INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue XI November 2024

# Advancing Digital Health using AI and Machine Learning Solutions for Early Ultrasonic Detection of Breast Disorders in Women

**Majd Oteibi[1]*, Adam Tamimi[2], Kaneez Abbas[3], Gabriel Tamimi[4], Danesh Khazaei[5], Hadi Khazaei[6]**

**[1,2,4]Validus Institute Inc**

**[3]Athreya Med Tech**

**[5]Portland State University**

**[6]Portland State University/ Athreya Med Tech**

***Corresponding Author**

**DOI: https://doi.org/10.51244/IJRSI.2024.11110039**

**Received: 25 September 2024; Revised: 08 October 2024; Accepted: 11 October 2024; Published: 07 December 2024**

## ABSTRACT

**Background:** Breast cancer is a significant global health concern accounting for 685,000 deaths in 2020 and 2.3 million cases worldwide. By 2070, the cases are expected to rise to 4.4 million, because it is usually discovered at a later stage when it is too late to help the patients. For the past two decades, innovations made in mobile health have improved the lives of people and accessibility in multiple disciplines.

This abstract explores the feasibility of using a portable ultrasound device integrated with artificial intelligence (AI) technology for the purpose of early screening and detection of breast cancer in women living in remote and rural areas, between the ages of 18 years to 75 years.

**Intervention:** Training healthcare professionals to use this portable ultrasound with the integration of AI technology will provide convenience and accuracy. This technology can provide high-resolution information regarding anatomic and tissue changes and holds promise for early detection of lumps in the breast. This is a critical screening and diagnostic tool for females living in rural and remote areas. The results will be compared with images of mammography testing for accuracy and patients will then be referred for further evaluation and biopsy of their lesions.

**Learning Objectives:**

1. To assess the feasibility and effectiveness of using AI Assisted 3D Ultrasound as a first line investigation for lesion screening
2. To Develop high-fidelity phantom tissue models as well as simulated images that mimic real tissue properties in ultrasound imaging and simulated images and provide anatomical variations for realistic AI training purposes.
3. To evaluate the feasibility of using portable ultrasound integrated with AI technology for early screening and detection of breast lesion

**Methods:**

Combining portable ultrasound with AI assisted technology holds significant promise for non- invasive and accessible early screening and detection of breast cancer. Here are some methods that can be employed:

1. Using phantom lab to create tissue mimicking materials to screen breast cancer tissues and use portable ultrasound to screen the created tissue mimicking materials to train AI
2. Automated Image Analysis: AI algorithms can analyze ultrasound images to detect abnormalities such as suspicious masses or microcalcifications.
3. Integration with clinical data: the ultrasound findings of the patient will be added with the patient's demographics, medical history and other medically relevant information which can improve the accuracy of cancer detection and provide more personalized care.

**Keywords:** breast cancer, digital health, ultrasound, AI technology, innovation

# INTRODUCTION

Breast cancer is the second leading cause of death from cancer in women (3), but early detection and treatment can considerably Formatted: Justified improve outcomes (1,4,5). Therefore, many developed nations have implemented large-scale mammography screening programs for women starting between the ages of 40 and 50(6–8). In the USA and UK combined, over 42 million exams are performed each year (9,10). Despite the widespread adoption of mammography, interpretation of these images remains challenging. The accuracy achieved by experts in cancer detection varies widely, and the performance of even the best clinicians leaves room for improvement (11,12). For the past two decades, innovations made in mobile health have improved the lives of people and accessibility in multiple disciplines.

False positives can lead to patient anxiety (13), unnecessary follow-up and invasive diagnostic procedures. Cancers that are missed at screening may not be identified until they are more advanced and less amenable to treatment (14). AI may be uniquely poised to help with this challenge. Studies have demonstrated the ability of AI to meet or exceed the performance of human experts on several tasks of medical image analysis (15–19). As a shortage of mammography professionals threatens the availability and adequacy of breast-screening services around the world (20– 23), the scalability of AI could improve access to high-quality care for all. Computer-aided detection (CAD) software for mammography was introduced in the 1990s, and several assistive tools have been approved for medical use (24). Despite early promise (25,26), this generation of software failed to improve the performance of readers in real-world settings (12,27,28). More recently, the field has seen a renaissance owing to the success of deep learning. A few studies have characterized systems for breast cancer prediction with stand-alone performance which approaches that of human experts (29,30). However, the existing work has several limitations. Most studies are based on small, enriched datasets with limited follow-up, and few have compared performance to readers in actual clinical practice, relying instead on laboratory-based simulations of the reading environment. So far there has been little evidence of the ability of AI systems to translate between different screening populations and settings without additional training data (31). Critically, the pervasive use of follow-up intervals that are no longer than 12 months (29,30,32,33). This abstract explores the feasibility of using a portable ultrasound device integrated with artificial intelligence (AI) technology for the purpose of early screening and detection of breast cancer in women living in remote and rural areas, between the ages of 18 years to 75 years.

