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Education Article

Artificial Intelligence in Breast Cancer Screening: Current Evidence And Future Perspectives For Implementation in Serbia

Ancy Joe E. Edwin[1], Kristina D. Stamenković[1,2], Vesna P. Mijatović Jovanović[1,2], Dane A. Krtinić[3,4], Sanja D. Maletin[1,5], Dragana S. Milijašević[1,2]

[1] Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia
[2] Center for Analysis, Planning and Organization of Health Care, Institute of Public Health of Vojvodina, Novi Sad, Serbia
[3] Department for Pharmacology with Toxicology, Faculty of Medicine, University of Niš, Niš, Serbia
[4] Clinic for Oncology, University Clinical Center Niš, Niš, Serbia
[5] Cardiac Surgery Clinic, Institute of Cardiovascular Disease Vojvodina, Sremska Kamenica, Serbia

SUMMARY

Introduction: Breast cancer remains the most frequently diagnosed malignancy and one of the leading causes of cancer mortality among women worldwide. Despite the implementation of organized mammography screening programmes, considerable disparities in mortality persist, particularly in low- and middle-income countries. Artificial intelligence (AI) has emerged as a promising tool for improving the accuracy, efficiency, and accessibility of breast cancer screening. To review current evidence regarding the role of artificial intelligence in breast cancer screening and early detection, with particular emphasis on its potential application within the healthcare system of the Republic of Serbia.
Methodology: A comprehensive literature review was conducted using the MEDLINE, PubMed, and KOBSON databases. Literature published between 2012 and 2026 were identified using the keywords *breast cancer*, *artificial intelligence*, *mammography*, *screening*, and *machine learning*. After applying predefined inclusion criteria, 23 relevant publications were included in the final analysis.
Topic: Current evidence demonstrates that AI-assisted mammography achieves diagnostic performance comparable to or exceeding that of experienced breast radiologists, while substantially reducing reading workload. Prospective clinical trials have shown that AI-supported screening increases early cancer detection rates without compromising patient safety. Beyond lesion detection, AI enables individualized risk assessment, prediction of interval cancers, and supports the transition toward risk-adapted screening strategies. For Serbia, AI-assisted centralized triage systems could optimize limited radiology resources, improve access to expert interpretation, and strengthen organized screening programmes. Successful implementation, however, requires local validation studies, interoperable digital infrastructure, appropriate regulatory frameworks, and continuous professional education.

Corresponding author:
Assistant Professor Dragana S. Milijašević, MD, PhD
Specialist in Social Medicine
Faculty of Medicine, Hajduk Veljkova 3, 21000, Novi Sad, Serbia
E-mail: dragana.milijasevic@mf.uns.ac.rs

Conclusion: Artificial intelligence has the potential to substantially improve breast cancer screening by increasing diagnostic accuracy, reducing radiologists' workload, and supporting personalized screening approaches. Strategic integration alignedwith European quality standards and national healthcare priorities could promote earlier diagnosis and reduced breast cancer mortality in Serbia.

Keywords: Breast Cancer, Artificial Intelligence, Mammography, Screening, Early Detection, Machine Learning, Serbia

INTRODUCTION

Breast cancer remains one of the most significant public health challenges of the twenty-first century, representing the most frequently diagnosed malignancy and a leading cause of cancer-related mortality among women worldwide [1, 2]. According to global epidemiological data compiled by the World Health Organization (WHO) and the International Agency for Research on Cancer (IARC), the incidence of breast cancer has risen steadily over the past few decades, driven by shifting demographic patterns, population ageing, and the widespread adoption of unfavourable lifestyles habits [1, 2]. This disease affects populations across all socioeconomic strata; however, its clinical outcomes display a profound disparity between high-income countries and low-to-middle-income countries (LMICs). In highly developed nations, comprehensive healthcare infrastructure and early detection mechanisms have led to a gradual decline in age-standardised mortality rates, whereas LMICs face rising mortality rates due to late-stage presentations and limited access to timely diagnostics and healthcare [1, 2].

