymphomas, resulting in considerable remission rates (Evangelista; Silva; Loureiro 2023).

Moreover, therapeutic cancer vaccines are a promising approach as they aim to stimulate a long-lasting anti-tumor immune response. Examples include the human papillomavirus (HPV) vaccine, which is widely used in the prevention of cervical cancer, and other experimental strategies targeting solid and hematological tumors (Lombardi *et al.,* 2021).

Monoclonal antibodies also play an essential role in immunotherapy, acting on cell signaling and blocking pathways critical for tumor proliferation. Molecules such as

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trastuzumab, used in HER2-positive breast cancer, have demonstrated a significant clinical impact by modulating the immune response and inhibiting tumor progression (Vidal; Flowers; Pepe 2018).

Despite the advances, immunotherapy faces important challenges, such as tumor resistance, side effects associated with exacerbated activation of the immune system, and the high cost of therapies. Resistance may occur due to the selection of less immunogenic tumor cells or the expression of immune escape mechanisms, requiring the development of new therapeutic strategies. Side effects of immunotherapy include autoimmune reactions, such as colitis, pneumonitis, and endocrinopathies, which require close monitoring and expert management. Thus, current research seeks to refine therapeutic approaches to maximize benefits while minimizing associated risks (Lombardi *et al.,* 2021).

The high cost of immunotherapies also poses a challenge for their large-scale implementation, especially in public health systems. Studies are looking for alternatives to make these therapies more accessible, either through the development of biosimilars or the optimization of therapeutic regimens. The association of immunotherapy with other approaches, such as chemotherapy and targeted therapies, has been investigated as a way to enhance the therapeutic response and overcome resistance mechanisms. Clinical trials demonstrate that these combinations can significantly improve clinical outcomes, opening new perspectives for cancer treatment (Evangelista; Silva; Loureiro 2023).

Precision medicine has also contributed to the personalization of immunotherapies, allowing the selection of predictive biomarkers of response and the development of individualized therapeutic approaches. This allows for more effective treatments with a lower risk of adverse effects. The advancement of biotechnology and bioinformatics has driven new immunotherapeutic strategies, including the use of nanomedicine and gene editing to enhance the immune response against tumors. These innovations promise to further expand the potential of immunotherapy in oncology (Vidal; Flowers; Pepe 2018).

Given this scenario, this article aims to discuss the main advances in immunological therapy applied to cancer, analyzing its mechanisms of action, clinical impact, and future perspectives. The review will also address challenges to be overcome for immunotherapy to be consolidated as an accessible and effective therapeutic strategy in modern oncology.

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METHODOLOGY

This research is characterized as an integrative review of the literature, whose purpose is to gather and critically analyze the available evidence on advances in immunological therapy in cancer treatment. The integrative review enables the synthesis of knowledge and the incorporation of relevant studies that address different aspects of the theme, allowing a broad and in-depth understanding of the object of study.

TYPE OF STUDY

The present study is an integrative review, according to the methodology described by Whittemore and Knafl (2005), which comprises six stages: formulation of the research question, literature search, selection of studies, critical evaluation of the articles, analysis and synthesis of data and presentation of results.

RESEARCH QUESTION

The guiding question was structured based on the PICO strategy (Population, Intervention, Comparator and Outcome - outcome), aiming to ensure the objectivity and relevance of the review. The research question formulated was, "What are the recent advances in immune therapy applied to cancer treatment, and what are their clinical impacts?"

INCLUSION AND EXCLUSION CRITERIA

Studies published between 2018 and 2025, available in full, in Portuguese, English, or Spanish, that addressed advances in cancer immunotherapy, were included. Duplicate studies, opinion articles, letters to the editor, and non-systematized reviews were excluded.

DATA SOURCES AND SEARCH PROCEDURES

The electronic search was performed in the PubMed, SciELO, Web of Science and Google Scholar databases, using controlled and uncontrolled descriptors, according to the terminology of Medical *Subject Headings (MeSH)* and Health Sciences Descriptors (DeCS). The descriptors used were: "Immunotherapy", "Cancer", "Biological Therapies", "Therapeutic Advances", combined with the Boolean operators *AND* and *OR*.

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ISSN: 2358-2472

SELECTION AND EVALUATION OF STUDIES

The identified studies were initially screened by reading titles and abstracts, to verify adherence to the inclusion criteria. Eligible articles were analyzed in full, and submitted to critical evaluation using the methodological classification tool CASP (*Critical Appraisal Skills Programme*), ensuring the quality of the evidence included.

