



# ARTIFICIAL INTELLIGENCE-DRIVEN EMERGING TECHNOLOGIES FOR CANCER PREVENTION: A REVIEW

<sup>1</sup>Punar Dutt Meena and <sup>2</sup>Vipul Kumar Parewa

<sup>1</sup>Associate Professor, Dept. of Zoology, Baba Gangadas Govt. Girls College Shahpura, Jaipur, Rajasthan (India)

<sup>2</sup>Assistant Professor, Dept. of Zoology, SPNKS Govt. PG. College, Dausa, Rajasthan (India)

## Abstract

Cancer remains a leading cause of mortality worldwide. While early detection and treatment have significantly improved outcomes, prevention remains crucial in reducing incidence and burden. The advent of Artificial Intelligence (AI) and related emerging technologies has provided new paradigms in cancer prevention through enhanced risk prediction, personalized strategies, behavior modification and population-level surveillance. This paper reviews the current state of AI in cancer prevention, examines key technological advancements, identifies challenges and explores future directions (1,2).

## Introduction

Cancer prevention encompasses strategies that reduce risk factors, improve early detection and prevent disease progression. Traditional methods include screening programs, lifestyle modification and chemoprevention. However, heterogeneous tumour biology and complex risk factors have limited the effectiveness of conventional approaches. AI offers powerful tools to integrate large-scale multi-modal data (clinical, genetic, lifestyle, imaging) for predictive and preventive interventions that can be personalized at the individual and population levels (1,2).

## Role of Artificial Intelligence in Cancer Prevention

### (i) Risk Prediction and Stratification

AI models use machine learning (ML) to identify individuals at high risk for specific cancers by analyzing complex patterns within demographic, clinical, genomic and lifestyle data.

- **Polygenic Risk Scores:** Algorithms combine multiple genetic variants to estimate cancer susceptibility.

- **Electronic Health Records (EHRs):** ML models extract risk features from longitudinal health data for diseases like breast, colorectal, and prostate cancers.

**Example:** Predictive models have been developed to estimate breast cancer risk using mammography data combined with clinical risk factors.

## (ii) Early Detection and Screening

AI enhances traditional screening tools by improving sensitivity and specificity:

- **Radiomics and Deep Learning:** Convolutional neural networks (CNNs) detect subtle imaging features beyond human perception in mammograms, CT, MRI (5).
- **Biomarker Discovery:** AI identifies novel biomarkers in blood or other body fluids for early cancer detection.

**Example:** AI-assisted imaging systems improve polyp detection rates during colonoscopy, reducing missed lesions.

## Emerging Technologies Empowered by AI

### (i) Wearable and Mobile Health Technologies

Smart wearables (smartwatches, biosensors) continuously monitor physiological parameters.

- **Digital Phenotyping:** Patterns in activity, sleep and heart rate variability may reflect early systemic changes associated with cancer risk or treatment response.
- **Behavioral Feedback:** AI-driven apps support smoking cessation, diet improvement, and physical activity, which are critical modifiable risk factors.

### (ii) Natural Language Processing (NLP) in Clinical Insights

- NLP extracts relevant clinical phenotypes from unstructured EHR notes to enrich predictive models.
- NLP tools help identify missed opportunities for preventive care (e.g., family history of cancer not captured in structured fields).

### (iii) Genomics and Multi-Omics Integration

AI algorithms integrate genomics, epigenomics, transcriptomics, proteomics and metabolomics to identify early signatures of cancer risk.

- **Multi-Modal Learning:** Combines multi-omics with clinical and imaging data.
- **Precision Prevention:** Tailoring lifestyle or pharmacologic interventions based on molecular risk profiles.

## (iv) Digital Twins for Personalized Prevention

Digital twin models simulate an individual's health trajectory using computational models. They can project how interventions (e.g., weight loss, smoking cessation) alter cancer risk.

### Applications by Cancer Type

#### (i) Breast Cancer

- AI algorithms improve mammogram interpretation.
- Integration of imaging with genomic risk profiles enhances stratification (3).

#### (ii) Colorectal Cancer

- AI assists real-time polyp detection in colonoscopy.
- Predictive models identify individuals requiring earlier screening (4).

#### (iii) Lung Cancer

- Low-dose CT analysis by AI reduces false positives.
- Smoking history combined with biomarkers refines risk estimation (7).

#### (iv) Prostate Cancer

- AI analyzes MRI and PSA patterns to stratify risk.
- Reduces unnecessary biopsies while identifying high-risk individuals.

### Benefits and Impact

- **Improved Accuracy:** AI models often outperform traditional statistical models.
- **Personalization:** Tailored prevention strategies maximize efficacy.
- **Scalability:** Automated analyses support large-scale screening programs.
- **Cost-Effectiveness:** Early detection and prevention reduce long-term healthcare costs.

### Challenges and Limitations

#### (i) Data Quality and Bias

Incomplete records and biased datasets can produce unfair predictions across populations.

#### (ii) Explain ability

Black-box models hinder clinical trust and regulatory approval.

### (iii) Integration in Clinical Practice

Workflow disruption, training needs and interoperability barriers restrict adoption.

### (iv) Ethical, Legal and Privacy Concerns

Data privacy and informed consent pose challenges, especially with genomic and wearable data (6).

### Future Directions (8)

- **Federated Learning:** Enables model training without centralizing sensitive data.
- **Explainable AI (XAI):** Enhances transparency for clinicians and patients.
- **Real-world Evidence Integration:** Continuous learning from deployed systems.
- **Global Health Implementation:** Focus on low-resource settings and diverse populations.

### Conclusion

AI-driven emerging technologies are transforming cancer prevention by enabling sophisticated risk prediction, personalized strategies and enhanced screening. While promising, addressing ethical, technical and integration challenges is essential for widespread implementation. Future efforts should prioritize equitable models, explainability and real-world validation to fully realize AI's potential in reducing the global cancer burden.

### References

1. Esteva, A., *et al.* (2021). Deep learning and cancer diagnosis: State of the art. *Nature Reviews Cancer*.
2. Topol, E. J. (2019). High-Performance Medicine: The Convergence of Human and Artificial Intelligence. *Nature Medicine*.
3. McKinney, S. M., *et al.* (2020). International evaluation of an AI system for breast cancer screening. *Nature*.
4. Sharma, A., *et al.* (2024). Machine learning for colorectal polyp detection: A systematic review. *Journal of Gastroenterology*.
5. Huang, X., *et al.* (2023). AI-driven wearable sensor analytics for early disease detection. *IEEE Journal of Biomedical and Health Informatics*.
6. Lungren, M. P., *et al.* (2022). Ethical considerations in AI for healthcare. *The Lancet Digital Health*.
7. Lee, J. K., *et al.* (2023). AI in lung cancer screening: Advances and challenges. *Radiology*.
8. Wang, S., *et al.* (2024). Explainable AI in clinical decision support: Methods and applications. *Frontiers in Artificial Intelligence*.