

Advancing women's health equity in cancer screening: A conceptual framework from determinants to action

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Received: May 24, 2026; Accepted: August 28, 2026; Published Online: September 11, 2026; <https://doi.org/10.59717/j.xinn-oncol.2026.100036>

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Citation: Wang C. and Li N. (2026). Advancing women's health equity in cancer screening: A conceptual framework from determinants to action. *The Innovation Oncology* 1:100036.

Cancer remains a leading cause of death among women globally, yet persistent gender gaps continue to limit the availability, accessibility, and effectiveness of cancer screening in real-world settings. Grounded in the multidimensional health ecological model, we propose a women-centered **WHOLE** conceptual framework to advance the gender-equitable implementation of cancer screening. This framework encompasses five interrelated components that span distal to proximal factors: **Welfare Policy, Hybrid Screening Modalities, Operational Workforce, Lifestyle Integration, and Engagement**. By moving beyond fragmented factors of screening access, **WHOLE** could provide a practical pathway that integrates influences across multiple levels, from individual motivation to the broader policy environment. It offers a novel paradigm for implementing equitable screening programs and improving women's health outcomes globally.

Cancers affecting women accounted for 48.6% of all new cancer cases and 43.8% of cancer-related deaths globally in 2024. Breast, lung, colorectal, and cervical cancers are the leading cancer types in women, accounting for 49.4% of incidence and 46.4% of mortality.¹ Importantly, a substantial proportion of this burden is preventable through effective primary prevention and evidence-based screening, with these four cancers identified as appropriate targets for screening by the US Preventive Services Task Force, based on demonstrated population benefits.

However, real-world screening programs for women remain suboptimal. Coverage, access, symptom recognition, and program effectiveness are influenced by interacting individual, contextual, socioeconomic, and policy factors. Addressing these challenges requires gender-responsive strategies to advance women's health.

WHAT UNMET NEEDS EXIST FOR WOMEN IN CANCER SCREENING?

Screenable cancers that predominantly affect women

Cervical and breast cancers, both highly amenable to early detection, remain marked by substantial global inequities in screening coverage across countries, ranging from 2.1% in Côte d'Ivoire to 86.3% for cervical cancer in Sweden and 1.7% in Bangladesh to 85.5% in England for breast cancer.² Although large-scale initiatives such as China's National Cervical and Breast Cancer Screening Programme have expanded screening access, disparities persist across regions and populations driven by barriers including limited health literacy, stigma of sexually transmitted infections, and fear of treatment consequences. Addressing these gaps requires resource-appropriate strategies, such as visual inspection in low-resource settings and HPV testing or cytology where infrastructure allows, supported by strengthened health systems.

Other cancers recommended for screening

Low-dose CT (LDCT) has been shown to significantly reduce lung cancer mortality, yet women remain underrepresented in key trials; in the NELSON trial, women accounted for only 5% of total participants.³ This gap is also evident in East Asia, where most women are never smokers and are excluded by smoking-based eligibility criteria despite potential risk. However, findings from the China National Lung Cancer Screening Programme indicated LDCT uptake was higher among women compared with men, suggesting the unmet screening potential.⁴ Similar disparities exist in colorectal cancer screening. Current evidence in the US also suggested fear and lower perceived susceptibility, including viewing colorectal cancer as a predominantly male disease, could reduced women's participation.⁵ These gaps high-

light missed opportunities to improve cancer outcomes and underscore the need for context-specific strategies to ensure equitable access to screening.

WHAT ACTIONS ARE NEEDED TO ADVANCE HEALTH EQUITY IN CANCER SCREENING FOR WOMEN?

Introducing the **WHOLE** framework

The health ecology model as articulated by Collins,⁶ provides a comprehensive lens for understanding the multilevel determinants of health. It posits that health outcomes arise from dynamic interactions across five domains: individual characteristics, behavioural factors, interpersonal networks, community conditions, and broader policy and health system environments. Together, these domains capture both proximal and distal influences that shape health across the life course. A health ecological perspective therefore highlights the need to move beyond fragmented, single-level interventions towards integrated, context-sensitive strategies that address the full spectrum of determinants.

However, while existing ecological frameworks are valuable for explaining why disparities arise, they provide limited guidance on how multilevel determinants could be translated into coordinated implementation strategies for equitable cancer screening. To address this gap, we propose a women-centred '**WHOLE**' framework as a conceptual framework to advance health equity in cancer screening. Rather than introducing new intervention components, **WHOLE** integrates established evidence into five interconnected components, to support the delivery of high-quality, accessible, and equitable screening for women (Figure 1). Each component addresses a distinct implementation challenge while reinforcing the others.

