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Biological ageing, AI-enabled imaging, and the future of cancer prevention: a conceptual framework

Abstract

Cancer prevention has traditionally focused on reducing exposure to known risk factors and detecting malignancy at its earliest clinically identifiable stage. While advances in screening have improved outcomes for several cancer types, most prevention strategies remain reactive, identifying disease after biological processes contributing to carcinogenesis have already been established. Emerging evidence suggests that alterations in metabolic health, body composition, inflammation, and biological ageing are associated with future cancer risk and may be detectable years before diagnosis. Recent developments in artificial intelligence (AI), medical imaging, and predictive analytics offer an opportunity to shift prevention upstream. Whole-body magnetic resonance imaging (MRI) can generate quantitative biomarkers related to visceral adiposity, liver fat, muscle quality, and organ morphology, while AI-enabled analysis may facilitate scalable interpretation of these data. This perspective examines the relationship between biological ageing and cancer development, explores the potential role of AI-powered imaging in precision prevention, and proposes a conceptual framework for integrating imaging-derived biomarkers into future cancer prevention pathways. As healthcare systems increasingly prioritize prevention and healthy longevity, AI-enabled risk assessment may become an important component of precision oncology.

Keywords: cancer prevention; biological ageing; whole-body MRI; artificial intelligence; precision oncology; visceral adiposity; metabolic health; imaging biomarkers

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Introduction

Cancer remains one of the leading causes of morbidity and mortality worldwide, accounting for approximately one in five deaths globally and imposing substantial societal and economic burdens on healthcare systems.[1,2] Despite advances in treatment and screening, the global burden of cancer continues to increase as populations age and exposure to modifiable risk factors accumulates.[2]

Historically, cancer prevention has focused on behavioural modification, vaccination programmes, reduction of environmental exposures, and screening strategies designed to detect disease at its earliest clinically identifiable stage.[3] While these approaches have improved outcomes for several malignancies, they largely intervene after biological processes associated with disease development have already begun.[4]

Emerging evidence suggests that cancer development may be preceded by years or decades of measurable physiological change, including metabolic dysfunction, chronic inflammation, immune dysregulation, and accelerated biological ageing.[5,6,7] These observations have contributed to growing interest in precision prevention, an approach that seeks to identify and address disease risk before pathology becomes clinically apparent.[8]

Recent advances in artificial intelligence, medical imaging, and computational biology have created new opportunities to quantify biological characteristics associated with future disease risk.[9,10] In particular, whole-body MRI combined with AI-enabled image analysis may provide quantitative biomarkers related to body composition, metabolic health, and physiological ageing processes.[11,12]

The biological ageing–cancer connection

Chronological age remains the strongest risk factor for most cancers. However, substantial variability exists between individuals of similar age, suggesting that biological ageing may provide additional insight into disease susceptibility.[13]

Biological ageing reflects the cumulative influence of genetic, environmental, metabolic, and lifestyle factors on physiological function. Accelerated biological ageing has been associated with chronic inflammation, insulin resistance, visceral adiposity, sarcopenia, mitochondrial dysfunction, and immune dysregulation.[13–15] Many of these processes overlap with pathways implicated in cancer development.[4,6]

Chronic low-grade inflammation has been associated with genomic instability, altered immune surveillance, angiogenesis, and cellular proliferation, all of which are recognised hallmarks of cancer.[4,16] Similarly, insulin resistance and hyperinsulinaemia influence growth-factor signalling pathways that have been implicated in multiple malignancies.[17]

Excess visceral adiposity is also associated with elevated levels of inflammatory mediators and endocrine factors that may contribute to carcinogenesis.[18] The International Agency for Research on Cancer has identified excess body fatness as a causal risk factor for at least thirteen cancer types.[19]

Taken together, these findings suggest that biological age and metabolic health may represent useful upstream indicators of future disease risk and may offer opportunities for earlier preventive intervention.[13,15]

Whole-body MRI as a prevention platform

Advances in MRI technology have expanded the role of imaging beyond traditional diagnosis toward quantitative assessment of health-related biomarkers.[11] Whole-body MRI enables evaluation of multiple organ systems without exposure to ionising radiation and can generate measurements of body composition, visceral adipose

tissue, hepatic fat content, skeletal muscle characteristics, and organ morphology.[11,20]

Large-scale population imaging initiatives have demonstrated the feasibility of deriving quantitative biomarkers from MRI data for epidemiological and disease-risk research.[20] These imaging-derived measurements may complement traditional clinical and laboratory assessments by providing additional information regarding physiological status and disease risk.[21]

Unlike isolated biochemical measurements, imaging provides a systems-level view of human physiology, enabling simultaneous assessment of multiple tissues and organs. This capability aligns with emerging concepts in preventive medicine and healthy longevity.[13,21]

Artificial Intelligence and Risk Stratification

The increasing volume and complexity of imaging data present challenges for conventional interpretation. Artificial intelligence has emerged as a promising approach for extracting quantitative information from medical images and supporting clinical decision-making.[9,10]

Machine-learning algorithms can automate image segmentation, quantify tissue characteristics, identify imaging phenotypes, and integrate multiple biomarkers into predictive models.[9,22] Such approaches have demonstrated potential across a range of diagnostic and prognostic applications in radiology.[22,23]

Importantly, AI is best viewed as an augmentation of clinical expertise rather than a replacement for healthcare professionals.[10] Its primary value lies in improving efficiency, reproducibility, and the ability to analyse complex datasets at scale.[9]

Emerging research and commercial platforms are exploring how AI-powered analysis of routine MRI examinations may transform imaging data into actionable preventive health information. Twinn Health, for example, is developing MRI-based AI analytics designed to quantify biomarkers related to body composition, organ health, and metabolic risk from routine imaging examinations. Preliminary validation has been conducted in collaboration with NHS clinicians using retrospective imaging datasets. Further prospective research is required to determine the role of such approaches within long-term cancer prevention strategies.

Conclusion

The future of cancer prevention may increasingly depend on the ability to identify and modify biological processes associated with disease risk before malignancy develops. Advances in AI, imaging science, and ageing research are creating new opportunities to support this transition from reactive detection toward proactive risk assessment.

Whole-body MRI can generate quantitative biomarkers related to body composition, metabolic health, and physiological ageing, while AI-enabled analysis may facilitate scalable interpretation of these data. Although substantial prospective validation remains necessary, the convergence of these technologies offers a promising framework for future precision prevention strategies.

Author biography

Dr. Wareed Alenaini is Founder and Chief Executive Officer of Twinn Health and holds a PhD in Bioimaging. Her work focuses on the application of artificial intelligence, medical imaging, and predictive analytics to preventive healthcare, at scale.

Disclosures

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Conflict of interest

The authors declare that they have no competing interests.

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