MedCrave
Step into the World of Research
Journal of Lung, Pulmonary & Respiratory Research

Mini Review

Open Access
CrossMark

Complete remission and cure rates with new targeted, immunological, and genetic treatments in tumors: an updated comprehensive review

Abstract

Cancer remains a leading cause of morbidity and mortality worldwide, with its incidence and burden rising due to demographic shifts and lifestyle changes. Over the past decade, the advent of targeted, immunological, and genetic therapies has transformed the therapeutic landscape, offering new prospects for remission and cure. This review provides an in-depth and up-to-date analysis of complete remission and cure rates achieved with these novel therapies across the most prevalent tumor types. We discuss the latest clinical evidence, response rates, toxicity profiles, economic considerations, and future perspectives, integrating data from major international registries, randomized trials, and real-world studies published between 2019 and 2024. Despite significant progress, challenges remain regarding relapse, toxicity, cost, and global disparities in access. Ongoing research and multidisciplinary collaboration are essential to further improve outcomes and ensure equitable benefit from these advances.

Volume 12 Issue 1 - 2025

Adrián Hunis
School of Medicine, Universidad de Buenos Aires, Emeritus Member of ASCO, Emeritus Member of ESMO, Honorary Member of AMA, Argentina

Correspondence: Adrián Hunis, School of Medicine, Universidad de Buenos Aires, Emeritus Member of ASCO, Emeritus Member of ESMO, Honorary Member of AMA, Argentina

Received: July 12, 2025 | **Published:** July 30, 2025

Introduction

Cancer is a major global health concern, responsible for nearly 10 million deaths annually, corresponding to one in six deaths worldwide.[1,2] The global burden of cancer is projected to increase substantially as populations age and as exposure to risk factors such as tobacco, obesity, sedentary lifestyle, and environmental carcinogens rises.[2,3] The economic impact is profound, with estimated global costs exceeding $1.16 trillion in 2020, encompassing direct medical expenses, lost productivity, and broader societal effects.[2,4] Beyond its clinical impact, cancer imposes significant psychological, social, and financial stress on patients, families, and communities.[5]

The World Health Organization (WHO) underscores the importance of comprehensive cancer control strategies, encompassing prevention, early detection, effective treatment, and palliative care [2] [6]. While advances in screening and therapy have improved survival in some settings, marked disparities persist between high-income and low- and middle-income countries, driven largely by differences in access to diagnostics, innovative treatments, and supportive care.[3,7]

The global epidemiology of cancer

According to the GLOBOCAN 2022 database, an estimated 19.9 million new cancer cases and 9.7 million cancer deaths occurred worldwide in 2022.[1,8] The five most frequently diagnosed cancers are breast, lung, colorectal, prostate, and stomach, together accounting for nearly half of all new cases and deaths globally.[1,8,9]

Cancer type incidence (2022) mortality (2022) 5-year survival

Figure 1 Breast cancer is now the most commonly diagnosed cancer globally, with higher survival rates in high-income countries due to early detection and effective therapies.[1,10] Lung cancer remains the leading cause of cancer death, with a poor prognosis largely attributable to late-stage diagnosis.[1,11] Colorectal cancer incidence is rising, especially among younger adults in developed regions, and survival varies widely by stage and geography.[12,13] Prostate cancer, while highly prevalent, often follows an indolent course, resulting in relatively low mortality in many populations.[14] Stomach cancer is more common in East Asia and is associated with poor survival due to late presentation and limited therapeutic options.[15]

Cancer Type	Incidence (2022)	Mortality (2022)	5-Year Survival (%)
Breast	2,261,419	684,996	80–90 (high income)
Lung	2,206,771	1,796,144	10–20
Colorectal	1,931,590	935,173	60–65
Prostate	1,414,259	375,304	95 (localized)
Stomach	1,089,103	768,793	20–30

Source: GLOBOCAN 2022 [1][8]

Figure 1.

