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Emerging Strategies in Cancer Detection and Treatment: A Systematic Review of Immunotherapy, Gene Editing, and Artificial Intelligence

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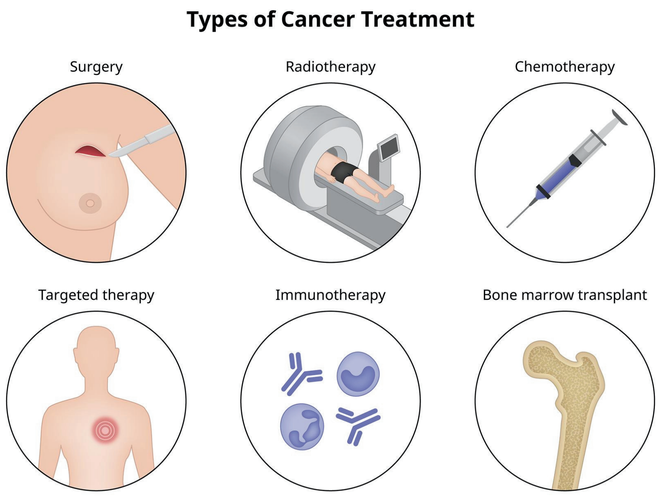
INTRODUCTION & AIM

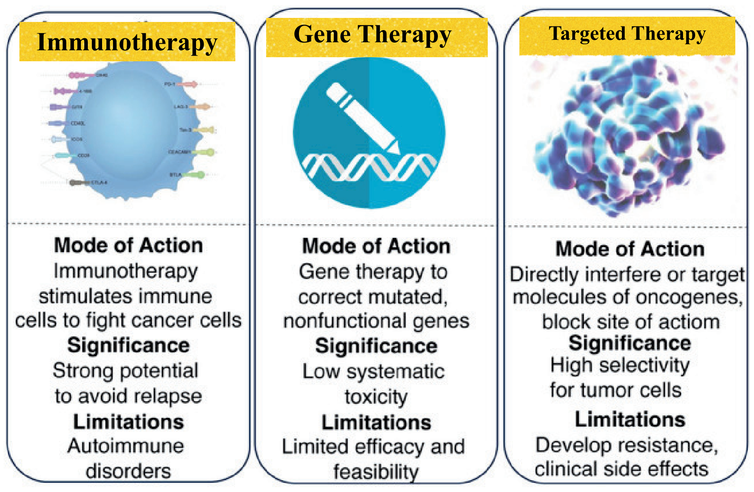
Cancer remains a major global health burden and a leading cause of death worldwide. While conventional therapies such as chemotherapy and radiotherapy have improved survival, their effectiveness is often limited by toxicity, resistance, and disease recurrence. Since 2020, significant advances in immunotherapy, gene editing, liquid biopsies, artificial intelligence, and targeted drug delivery have revolutionized cancer diagnosis and treatment, offering more precise and personalized therapeutic approaches.

Aim: To systematically review recent innovations in cancer diagnosis and treatment since 2020 and evaluate their potential to improve therapeutic outcomes, early detection, and personalized cancer care.

Types of Cancer Treatments

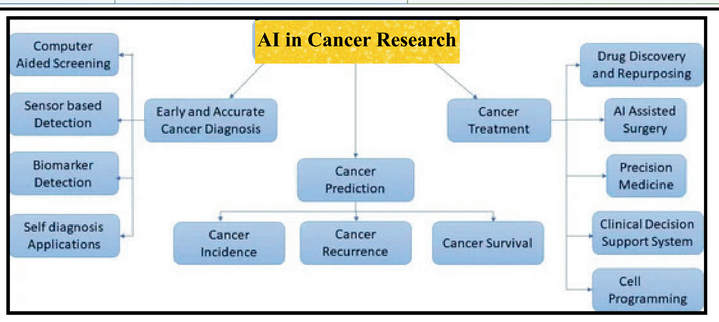


Emerging Cancer Therapies.



Comparison of Conventional and Emerging Cancer Therapies.