Welfare policy. (aligned with the fifth layer of the health ecological model: policy and health system environments)

This component emphasizes the integration of sex and gender considerations into cancer screening policies and guidelines, to advance women's well-being at the health system level. A key concern is lung cancer screening eligibility. Current screening guidelines underrepresent never-smoking women in East Asia and should incorporate gender heterogeneity to improve risk stratification and equitable access.⁴ Global instruments such as the World Bank's Gender-Responsiveness of Primary Health Care framework, provide governments with feasible tools to monitor screening delivery using gender-sensitive indicators at the facility level. The long-term impact of such policy instruments on equitable access to cancer outcomes remains to be established.

Hybrid screening modalities. (aligned with the fourth layer of the health ecological model: community conditions)

This component proposes a hybrid model combining population-based organized screening with hospital-based opportunistic screening, adapted to local health system capacity and community needs. Organized screening is delivered through population-based national or regional programs, whereas opportunistic screening occurs during routine healthcare encounters such as visits for unrelated medical conditions or general health examinations. While organized screening enables systematic outreach and quality assurance, opportunistic screening helps reach individuals who might otherwise be missed. Opportunistic screening could serve as an important complement to organized screening, especially in regions not yet covered by organized programs or for cancers without population-wide screening. Emerging evidence suggests potential benefits of such approaches in resource-limited settings. For example, in Lagos, Nigeria, a hybrid cervical cancer screening model combining facility-based organized and community-based opportunistic delivery increased screening knowledge from 13.7% at baseline to

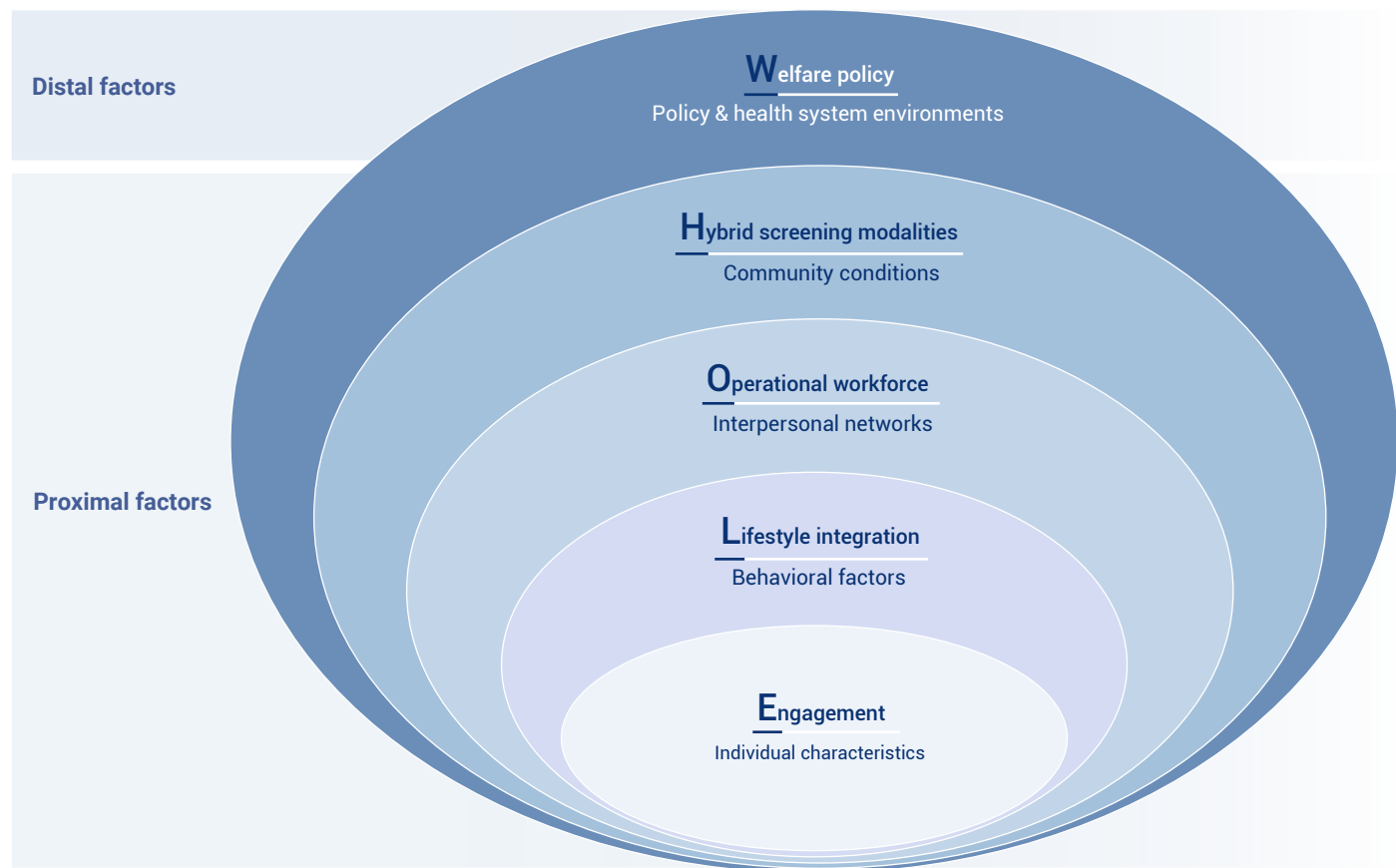


Figure 1. The five-component WHOLE framework for women-centered cancer screening.