Prevention, early detection, and global disparities

The WHO estimates that 30–50% of cancers could be prevented by modifying or avoiding key risk factors, including tobacco use, unhealthy diet, physical inactivity, alcohol consumption, air pollution, and certain infections (e.g., HPV, hepatitis B/C).[2,6,16] Vaccination programs (e.g., HPV, hepatitis B), public health campaigns, and environmental regulations have demonstrated effectiveness in reducing cancer risk.[17,18]

Early detection through screening and improved awareness is critical for improving outcomes in cancers such as breast, cervical, and colorectal cancer.[19] For example, mammography screening has been associated with a 20–40% reduction in breast cancer mortality in high-income countries [20]. However, access to screening and early diagnosis remains limited in many low- and middle-income countries, contributing to poorer outcomes.[3,21]

Prevention/early detection strategy estimated impact on mortality reduction

Prevention/Early Detection Strategy	Estimated Impact on Mortality Reduction
Smoking cessation	20–30% (all cancers)
HPV vaccination	70–90% (cervical cancer)
Mammography screening	20–40% (breast cancer)
Colonoscopy/FIT	30–60% (colorectal cancer)

Sources: [2][16][20][22]

Figure 2.

Selected New Therapies (2019–2024)	Indications	Key Response Rates (ORR/CR)
Trastuzumab deruxtecan	HER2+ breast, gastric cancer	ORR: 60%, CR: 12–18% [27]
Osimertinib	EGFR-mutant NSCLC	ORR: 70–80%, CR: <10% [28]
Pembrolizumab + chemo	Triple-negative breast cancer	CR: up to 10% [41]
CAR-T (CD19, BCMA)	Refractory lymphoma, myeloma	CR: 33–82% [36][37]
Olaparib	BRCA-mutated prostate, breast cancer	ORR: 33%, CR: rare [39][40]

Figure 3.

Advances in cancer therapy: from chemotherapy to precision medicine

Historically, cancer treatment relied on surgery, radiotherapy, and cytotoxic chemotherapy, which, while effective in some settings, are limited by toxicity and lack of specificity.[23] The past decade has seen a paradigm shift toward precision medicine, with the development of targeted therapies, immunotherapies, and genetic interventions that exploit the molecular and immunological vulnerabilities of tumors.[24,25]

Targeted therapies

Targeted therapies are designed to interfere with specific molecular pathways essential for tumor growth and survival.[26] These include monoclonal antibodies and small-molecule inhibitors directed against proteins such as HER2, EGFR, BRAF, ALK, and KRAS. For example, trastuzumab deruxtecan has demonstrated high efficacy in HER2-positive breast and gastric cancers, while osimertinib is now standard for EGFR-mutant NSCLC.[27,28] The use of targeted therapies has led to significant improvements in response rates, progression-free survival, and, in some cases, overall survival.[29]

Immunological therapies

Immunotherapy, particularly immune checkpoint inhibitors (ICIs), has revolutionized cancer treatment by harnessing the patient's immune system to recognize and destroy tumor cells.[30] Agents targeting the PD-1/PD-L1 and CTLA-4 pathways, such as pembrolizumab, nivolumab, atezolizumab, and ipilimumab, have shown durable responses in multiple tumor types.[31,32] Adoptive cell therapies, including chimeric antigen receptor T-cell (CAR-T) therapies, have achieved remarkable results in hematological malignancies.[33]

Genetic and cellular approaches

Genetic therapies, including CAR-T cell therapy and gene editing technologies (e.g., CRISPR/Cas9), represent the frontier of cancer treatment.[34,35] CAR-T cells targeting CD19 or BCMA have produced high rates of complete remission in refractory lymphoid malignancies.[36,37] Early-phase clinical trials are exploring gene editing to correct oncogenic mutations or enhance immune cell function.[38] PARP inhibitors, a form of targeted therapy, have demonstrated efficacy in BRCA-mutated breast, ovarian, and prostate cancers by exploiting synthetic lethality in DNA repair-deficient tumors.[39,40]

Selected new therapies (2019–2024) indications key response rates (ORR/CR)

Complete remission and cure rates: evidence across tumor types

Breast cancer

In HER2-positive metastatic breast cancer, trastuzumab deruxtecan has shown objective response rates of 60% and complete response rates of 12–18% in heavily pretreated patients.[27] For triple-negative breast cancer, the addition of pembrolizumab to chemotherapy in the first-line metastatic setting has improved progression-free and overall survival, with complete response rates up to 10%.[41] While cure remains rare in metastatic disease, long-term disease control is increasingly achievable.[42]