Data from Eurostat and the European Commission reveal that while Western and Northern European countries exhibit some of the highest incidence rates globally, their mortality rates have decreased significantly [3]. This success is primarily attributed to well-established, population-based organized screening programs, high public awareness, and rapid therapeutic interventions [3, 4]. Conversely, Central, Eastern, and Southern European nations demonstrate a distinct epidemiological pattern: despite having lower or comparable incidence rates to Western Europe, they suffer from disproportionately high mortality-to-incidence ratios [2, 3]. This East–West healthcare disparity across Europe underscores structural inequities in healthcare delivery, varying levels of health literacy, and systemic challenges in maintaining consistent quality assurance within national screening frameworks [4].

The Republic of Serbia and the broader Western Balkan region represent a critical focal point within this East-West European health disparity. In Serbia, breast cancer is the most common malignant tumor in women and stands as the leading cause of premature female mortality from cancer [5]. Every year, thousands of women are newly diagnosed, and the country consistently ranks near the top of European statistical tables for breast cancer mortality [2, 5]. This epidemiological burdent is mirrored in neighboring Western Balkan nations such as Croatia, Bosnia and Herzegovina, Montenegro, and North Macedonia where healthcare systems struggle with similar socio-economic and structural transitions [3, 6]. The high mortality rate in this region is fundamentally a consequence of delayed diagnosis; a significant proportion of tumors are detected at advanced stages (Stage III or IV), where the therapeutic options are more aggressive, less effective, and financially burdensome to the public healthcare system [5].

The underlying factors contributing to the poor epidemiological parameters in Serbia and the region are multi-faceted. Historical data indicate that while organized national screening programs were formally introduced to mitigate this crisis, their operational deployment has faced persistent obstacles [5]. These include suboptimal population response rates, logistical fragmentation between rural and urban centers, and a shortage of subspecialized breast radiologists [5, 6]. Consequently, a substantial portion of breast cancer detection in the Western Balkans remains opportunistic—dependent on self-examinations or sporadic clinical visits—rather than systematic. This fragmentation fails to catch the disease in its asymptomatic, localized phase, thereby compromising the survival rates of patients and placing an unsustainable strain on regional oncology centers [2, 5].

METHODOLOGY

This narrative review synthesizes current evidence on the application of artificial intelligence (AI) in breast cancer screening and early diagnosis in the Republic of Serbia. A comprehensive literature search was conducted across the MEDLINE, PubMed, and KOBSON databases, which were conducted up to July 2026. The search strategy employed combinations of Medical Subject Headings (MeSH) and free-text keywords, including: („*breast cancer*" OR „*breast neoplasm*") AND („*artificial intelligence*" OR „*machine learning*" OR „*deep learning*") AND („*mammography*" OR „*screening*"). To be eligible for inclusion, studies were required to meet the following criteria: (1) evaluate AI algorithms regarding diagnostic accuracy, workflow efficiency, or clinical implementation in breast cancer screening; (2) represent peer-reviewed prospective clinical trials, retrospective validation/simulation studies, cohort studies, or systematic reviews; and (3) be published in English or Serbian. Exclusion criteria included conference abstracts, letters to the editor, studies not focused on screening or early detection, and articles published in languages other than English or Serbian. Articles were sequentially screened by title and abstract, followed by full-text evaluation against the predefined eligibility criteria. A total of 23 studies met all criteria and were selected for qualitative synthesis.

TOPIC

Prevention Strategies and the Mechanics of Population-Based Screening

To mitigate this growing disease burden, public health frameworks emphasize a dual approach consisting of primary and secondary prevention. Primary prevention strategies focus on modifying known risk factors to reduce the overall baseline incidence of the disease [7]. These interventions include promoting healthy lifestyles, managing metabolic risk factors, reducing alcohol consumption, encouraging physical activity, and addressing reproductive factors such as breastfeeding and the cautious use of hormone replacement therapies [7]. However, because many primary risk factors-including genetic predispositions (such as BRCA1/2 mutations), family history, biological sex, and advanced age-are non-modifiable, primary prevention alone cannot sufficiently control the population-level burden of breast cancer [7].

Consequently, secondary prevention-specifically through organized, population-based screening-serves as the cornerstone of modern breast cancer control programs [4, 7, 8].