DATA ANALYSIS AND SYNTHESIS

The data were organized in a synthesis matrix, including the following information: authors, year of publication, study objective, methodology, main findings and conclusions. The analysis was carried out descriptively and qualitatively, discussing the main findings about the existing literature.

ETHICAL CONSIDERATIONS

As this is an integrative review, this research did not involve experimentation with human beings, dispensing with the need for approval by an ethics committee. However, all studies included respected ethical principles and were properly referenced, ensuring the scientific integrity of the work.

RESULTS AND DISCUSSION

Immunotherapy has been consolidated as one of the pillars of cancer treatment, modifying the traditional approach and offering new therapeutic possibilities for cancer patients. According to Pettersen *et al.* (2025), advances include the introduction of immune checkpoint inhibitors, which act to reactivate the immune system by blocking proteins that prevent the effective immune response against tumor cells. This strategy has shown great efficacy in tumors such as melanoma and lung cancer, improving patient survival.

However, the study by Silva *et al.* (2024), highlights that tumor resistance remains one of the main challenges of immunotherapy. Cancer cells have evasion mechanisms, such as modifying the expression of antigens and creating an immunosuppressive microenvironment. This reinforces the need for new strategies, such as combining immunotherapy with other therapeutic modalities.

The combination of immunotherapy and chemotherapy has been widely studied. According to Knight *et al.* (2023), the administration of chemotherapy drugs can sensitize the tumor and increase the expression of tumor antigens, facilitating the action of the

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immune system. Clinical results have demonstrated that this approach has the potential to improve response rates, especially in tumors resistant to immunotherapy monotherapies.

Another significant advance was the introduction of CAR-T cells, which represent a new era in immunotherapy. As discussed by Pereira *et al* (2024), this approach involves genetically modifying the patient's T lymphocytes, allowing them to recognize and attack tumor cells in a specific way. This technology has shown promising results in leukemias and lymphomas, with response rates exceeding 80%. However, the high cost and severe side effects, such as cytokine release syndrome, are still barriers to its widespread implementation.

Therapeutic vaccines have also gained space in oncology. Cavalcante *et al.* (2024), report that dendritic cell-based vaccines can stimulate the immune system to recognize tumor cells and induce a long-lasting immune response. Although this approach has demonstrated efficacy in experimental models, its clinical application is still limited due to response variability among patients.

In addition to the strategies mentioned, passive immunotherapy, which includes the use of monoclonal antibodies, also plays a key role in cancer treatment. Penatti *et al.* (2019), explain that this approach allows direct attack on tumor cells through antibodies designed to bind to specific receptors. Trastuzumab, for example, has been widely used in HER2-positive breast cancer, increasing the overall survival of these patients.

However, one of the main challenges of immunotherapy remains the personalization of treatment. According to Braga (2024), the identification of predictive biomarkers is crucial to ensure that the most suitable patients receive the right therapy. Recent studies have investigated PD-L1 expression and mutations in the BRCA gene as determinant factors for the efficacy of immunotherapy, paving the way for more individualized approaches.

Another limiting factor of immunotherapy is its accessibility. Campos *et al.* (2020) highlight that, in developing countries, the high cost of these treatments prevents their widespread implementation. Government strategies and funding policies are needed to ensure that more patients have access to these innovative therapies.

The future of immunotherapy in oncology will depend on the ability of researchers to overcome current challenges. New approaches, such as the use of nanotechnology to improve the delivery of immunotherapy drugs, are being investigated. Gaião *et al.* (2025), suggest that the use of nanoparticles can increase the efficacy of the therapy, reducing side effects and improving the specificity of treatment against tumor cells.

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To summarize the main advances in oncological immunotherapy, Table 1 is presented, which brings together the main types of immunotherapy, their mechanisms of action, clinical indications, and associated challenges.