Feature	Conventional Therapies (Chemotherapy & Radiotherapy)	Advanced Cancer Therapies (Immunotherapy, Gene Editing, Liquid Biopsies, Artificial Intelligence, Targeted Drug Delivery)
Treatment Approach	Broad, non-specific destruction of cancer cells	Precision targeting of cancer-specific pathways and biomarkers
Specificity	Limited; affects both cancerous and healthy cells	High; targets cancer cells or specific molecular targets
Side Effects	High toxicity and adverse effects	Reduced toxicity and improved tolerability
Personalization	Generally standardized treatment for all patients	Personalized based on genetic and molecular profiles
Diagnosis & Monitoring	Imaging and tissue biopsy	Liquid biopsies and AI-based analysis enable real-time monitoring
Drug Resistance	Common; leads to treatment failure and recurrence	Designed to overcome or minimize resistance mechanisms
Role of Technology	Minimal integration of digital technologies	Extensive use of AI, genomics, and advanced biotechnology
Clinical Outcomes	Improved survival but limited by toxicity and recurrence	Better response rates, improved survival, and quality of life
Limitations	Toxicity, resistance, lack of specificity	High cost, accessibility, and need for long-term validation

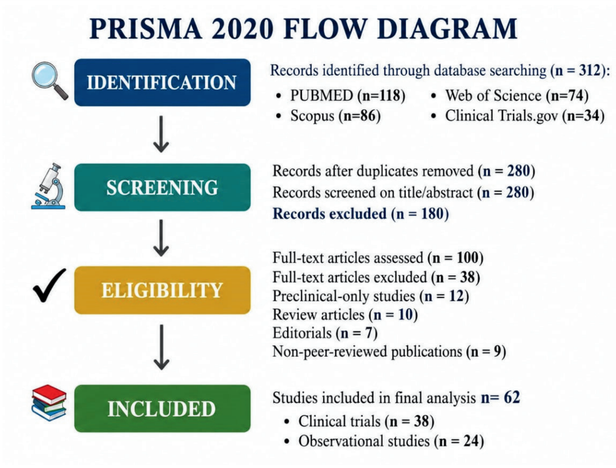


METHOD

Systematic review conducted according to PRISMA 2020 guidelines.

- **Databases searched:** PubMed, Scopus, Web of Science, and ClinicalTrials.gov (January 2020–December 2025).
- **Inclusion:** Clinical trials, observational studies, and regulatory approvals reporting measurable clinical outcomes related to immunotherapy, gene editing, liquid biopsies, artificial intelligence, and targeted drug delivery in cancer care.
- **Exclusion:** Preclinical-only studies, review articles, editorials, conference abstracts, and non-peer-reviewed publications.
- **Screening, data extraction, and quality assessment** were independently performed by two reviewers using the Cochrane Risk of Bias Tool and Newcastle–Ottawa Scale

Total records = 312
Duplicates removed = 32
Title/abstract exclusions = 180
Full-text exclusions = 38
Final included studies = 62
Clinical trials = 38
Observational studies = 24



RESULTS & DISCUSSION

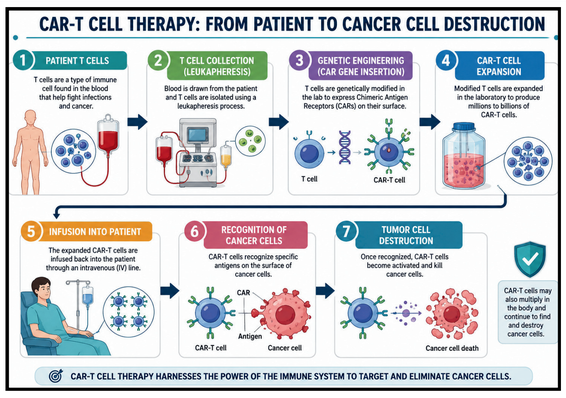
📊 **CAR-T Cell Therapy**
- Hematological malignancies: 52–83% response rate
- Solid tumors: 15–35% response rate

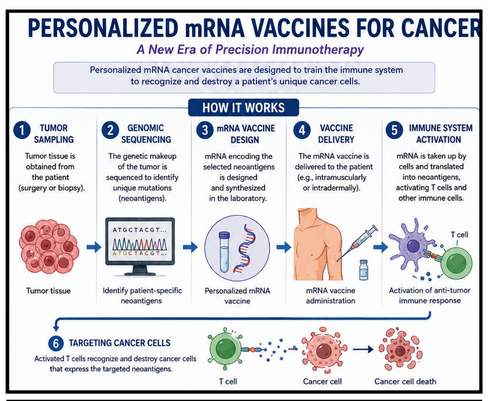
📊 **Personalized mRNA Vaccines**
- 60–80% immune response rate
- Strong potential for individualized cancer treatment