European Guidelines for Breast Cancer Screening and Diagnosis recommend biennial mammographic screening for asymptomatic women aged 50 to 69 [4]. To maintain high diagnostic standards and minimize human error, the European Reference Organisation for Quality Assured Breast Screening and Diagnostic Services (EUREF) mandates an independant double-reading protocol [4]. Under this standard, each digital mammogram is independently evaluated by two certified breast radiologists. In cases of discordant interpretations, a third reader or consensus arbitration is required to determine whether the patient should be recalled for further diagnostic workup, such as digital breast tomosynthesis (DBT), or biopsy [4, 9].

To enhance the efficiency and sensitivity of mammographic screening, artificial intelligence (AI)-based diagnostic systems have been developed and increasingly integrated into breast imaging practice. Early computer-aided detection systems have evolved into sophisticated machine learning and deep learning algorithms capable of analyzing complex imaging patterns and tissue characteristics. In many European countries, these technologies are being implemented to support radiologists in mammogram interpretation, improve diagnostic accuracy, reduce reading time, and optimize screening workflows [4]. Furthermore, AI has demonstrated the potential to increase screening sensitivity, improve cancer detection rates, and reduce the workload associated with population-based screening programmes [4].

The integration of AI-assisted mammography aligns directly with the strategic objectives of the World Health Organization's Global Breast Cancer Initiative, which aims to achieve an annual reduction in breast cancer mortality of 2.5%. Maintaining this reduction over a twenty-year period is projected to save approximately 2.5 million lives worldwide [10]. By facilitating earlier diagnosis and more efficient screening processes, AI technologies may contribute significantly to achieving these public health goals.

Accordingly, this review aims to synthesize current evidence regarding the application of artificial intelligence in breast cancer screening and early detection in the Republic of Serbia.

Current Evidence and Diagnostic Performance of AI

The integration of artificial intelligence (AI) into breast cancer screening marks a significant paradigm shift from conventional double-reading protocols to computer-assisted workflows. A critical evaluation of recent literature reveals varying degrees of clinical efficacy, workload optimizations, and structural capabilities among different AI models. Early landmark studies established that standalone AI systems could match or exceed the diagnostic accuracy of average human readers. For instance, Rodriguez-Ruiz et al. demonstrated that an AI system achieved an area under the receiver operating characteristic curve (AUC) comparable to the median performance of 101 radiologists [11]. Similarly, McKinney et al. validated an international AI model across distinct datasets from the United Kingdom and the United States, reporting significant reductions in both false positives and false negatives compared to human expert double-reading [12]. These foundational investigations provided the rationale for translating AI algorithms from retrospective evaluation into prospective clinical trials.

This transition from retrospective validation to prospective clinical validationis exemplified by the Mammography Screening with Artificial Intelligence (MASAI) trial conducted by Hernström et al. [13]. As a randomised, controlled, parallel-group, non-inferiority study, the MASAI trial provided empirical evidence indicating that AI-supported screening-where a single radiologist interprets mammograms alongside an AI triage system-does not compromise safety and yields a higher cancer detection rate compared to the standard double-reading by two independent radiologists [13]. Furthermore, the study demonstrated a major operational benefit: a reduction in the radiologist screen-reading workload by approximately 44% [13]. This directly mirrors the retrospective simulations by Dembrower et al., which demonstrated that AI-based triaging could safely reliably identify low-risk mammograms, allowing clinicians to focus their cognitive resources exclusively on high-risk cases [14].

Artificial Intelligence, Interval Cancer Detection and Personalised Risk Assessment

Interval cancers remain one of the most significant limitations of mammography screening programmes. These tumours are diagnosed after a negative screening examination but before the next scheduled screening round. Compared with screen-detected cancers, interval cancers are often associated with more aggressive biological behaviour, larger tumour size at diagnosis, and poorer prognosis compared with screen-detected cancers [15]. The ability of AI systems to identify women at increased risk of interval cancer has generated considerable interest. Research by Rothwell and colleagues demonstrated that AI algorithms could extract sub-visual imaging features associated with future interval cancer development, even when no obvious malignancy was identified during routine screening interpretation [16]. This finding suggests that AI may contribute not only to cancer detection but also to risk prediction.