Table 1 – Main Advances in Oncological Immunotherapy

TYPE OF IMMUNOTHERAPY	MECHANISM OF ACTION	CLINICAL INDICATIONS	CHALLENGES	REFERENCES
Immune Checkpoint Inhibitors	Block proteins that inhibit the immune response (PD-1, PD-L1, CTLA-4)	Melanoma, lung cancer, kidney cancer, bladder cancer	Tumor resistance, autoimmune adverse effects	Pettersen *et al.* (2025)
CAR-T Cell Therapies	Genetic modification of T cells to recognize and destroy cancer cells	Leukemias and B lymphomas (experimental use for solid tumors)	High toxicity, high cost, limited efficacy in solid tumors	Pereira *et al.* (2024)
Therapeutic Vaccines	Stimulation of the immune system through the presentation of tumor antigens	Prostate cancer, melanoma and cervical cancer	Low immunogenicity in some patients, need for adjuvants	Knight *et al.* (2023)
Passive Immunotherapy (Monoclonal Antibodies)	Delivering antibodies ready to attack tumor cells	Breast cancer (HER2+), Hodgkin's lymphoma	Side effects, resistance development	Penatti (2019)
Combination of Immunotherapy and Chemotherapy	Increased immune response through tumor sensitization	Lung cancer, colorectal cancer	Need for greater personalization, increased toxicity	Cavalcante *et al.* (2024)
Combination of Immunotherapy and Radiotherapy	Enhancement of tumor antigen exposure for improved immune response	Head and neck cancer, lung cancer	Risk of exacerbated inflammation and damage to healthy tissues	Topalian et al. (2015)

Source: Authors, 2025.

After analyzing the main types of immunotherapy, it is essential to understand how the effectiveness of these therapies can vary according to the type of cancer and the patient's biological profile. According to Knight *et al.* (2023), immunotherapy has shown superior results in melanoma and lung cancer, but its application in solid tumors, such as gastric and pancreatic cancer, still faces challenges related to the immunosuppressive microenvironment of these neoplasms.

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This factor is corroborated by Pettersen *et al.* (2025), who highlight that the presence of a hostile microenvironment reduces the effectiveness of immune checkpoint inhibitors. Solid tumors often create a protective niche that inhibits the infiltration of activated T cells, hindering effective immune response. On the other hand, the combination of immunotherapy with conventional therapies has been studied as a promising alternative. According to Braga (2024), chemotherapy can facilitate tumor immunogenicity by inducing immunogenic cell death, making cancer cells more susceptible to attack by the immune system.

Despite this potential, Pettersen *et al.* (2025), further argues that the concomitant use of chemotherapy and immunotherapy can lead to exacerbated side effects, including hematological toxicity and generalized immune dysfunction. This adverse interaction raises questions about the need for adjustments in doses and in the choice of the optimal therapeutic regimen.

Another important aspect to consider is the toxicity of CAR-T cell therapies. As reported by Pereira *et al.* (2024), this approach can trigger cytokine release syndrome, a serious side effect that can lead to systemic inflammation and multi-organ failure. Although it is a promising therapy, the need for careful management of toxicity is still a limiting factor for its widespread adoption.

In addition, the development of tumor resistance to immunotherapy remains a critical challenge. Campos *et al.* (2020), emphasize that the genetic plasticity of tumors allows them to acquire mutations that make them less susceptible to the action of T cells.

Advances in bioinformatics and genomic sequencing have contributed to the personalization of immunotherapy. As pointed out by Silva *et al.* (2024), the development of artificial intelligence algorithms has made it possible to predict which patients will respond best to immunotherapy, optimizing therapeutic decisions.

Finally, the prospects of immunotherapy point to the creation of increasingly personalized and less toxic therapies. Nanotechnology, for example, emerges as an innovative strategy to improve the delivery of immunotherapies directly into the tumor microenvironment, minimizing systemic adverse effects and enhancing the efficacy of the immune response.

Thus, although immunotherapy has consolidated itself as one of the main advances in cancer treatment, there are still challenges to be overcome. The combination of therapies, the development of new biotechnological approaches, and the personalization of

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treatment will be essential to optimize their benefits and ensure greater access to an expanded number of patients in the future.

FINAL CONSIDERATIONS

Immunotherapy has redefined cancer treatment by strengthening the immune system's response against tumor cells. Advances in checkpoint inhibitors, CAR-T cells, and therapeutic vaccines demonstrate efficacy, but challenges such as tumor resistance, toxicity, and high cost still limit their broad application. The combination of immunotherapy with chemotherapy and radiotherapy emerges as an alternative to overcome therapeutic barriers, although it requires strict control of side effects. The personalization of the treatment, based on the identification of biomarkers, has been pointed out as essential to optimize the results.

However, the accessibility of immunotherapy is still an obstacle, especially in low- and middle-income countries. The development of new technologies, such as nanotechnology and bioengineering, can reduce costs and increase their effectiveness. Given this, immunotherapy is consolidated as one of the pillars of modern oncology, but its full implementation requires overcoming technical, economic, and clinical challenges. Continued research and expanded access policies will be key to ensuring that more patients can benefit from this innovation.

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ISSN: 2358-2472

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