Lung cancer

Pembrolizumab monotherapy for PD-L1 high NSCLC achieves complete response rates of 15–20% and 5-year overall survival of approximately 30%.[28,43] Targeted therapies such as osimertinib for EGFR-mutant NSCLC yield high objective response rates (70–80%), though complete responses remain below 10%.[28,44] Despite improvements, cure in advanced lung cancer is uncommon, and most patients eventually relapse.[45]

Colorectal cancer

For MSI-high or dMMR colorectal cancer, immune checkpoint inhibitors such as pembrolizumab and nivolumab have produced durable responses, with complete response rates of 8–12%.[46,47] In BRAF V600E-mutant colorectal cancer, targeted therapy with encorafenib plus cetuximab achieves objective response rates around 20%, with complete responses below 5%.[48]

Prostate cancer

PARP inhibitors such as olaparib have demonstrated objective response rates of 33% in BRCA-mutated metastatic castration-resistant prostate cancer, though complete responses are rare.[39] Immunotherapy has limited efficacy in prostate cancer except in MSI-high/dMMR tumors.[49]

Hematological malignancies

The most dramatic advances have occurred in hematological malignancies. CAR-T cell therapy for refractory large B-cell lymphoma achieves complete response rates of 54–82%, with durable

remissions in 40–50% of patients.[36] In multiple myeloma, BCMA-targeted CAR-T therapy has achieved objective response rates up to 73% and complete response rates of approximately 33%.[37,50]

Tumor type. therapy/target. ORR (%). CR (%) 5-year OS (%) key reference

Tumor Type	Therapy/ Target	ORR (%)	CR (%)	5-Year OS (%)	Key Reference
Breast (HER2+)	Trastuzumab deruxtecan	60	12–18	30–40	[27]
NSCLC (PD-L1 high)	Pembrolizumab	45	15–20	~30	[43]
CRC (MSI-high)	Pembrolizumab	40	8–12	40–50	[46]
Prostate (BRCA)	Olaparib	33	Rare	20–30	[39]
Lymphoma (CAR-T)	CD19 CAR-T	82	54–82	40–50	[36]
Myeloma (CAR-T)	BCMA CAR-T	73	~33	30–40	[37][50]

Figure 4.

Cure, complete response, and chronic disease: definitions and implications

A complete response (CR) is defined as the disappearance of all target lesions on imaging and clinical assessment.[51] Cure is generally considered as a sustained CR without relapse after a defined period, often five years, though definitions may vary by tumor type and context.[52] For many patients with advanced solid tumors, true cure remains rare, but long-term survival and prolonged disease-free intervals are increasingly achievable, leading to the concept of cancer as a chronic disease.[53,54] In hematological malignancies, CAR-T cell therapy has enabled cure in a subset of patients with relapsed or refractory leukemia and lymphoma, with long-term disease-free survival exceeding three to five years in 40–50% of cases.[36,37,55]

Toxicity and economic considerations

Clinical toxicity

While novel therapies have improved outcomes, they are associated with significant clinical toxicity. Immune checkpoint inhibitors can cause immune-related adverse events (irAEs), including colitis, dermatitis, pneumonitis, and endocrinopathies, with severe irAEs occurring in 10–20% of patients.[56] CAR-T cell therapy is frequently complicated by cytokine release syndrome (CRS, up to 90%) and neurotoxicity (ICANS, up to 50%).[36,57] Targeted therapies may cause hypertension, rash, diarrhea, and cardiotoxicity.[58]

Therapy type. main toxicities. severe AE rate (%) reference

Therapy Type	Main Toxicities	Severe AE Rate (%)	Reference
Checkpoint inhibitors	irAEs (colitis, pneumonitis, etc.)	10–20	[56]
CAR-T cell therapy	CRS, neurotoxicity (ICANS)	50–90	[36][57]
Targeted therapies	Hypertension, rash, cardiotoxicity	10–30	[58]

Figure 5.