80% post-intervention.⁷ However, further evidence from large-scale, randomized trials is needed to assess the comparative effectiveness of hybrid models in improving cancer outcomes versus either strategy alone in real-world settings.

Operational workforce. (aligned with the third layer of the health ecological model: interpersonal networks)

This component focuses on building a gender-responsive workforce capable of delivering cancer screening. Evidence suggests that gender concordance between patients and clinicians can improve screening uptake. A study conducted in Minneapolis examining cervical and breast cancer screening practices found that women were significantly more likely to undergo Papanicolaou testing and mammography when cared for by female rather than male physicians. Similar patterns have been observed in colorectal cancer screening, where women often report a preference for female endoscopists during colonoscopy, driven by concerns about embarrassment, perceived bodily intrusion, and anxiety related to procedural complications such as perforation risk.⁸ Additionally, workforce responsiveness extends beyond clinician gender. Health systems should enable informed patient choice whenever feasible, protect privacy, equip all healthcare professionals with training in respectful and gender-sensitive care, and strengthen patient navigation and follow-up to promote equitable access to timely diagnosis and treatment.

Lifestyle integration. (aligned with the second layer of the health ecological model: behavioral factors)

This component emphasizes the importance of embedding lifestyle intervention strategies within screening delivery. Evidence from the NHS Breast Screening Programme indicates that among the 205 women attending screening services at a UK centre, all participants reported that incorporating preventive interventions into screening programs would not deter attendance at mammography appointments.⁸ Collectively, these findings have the poten-

tial to support the integration of preventive and lifestyle-oriented interventions into cancer screening programs as an effective strategy to enhance continuity of care. To ensure feasible implementation, providers should tailor delivery strategies to the populations they serve, supported by a trained workforce, well-defined referral pathways, and adequate resources.

Engagement. (aligned with the first layer of the health ecological model: individual characteristics)

This component focuses on enhancing women's active engagement in cancer screening through multilevel motivational strategies, particularly in populations with limited awareness and in low-resource settings. A systematic review of 15 cross-sectional studies reported positive associations between higher health literacy and participation in breast (OR: 1.73, 95% CI: 1.27, 2.36), cervical (1.64, 1.30, 2.09), and colorectal (1.25, 1.12, 1.39) cancer screening.⁹ Embedding sustained cancer education within screening programs may therefore strengthen women's autonomy and sustained engagement in screening. In addition, self-sampling approaches offer a practical means to improve engagement. In a large community-based study in China, menstrual blood collected via minipads showed comparable diagnostic accuracy to clinician-collected cervical samples for HPV testing. This non-invasive method addresses barriers related to privacy concerns, embarrassment, and stigma, and may serve as a viable alternative to clinician-based sampling to improve the acceptability and feasibility of large-scale screening programs.¹⁰

ARE WOMEN-CENTERED DOMAINS IMPERATIVE FOR CANCER SCREENING IMPLEMENTATION?

Advancing gender-equitable cancer screening requires more than rhetoric; it depends on resilient health systems, political commitment, and strong implementation capacity. Besides the five specific component, the feasible, equitable cancer screening requires a coordinated pathway that includes appropriate eligibility assessment, informed participation, high-quality

screening, timely diagnostic evaluation, available access to treatment, and ongoing monitoring of both benefits and potential harms. Risk-stratified screening may represent a promising strategy that can be embedded throughout this pathway to optimize resource allocation and improve health equity.⁷ Embedding women's specific needs into screening delivery is therefore not a technical refinement but a necessary step towards realizing gender-responsive cancer care. Grounded in the established theoretical framework and empirical evidence, the WHOLE conceptual framework calls for prioritizing investment in women-centered screening research and translating evidence into optimal strategies to improve cancer outcomes for women.

CONCLUSION

We propose the WHOLE framework from a health ecological perspective, to integrate gender equity across key implementation domains spanning from individual motivation to the broader policy environment in cancer screening. Rather than addressing isolated determinants, this framework may guide a multidimensional approach to implementing sustainable screening programs and advancing women's health equity.

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FUNDING AND ACKNOWLEDGMENTS

This study was funded by the National Natural Science Foundation of China (82273722). The funders of this study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report.

AUTHOR CONTRIBUTIONS

NL conducted the study design and reviewed the manuscript. CW conducted study design, literature search, and drafted the manuscript. All authors had access to all the data in the study and had approved the final version before submission.

DECLARATION OF INTERESTS

The authors declare no competing interests.