📊 **Liquid Biopsy**
- Early detection sensitivity: 70–90%
- Residual disease monitoring accuracy: >85%

📊 **Artificial Intelligence**

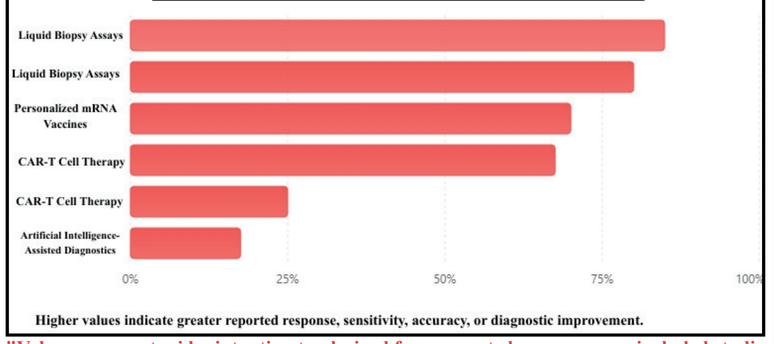
Diagnostic accuracy improved by 10–25%





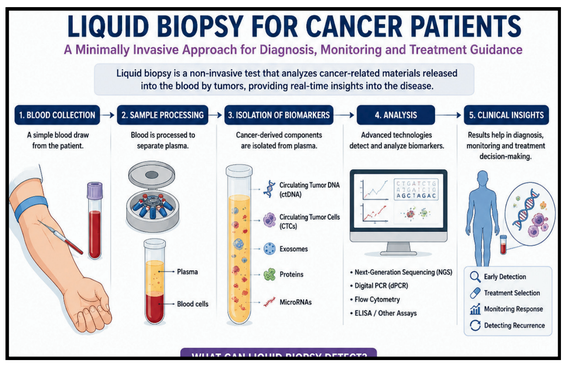
Clinical Performance of Emerging Technologies in Cancer Management

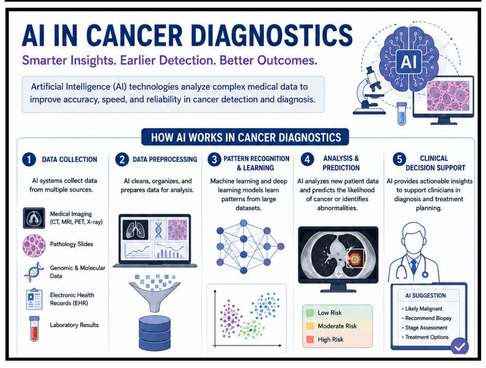
Technology	Percentage (%) *
Liquid Biopsy Assays *(Residual Disease Monitoring Accuracy)*	85
Liquid Biopsy Assays *(Early Detection Sensitivity)*	80
Personalized mRNA Vaccines *(Immune Response Rate)*	70
CAR-T Cell Therapy in Hematological Malignancies *(Response Rate)*	67.5
CAR-T Cell Therapy in Solid Tumors *(Response Rate)*	25
Artificial Intelligence-Assisted Diagnostics *(Improvement in Diagnostic Accuracy)*	17.5



Higher values indicate greater reported response, sensitivity, accuracy, or diagnostic improvement.

"Values represent midpoint estimates derived from reported ranges across included studies.





Strengths & Limitations

- Most studies showed low-to-moderate risk of bias
- Considerable heterogeneity in study design and outcomes
- Meta-analysis not feasible
- Some studies had small sample sizes and short follow-up periods

CONCLUSIONS

All of these inventions are transforming the world of cancer treatment into a more progressive, personalised, and even curative process. There are still problems related to large-scale production, equitable global supply, and continuous safety.

FUTURE WORK

- Future research should focus on integrating immunotherapy, gene editing, artificial intelligence, and liquid biopsy technologies into unified precision oncology frameworks.
- Long-term follow-up studies are required to evaluate durability of response, late adverse effects, and survival benefits of emerging therapies.
- Development of predictive biomarkers will enable better patient stratification and treatment selection, maximizing therapeutic efficacy.
- Standardization of AI algorithms and liquid biopsy platforms is essential to support widespread clinical adoption.
- Collaborative international research efforts are needed to accelerate translation of innovative cancer therapies into routine clinical practice.

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