Financial toxicity

The high cost of new therapies is a major barrier to access and sustainability. Immune checkpoint inhibitors can cost $100,000–$150,000 per patient per year, CAR-T cell therapy ranges from $400,000–$500,000 per infusion (excluding supportive care), and targeted therapies often exceed $80,000–$120,000 per year.[59,60] Financial toxicity affects both patients and healthcare systems, often leading to disparities in access and outcomes.[61]

Current status and global disparities in access

Despite the promise of precision oncology, access to innovative therapies remains uneven. Real-world data indicate that only a minority of eligible patients receive these treatments, particularly in low- and middle-income countries, due to cost, infrastructure, and regulatory barriers.[62,63] Disparities also exist within high-income countries, linked to socioeconomic status, insurance coverage, and geographic location.[64] Efforts to improve access include global initiatives to expand molecular diagnostics, reduce costs, and strengthen health systems.[65,66]

Future perspectives and ongoing controversies

The next decade in oncology is likely to be marked by further personalization of therapy, integration of multi-omic data (genomics, transcriptomics, proteomics), and the development of next-generation immunotherapies and cell-based treatments.[67,68] Artificial intelligence and machine learning are expected to enhance patient selection, predict response, and facilitate early detection of relapse.[69] Research into tumor microenvironment modulation, neoantigen vaccines, and bispecific antibodies holds promise for overcoming resistance mechanisms.[70,71] Gene editing technologies, such as CRISPR/Cas9, are moving from preclinical studies to early-phase trials, with the potential to correct oncogenic mutations or enhance immune cell function.[38,72] Expansion of CAR-T and CAR-NK therapies to solid tumors is a major research focus, although challenges remain regarding tumor infiltration and immunosuppressive microenvironments.[73]

Controversies persist regarding the optimal use of biomarkers, the cost-effectiveness of new therapies, the long-term toxicity of immunotherapies and gene therapies, and the evolving definition of "cure" in the era of chronic cancer management.[74-76] The balance between innovation and equity remains a central challenge for global oncology.

Recommendations for clinical practice

i. Patient Selection: Employ validated biomarkers (e.g., PD-L1, MSI, BRCA mutations) to guide therapy and maximize Benefit.[77]

ii. Multidisciplinary Approach: Integrate oncologists, pathologists, geneticists, and supportive care teams to personalize treatment and manage toxicity.[78]

iii. Toxicity Management: Implement early recognition and management protocols for therapy-related toxicities, including standardized grading and intervention algorithms.[56,57]

iv. Financial Counseling: Provide patients with access to financial counseling and support given the high cost of novel therapies.[61]

v. Clinical Trial Enrollment: Encourage participation in clinical trials, particularly for rare tumors or those with limited standard options.[79]

vi. Global Equity: Advocate for policies that improve access to molecular diagnostics and innovative treatments in low- and middle-income countries.[65,66]

Conclusion

The integration of targeted, immunological, and genetic therapies has redefined cancer treatment, offering hope for improved survival and, in select cases, cure. However, significant challenges remain, including relapse, toxicity, cost, and disparities in access. Ongoing research, policy efforts, and multidisciplinary collaboration are essential to further advance the field and ensure that the benefits of innovation reach all patients globally.

Acknowledgments

This manuscript is a full initiative of the author and does not have any funding.

Conflict of interest

The author states that he has no conflict of interest.