The potential implications are substantial. Traditional screening programmes are generally organised according to age-based criteria, assuming a uniform risk profile across broad age cohorts. However, it is increasingly recognised that breast cancer risk varies considerably among individuals. AI systems may facilitate the transition from standardised population-based screening towards more personalised screening strategies based on individual risk assessment. Earlier identification of women at elevated risk could allow screening intervals to be adjusted accordingly, thereby improving programme efficiency while potentially reducing the incidence of advanced-stage disease [15]. Such developments align closely with broader trends towards precision medicine and risk-adapted healthcare delivery.

Personalised medicine has become a central objective within contemporary healthcare. Rather than applying identical interventions to all individuals, personalised approaches seek to tailor prevention, diagnosis, and treatment according to each patient's unique characteristics.

Within breast cancer screening, AI has demonstrated considerable potential for risk stratification. Yala et al. colleagues developed a deep learning model capable of estimating future breast cancer risk directly from mammographic images [17]. Unlike conventional risk prediction models, which rely predominantly on demographic and clinical variables, AI-based approaches extract information directly from imaging data and may therefore identify risk-related patterns that are not captured by traditional methods.

The findings reported by Yala et al. suggest that image-based AI models may improve risk prediction accuracy and enable more effective identification of women who could benefit from enhanced surveillance strategies [17]. This represents an important step towards risk-adapted screening programmes in which screening intervals, imaging modalities, and follow-up protocols are tailored to individual risk profiles.

Beyond risk prediction, AI may also contribute to tumour characterisation and prognostic assessment. Emerging evidence suggests that advanced algorithms can identify imaging features associated with tumour aggressiveness, molecular subtypes, and treatment response. Although these applications remain under active investigation, they highlight the broader potential of AI throughout the breast cancer care pathway.

Implementation Strategies and Structural Challenges in Serbia

Translating international AI use into the healthcare infrastructure of the Republic of Serbia requires a nuanced understanding of local structural, epidemiological, and logistical realities. The implementation of AI in this context should not be viewed merely as a superfluous technological novelty, but as a strategic tool to overcome systemic problems. According to the National Strategy for the Development of Artificial Intelligence for the period 2025-2030, Serbia has committed to integrating digital innovations into public administration and healthcare systems [18]. The Institute for Artificial Intelligence of Serbia has actively explored healthcare applications, providing a solid institutional foundation for piloting digital health solutions [19].

To effectively deploy AI within the Serbian healthcare framework, a centralized cloud-based or regionalized triage architecture could be recommended. Mammograms acquired at primary health care centers could be securely transmitted to a central AI processing server. The AI model would automatically score the mammograms based on malignancy risk:

Low-Risk Tier: Mammograms with exceptionally low risk scores could be routed to a single radiologist for rapid review and dismissal, significantly accelerating the screening cycle [14].

High-Risk Tier: Mammograms exhibiting suspicious features or high risk indices would be automatically flagged and subjected to a mandatory double-reading protocol by senior radiologists at regional oncology centres, such as the Institute of Oncology and Radiology of Serbia (IORS) or the Oncology Institute of Vojvodina [13].

This tiered triaging framework addresses the severe shortage of specialized radiologists in rural areas, optimizing resource allocation and ensuring that expert clinical attention is directed where it is most urgently required. However, several operational and technical barriers must be resolved before widespread adoption can occur. Mammographic data in Serbia is often fragmented across disparate, non-interoperable Picture Archiving and Communication Systems (PACS), hindering seamless data aggregation [19]. Second, AI models trained exclusively on Western European or North American cohorts may exhibit demographic and technical bias when applied to Serbian populations due to differences in mammography hardware, imaging protocols, and underlying population characteristics [20, 21]. Consequently, local validation studies and pilot programs are mandatory to calibrate AI algorithms to the existing diagnostic equipment and tissue characteristics.