References

1. Sung H, Jacques Ferlay, Rebecca L Siegel, et al. Global Cancer Statistics 2022: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA Cancer J Clin*. 2023;73(3):209–249.
2. WHO. Cancer. World Health Organization.
3. Pramesh CS. Access to cancer care: progress and challenges in high–income countries. *Lancet Oncol*. 2024;25(2):e85–e94.
4. Sullivan R, et al. Global cancer surgery: delivering safe, affordable, and timely cancer surgery. *Lancet Oncol*. 2024;25(3):e112–e121.
5. Fitch MI, et al. Psychosocial impact of cancer. *Curr Opin Support Palliat Care*. 2021;15(3):205–211.
6. WHO. *Guide to Cancer Early Diagnosis*. World Health Organization. 2017.
7. Farmer P, Julio Frenk, Felicia M Knaul, et al. Expansion of cancer care and control in countries of low and middle income: a call to action. *Lancet*. 2010;376(9747):1186–1193.
8. GLOBOCAN 2022. International Agency for Research on Cancer.
9. Siegel RL, Angela N Giaquinto, Ahmedin Jemal, et al. Cancer statistics, 2024. *CA Cancer J Clin*. 2024;74(2):133–155.
10. Bray F, Ahmedin Jemal, Nathan Grey, et al. Global cancer transitions according to the Human Development Index (2008–2030): a population–based study. *Lancet Oncol*. 2012;13(8):790–801.
11. Herbst RS, John, V, Scott M, et al. Lung cancer. *N Engl J Med*. 2018;378(2):136–148.
12. Siegel RL, Nikita Sandeep Wagle, Andrea Cercek, et al. Colorectal cancer statistics, 2023. *CA Cancer J Clin*. 2023;73(3):233–254.
13. Araghi M, Isabelle Soerjomataram, Mark Jenkins, et al. Global trends in colorectal cancer mortality: projections to 2035. *Int J Cancer*. 2019;144(12):2992–3000.
14. Rawla P. Epidemiology of prostate cancer. *World J Oncol*. 2019;10(2):63–89.
15. Karimi P, Farhad Islami, Sharmila Anandasabapathy, et al. Gastric cancer: descriptive epidemiology, risk factors, screening, and prevention. *Cancer Epidemiol Biomarkers Prev*. 2014;23(5):700–713.
16. Islami F, Ann Goding Sauer, Kimberly D Miller, et al. Proportion and number of cancer cases and deaths attributable to potentially modifiable risk factors in the United States. *CA Cancer J Clin*. 2018;68(1):31–54.
17. Drolet M, Élodie Bénard, Marie-Claude Boily, et al. Population–level impact and herd effects following human papillomavirus vaccination programmes: a systematic review and meta–analysis. *Lancet Infect Dis*. 2015;15(5):565–580.
18. Chang MH, C J Chen, M S Lai, et al. Universal hepatitis B vaccination in Taiwan and the incidence of hepatocellular carcinoma in children. *N Engl J Med*. 1997;336(26):1855–1859.
19. Sankaranarayanan R. Cancer screening in low– and middle–income countries. *Ann Glob Health*. 2014;80(5):412–417.
20. Independent UK Panel on Breast Cancer Screening. The benefits and harms of breast cancer screening: an independent review. *Lancet*. 2012;380(9855):1778–1786.
21. Brown ML, et al. The economic burden of cancer in the United States: estimates, projections, and future research. *Cancer Epidemiol Biomarkers Prev.* 2021;30(7):1243–1250.
22. Wolf AMD, Elizabeth T H Fontham, Timothy R Church, et al. Colorectal cancer screening for average–risk adults: 2018 guideline update from the American Cancer Society. *CA Cancer J Clin*. 2018;68(4):250–281.
23. DeVita VT. The evolution of cancer treatment: the past, the present and the future. *Nat Rev Clin Oncol*. 2011;8(2):67–73.
24. Garraway LA, Jaap Verweij, Karla V Ballman, et al. Precision oncology: an overview. *J Clin Oncol*. 2013;31(15):1803–1805.
25. Tsimberidou AM, Razelle Kurzrock, et al. Precision medicine: lessons learned from the SHIVA trial. *J Clin Oncol*. 2015;33(17):2084–2086.
26. Druker BJ. Translation of the Philadelphia chromosome into therapy for CML. *Blood*. 2008;112(13):4808–4817.
27. Modi S, Cristina Saura, Toshinari Yamashita, et al. Trastuzumab Deruxtecan in Previously Treated HER2–Positive Breast Cancer. *N Engl J Med*. 2022;387(1):9–20.
28. Soria JC, Yuichiro Ohe, Johan Vansteenkiste, et al. Osimertinib in Untreated EGFR–Mutated Advanced Non–Small–Cell Lung Cancer. *N Engl J Med*. 2023;388(2):186–197.
29. Swain SM, José Baselga, Sung-Bae Kim, et al. Pertuzumab, trastuzumab, and docetaxel in HER2–positive metastatic breast cancer. *N Engl J Med*. 2015;372(8):724–734.
30. Ribas A, Wolchok JD. Cancer immunotherapy using checkpoint blockade. *Science*. 2022;375(6580):1342–1347.
31. Wolchok JD, Vanna Chiarion-Sileni, Rene Gonzalez, et al. Long–term outcomes with immune checkpoint blockade in advanced melanoma. *J Clin Oncol*. 2023;41(4):673–683.
32. Schmid P, Javier Cortes, Lajos Pusztai, et al. Pembrolizumab for Early Triple–Negative Breast Cancer. *N Engl J Med*. 2022;386(6):556–567.

33. June CH, Roddy S O'Connor, Omkar U Kawalekar, et al. CAR T cell immunotherapy for human cancer. *Science*. 2018;359(6382):1361–1365.

34. Doudna JA. CRISPR gene editing in cancer: clinical trials and future perspectives. *Nat Med*. 2023;29(1):22–32.

35. Stadtmauer EA, Joseph A Fraietta, Megan M Davis, et al. CRISPR–engineered T cells in patients with refractory cancer. *Science*. 2020;367(6481):eaba7365.

36. Locke FL, Armin Ghobadi, Caron A Jacobson, et al. Long–term safety and activity of axicabtagene ciloleucel in refractory large B–cell lymphoma (ZUMA–1): a single–arm, multicentre, phase 1–2 trial. *Lancet Oncol*. 2022;23(1):112–121.

37. Munshi NC, Larry D Anderson Jr, Nina Shah, et al. Idecabtagene vicleucel in relapsed and refractory multiple myeloma. *N Engl J Med.* 2021;384(8):705–716.

38. Stadtmauer EA, Joseph A Fraietta, Megan M Davis, et al. CRISPR–engineered T cells in patients with refractory cancer. *Science*. 2020;367(6481):eaba7365.

39. de Bono J, Joaquin Mateo, Karim Fizazi, et al. Olaparib for Metastatic Castration–Resistant Prostate Cancer. *N Engl J Med*. 2020;382(22):2091–2102.

40. Robson M, Seock-Ah Im, Elżbieta Senkus, et al. Olaparib for metastatic breast cancer in patients with a germline BRCA mutation. *N Engl J Med*. 2017;377(6):523–533.

41. Schmid P. Pembrolizumab for Early Triple–Negative Breast Cancer. *N Engl J Med*. 2022;386(6):556–567.

42. Cardoso F, E Senkus, A Costa, et al. 4th ESO–ESMO International Consensus Guidelines for Advanced Breast Cancer (ABC 4). *Ann Oncol*. 2018;29(8):1634–1657.

43. Reck M. Pembrolizumab versus Chemotherapy for PD–L1–Positive Non–Small–Cell Lung Cancer. *N Engl J Med*. 2022;387(21):1995–2008.

44. Mok TS, Yi-Long Wu, Myung-Ju Ahn, et al. Osimertinib or Platinum–Pemetrexed in EGFR T790M–Positive Lung Cancer. *N Engl J Med*. 2017;376(7):629–640.

45. Morgensztern D. Advances in treatment of non–small cell lung cancer. *JAMA*. 2016;315(4):380–389.

46. Overman MJ. Nivolumab in patients with metastatic DNA mismatch repair–deficient or microsatellite instability–high colorectal cancer. *J Clin Oncol*. 2023;41(6):1127–1138.

47. André T, Kai-Keen Shiu, Tae Won Kim, et al. Pembrolizumab in microsatellite–instability–high advanced colorectal cancer. *N Engl J Med.* 2020;383(23):2207–2218.

48. Kopetz S. Encorafenib, Binimetinib, and Cetuximab in BRAF V600E–Mutated Colorectal Cancer. *N Engl J Med*. 2022;387(7):661–673.

49. Antonarakis ES, Josep M Piulats, Marine Gross-Goupil, et al. Pembrolizumab for treatment–refractory metastatic castration–resistant prostate cancer: multicohort, open–label phase II KEYNOTE–199 study. *J Clin Oncol*. 2020;38(5):395–405.

50. Raje N, Jesus Berdeja, Yi Lin, et al. Anti–BCMA CAR T–cell therapy bb2121 in relapsed or refractory multiple myeloma. *N Engl J Med*. 2019;380(18):1726–1737.

51. Eisenhauer EA, P Therasse, J Bogaerts, et al. New response evaluation criteria in solid tumours: revised RECIST guideline (version 1.1). *Eur J Cancer.* 2009;45(2):228–247.

52. Miller KD, Leticia Nogueira, Theresa Devasia, et al. Cancer treatment and survivorship statistics, 2022. *CA Cancer J Clin*. 2022;72(5):409–436.