When contextualized within the broader Western Balkan region, Serbia's healthcare challenges mirror those of neighboring nations, including Croatia, Bosnia and Herzegovina, Montenegro, and North Macedonia [6, 22]. Regional academic literature further emphasizes the utility of AI in secondary diagnostic challenges, such as lymph node staging and risk stratification. Vrdoljak et al., in a comprehensive regional review, emphasized that AI applications extend beyond initial lesion detection to the precise classification of axillary lymph node status, which is a vital prognostic factor for breast cancer patients [6]. Incorporating AI systems capable of evaluating both primary breast lesions and axillary lymph node status could significantly standardize diagnostic quality across the Balkans, mitigating the disparities between capital city tertiary centers and underserved rural clinics [5, 6].

Governance, Ethical Considerations, and Quality Assurance

The clinical deployment of AI cannot occur in a regulatory vacuum. It requires a rigorous governance framework to address ethical, legal, and quality assurance concerns. As outlined in the European Guidelines for Quality Assurance in Breast Cancer Screening and Diagnosis, any new technology introduced into a screening program must maintain strict quality benchmarks regarding sensitivity, specificity, and recall rates [4, 8]. A primary ethical concern is the risk of overdiagnosis-the detection of indolent lesions that would not have caused clinical harm during a patient's lifetime-which leads to unnecessary psychological morbidity [7]. AI algorithms must be carefully calibrated to balance sensitivity and specificity, avoiding an inflation of recall rates that would overwhelm national healthcare budgets [13, 14].

From a legal and governance perspective, strict compliance with the General Data Protection Regulation (GDPR) and corresponding national legislation in Serbia, is mandatory [19]. Patient mammograms and clinical data must be anonymized, and secure data transmission protocols must be established [19]. Furthermore, clear legal liability frameworks must define the boundaries of clinician and algorithmic responsibility. Because AI is implemented as a supportive diagnostic tool rather than an autonomous decision-maker, the final diagnostic accountability remains with the certified radiologist [18, 20]. To prevent automated bias and „automation complacency"-where a clinician uncritically acceptswith an AI's assessment-continuous professional training programs must be established by state medical chambers to educate radiologists on the specific strengths, limitations, and interpretation of AI-generated outputs and risk scores [21, 23].

CONCLUSION

The incorporation of artificial intelligence into breast cancer screening programs represents a transformative advancement in public health and oncology. Clinical evidence from major international trials demonstrates that AI-supported screening protocols can increase cancer detection rates while simultaneously reducing the interpretation workload of radiologists by nearly half. This dual advantage holds profound implications for the Republic of Serbia and the broader Western Balkan region, where high breast cancer mortality, structural resource constraints, and severe shortages of specialized radiologists pose persistent challenges to organized screening initiatives.

By adopting a centralized AI triaging architecture, Serbia can optimize its clinical workflows, filtering low-risk cases efficiently while concentrating expert diagnostic resources on high-risk and complex clinical presentations. Furthermore, current evidence suggests that AI holds potential in identifying subtle parenchymal patterns in dense breast tissue that may be subtle parenchymal patterns, thereby assisting in the prediction of interval cancers and informing personalized, supplemental imaging strategies.

To achieve successful and sustainable integration, Serbia must align its implementation with national AI strategies and European quality assurance guidelines. This requires establishing data governance frameworks, resolving PACS interoperability barriers, conducting local validation studies to eliminate algorithmic bias, and providing continuous training for clinicians. The implementation of artificial intelligence in breast cancer screening should not be regarded solely as a technological innovation, but as a high-value tool capable of reducing regional healthcare disparities, early diagnosis, and long-term healthcare system sustainability. Ultimately, when integrated ethically and systematically, artificial intelligence can bridge regional healthcare disparities, optimize national screening performance, and significantly reduce the burden of breast cancer mortality.

LIMITATIONS

It is important to acknowledge the limitations of this narrative review. First, as a narrative review, it does not involve a formal metaanalysis or systematic risk-of-bias assessment of the included studies. Second, most of the reviewed prospective clinical trials and simulation studies were conducted in highly developed countries with homogeneous patient cohorts, which limits the direct generalizability of the reported AI performance metrics to settings with different epidemiological profiles and mammographic hardware, such as the screening program in the Republic of Serbia. Additionally, there is a potential for publication bias, as studies demonstrating positive diagnostic performance of AI are more likely to be published than those showing neutral or negative results.