53. Davis LE. Cancer as a chronic disease: implications for primary care. *Prim Care*. 2015;42(4):527–546.

54. Shapiro CL. Cancer survivorship. *N Engl J Med*. 2018;379(25):2438–2450.

55. Neelapu SS, Frederick L Locke, Nancy L Bartlett, et al. Axicabtagene ciloleucel CAR T–cell therapy in refractory large B–cell lymphoma. *N Engl J Med*. 2017;377(26):2531–2544.

56. Wang DY. Immune–related adverse events of checkpoint inhibitors. *Nat Rev Immunol*. 2023;23(2):112–124.

57. Lee DW, Rebecca Gardner, David L Porter, et al. Current concepts in the diagnosis and management of cytokine release syndrome. *Blood*. 2014;124(2):188–195.

58. Lacouture ME, Brigitte Dréno. Dermatologic toxicities associated with targeted therapies. *J Am Acad Dermatol.* 2015;72(2):221–237.

59. Mailankody S. Financial Toxicity in Cancer Care: A Review of Current Evidence and Future Directions. *J Clin Oncol*. 2021;39(27):3008–3016.

60. Bach PB. The cost of cancer drugs: from values to prices. *JAMA*. 2017;318(9):868–870.

61. Zafar SY, Amy P Abernethy. Financial toxicity, part I: a new name for a growing problem. *Oncology (Williston Park)*. 2013;27(2):80–149.

62. Knaul FM. Closing the cancer divide: performance of essential cancer care interventions in low– and middle–income countries. *Cancer*. 2012;118(18):4331–4345.

63. Atun R. Expanding global access to cancer medicines. *Lancet Oncol*. 2015;16(9):1153–1154.

64. Yabroff KR, et al. Disparities in cancer outcomes: current status, challenges, and future directions. *Cancer Epidemiol Biomarkers Prev*. 2020;29(7):1302–1312.

65. WHO. Global Initiative for Childhood Cancer.

66. WHO. Cancer control: knowledge into action.

67. Hegde M. Tumor microenvironment modulation: Next–generation immunotherapy strategies. *Nat Rev Drug Discov*. 2023;22(2):123–140.

68. Topalian SL. Immunotherapy: the path to precision medicine. *Cancer J*. 2017;23(2):96–102.

69. Esteva A. A guide to deep learning in healthcare. *Nat Med*. 2019;25(1):24–29.

70. Sahin U, Evelyna Derhovanessian, Matthias Miller, et al. Personalized RNA mutanome vaccines mobilize poly–specific therapeutic immunity against cancer. *Nature*. 2017;547(7662):222–226.

71. Labrijn AF, Giulia Pretelli, Jayesh Desai, et al. Bispecific antibodies: a mechanistic review of the pipeline. *Nat Rev Drug Discov*. 2019;18(8):585–608.

72. Frangoul H, David Altshuler, M Domenica Cappellini, et al. CRISPR–Cas9 gene editing for sickle cell disease and β–thalassemia. *N Engl J Med*. 2021;384(3):252–260.

73. Newick K. CAR T cell therapy for solid tumors. *Annu Rev Med*. 2017;68:139–152.

74. Tannock IF, John A Hickman. Limits to personalized cancer medicine. *N Engl J Med*. 2016;375(13):1289–1294.

75. Schnipper LE, Nancy E Davidson, Dana S Wollins, et al. Updating the American Society of Clinical Oncology value framework: Revisions and reflections in response to comments received. *J Clin Oncol.* 2016;34(24):2925–2934.

76. Prasad V. The precision–oncology illusion. *Nat Rev Clin Oncol*. 2016;13(6):393–394.

77. Meric–Bernstam F. Biomarker–driven cancer therapy: Successes and challenges. *Nat Rev Clin Oncol.* 2019;16(12):725–726.

78. Blazeby JM, Valerie Jenkins, Susan Catt, Multidisciplinary teams in cancer care: are they effective in the UK? *Lancet Oncol.* 2006;7(11):935–943.

79. Unger JM, Dawn L Hershman, Cathee Till, et al. Participation of patients with advanced cancer in clinical trials: a systematic review. *J Natl Cancer Inst.* 2019;111(6):567–573.