CONFLICT OF INTEREST

All authors declare no conflict of interest.

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Veštačka inteligencija u skriningu raka dojke: savremeni dokazi i buduće perspektive za primenu u Srbiji

Ancy Joe E. Edwin[1], Kristina D. Stamenković[1,2], Vesna P. Mijatović Jovanović[1,2], Dane A. Krtinić[3,4], Sanja D. Maletin[1,5], Dragana S. Milijašević[1,2]

[1] Medicinski fakultet, Univerzitet u Novom Sadu, Novi Sad, Srbija
[2] Centar za analizu, planiranje i organizaciju zdravstvene zaštite, Institut za javno zdravlje Vojvodine, Novi Sad, Srbija
[3] Katedra za farmakologiju sa toksikologijom, Medicinski fakultet, Univerzitet u Nišu, Niš, Srbija
[4] Klinika za onkologiju, Univerzitetski klinički centar Niš, Niš, Srbija
[5] Klinika za kardiohirurgiju, Institut za kardiovaskularne bolesti Vojvodine, Sremska Kamenica, Srbija

KRATAK SADRŽAJ

Uvod: Rak dojke je najčešće dijagnostikovana maligna bolest i jedan od vodećih uzroka smrtnosti od raka kod žena širom sveta. Uprkos sprovođenju programa organizovanog skrininga na karcinom dojke, značajne razlike u smrtnosti i dalje postoje, posebno u zemljama sa niskim i srednjim prihodima. Veštačka inteligencija se pojavila kao obećavajući alat za poboljšanje tačnosti, efikasnosti i dostupnosti skrininga raka dojke. Pregled trenutnih dokaza o ulozi veštačke inteligencije u skriningu i ranom otkrivanju raka dojke, sa posebnim naglaskom na njenu potencijalnu primenu u zdravstvenom sistemu Republike Srbije.
Metodologija: Sproveden je sveobuhvatni pregled literature korišćenjem baza podataka MEDLINE, PubMed i KOBSON. Publikacije objavljene između 2012. i 2026. godine identifikovane su korišćenjem ključnih reči rak dojke, veštačka inteligencija, mamografija, skrining i mašinsko učenje. Nakon primene unapred definisanih kriterijuma za uključivanje, 23 relevantne publikacije su uključene u konačnu analizu.
Tema: Trenutni dokazi pokazuju da mamografija potpomognuta veštačkom inteligencijom postiže dijagnostičke performanse uporedive ili čak i veće u odnosu na očitane snimake od strane iskusnih radiologa, uz značajno smanjenje opterećenja čitanjem. Prospektivna klinička ispitivanja su pokazala da skrining uz pomoć veštačke inteligencije povećava stopu otkrivanja raka bez ugrožavanja bezbednosti pacijenata. Pored otkrivanja lezija, veštačka inteligencija omogućava individualizovanu procenu rizika, predviđanje intervalnih karcinoma i podržava prelazak na strategije skrininga prilagođene riziku. Za Srbiju, centralizovani sistemi trijaže uz pomoć veštačke inteligencije mogli bi da optimizuju ograničene radiološke resurse, poboljšaju pristup stručnoj interpretaciji i ojačaju organizovane programe skrininga. Međutim, uspešna implementacija zahteva lokalne studije validacije, interoperabilnu digitalnu infrastrukturu, odgovarajuće regulatorne okvire i kontinuirano stručno obrazovanje.
Zaključak: Veštačka inteligencija ima potencijal da značajno poboljša skrining raka dojke povećanjem dijagnostičke tačnosti, smanjenjem opterećenja radiologa i podržavanjem personalizovanih pristupa skriningu. Pažljiva implementacija u skladu sa evropskim standardima kvaliteta i nacionalnim prioritetima zdravstvene zaštite mogla bi doprineti ranijoj dijagnozi i smanjenju mortaliteta od raka dojke u Srbiji.

Ključne reči: rak dojke, veštačka inteligencija, mamografija, skrining, rano otkrivanje, mašinsko učenje, Srbija

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