# METHODS

Combining portable ultrasound with AI holds significant promise for non-invasive and accessible early screening and detection of breast lesions. Some methods that can be employed include the integration of artificial intelligence technologies.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue XI November 2024

According to a published study, artificial intelligence incorporates convolutional deep learning algorithms to achieve quantitative assessments and recognize complex patterns. The capabilities of these deep learning algorithms enable AI to make diagnostic predictions, making it increasingly prevalent in medical imaging.

For instance, Lutz et al. (2013), in their publication within oncology and palliative care, highlighted multiple efforts to explore radiomics as a tool for assisting clinical decision-making related to the diagnosis and risk stratification of various cancers. More recently, radiomics has incorporated deep learning techniques to learn from readily available imaging data.

Our research is focused on following methodology:

1. **Automated Image Analysis:** AI algorithms can analyze ultrasound images to detect abnormalities such as suspicious masses or microcalcifications.
2. **Data Extraction:** AI can discern relevant features from ultrasound images, including the shape, texture, and echogenicity of lumps or lesions. These features can then be utilized to classify the likelihood of malignancy and assist in making diagnostic predictions.
3. **Integration with Clinical Data:** The ultrasound findings will be combined with the patient's demographics, medical history, and other relevant medical information. This integration can improve the accuracy of cancer detection and provide more personalized care.
4. **Real-Time Support:** AI can offer real-time decision support to surgeons and radiologists during ultrasound examinations. Convolutional deep learning algorithms can highlight suspicious regions by providing probability scores for malignancy.
5. **Remote Diagnosis and Telemedicine:** Portable ultrasound devices combined with AI can facilitate remote diagnosis and telemedicine initiatives for patients in rural or remote areas, allowing women to undergo testing from the convenience of their homes. This approach can enhance early detection of breast cancer and improve access to timely screening and diagnostic services before the lesion advances to late-stage cancer. (Figure 1-4)


Figure 1 Glandular lesion seen in breast phantom tissue using point of care ultrasonic device

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue XI November 2024

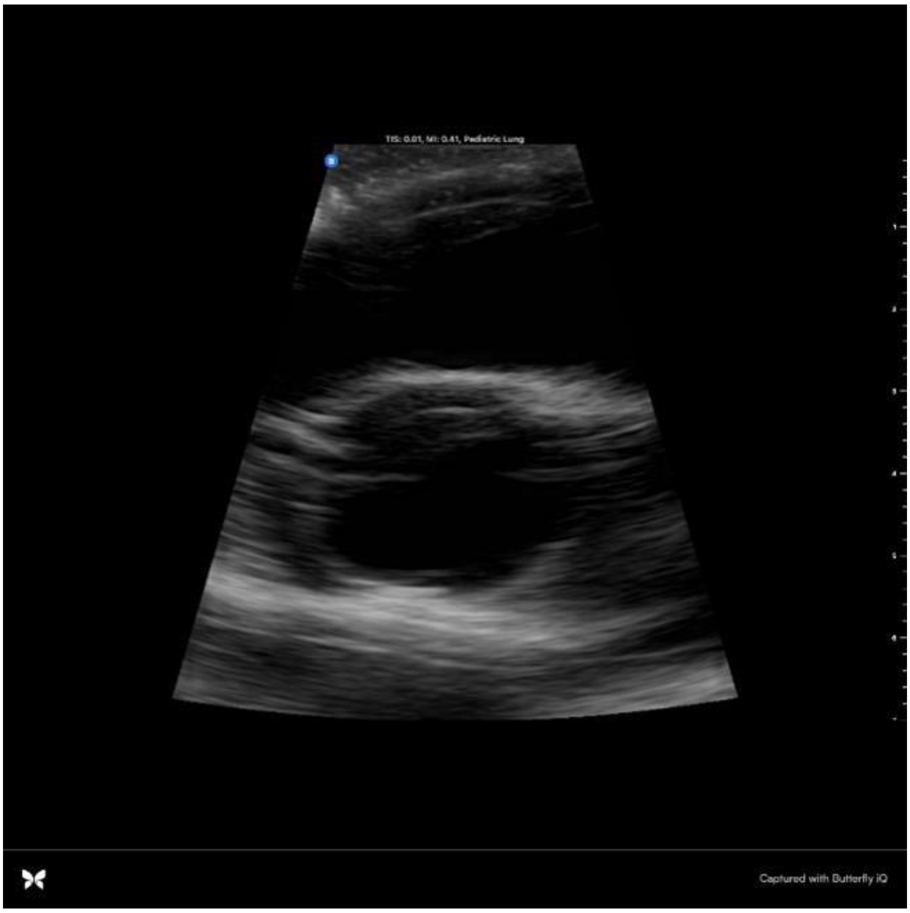


Figure 2 Cystic lesion seen in breast phantom tissue using point of care ultrasonic device

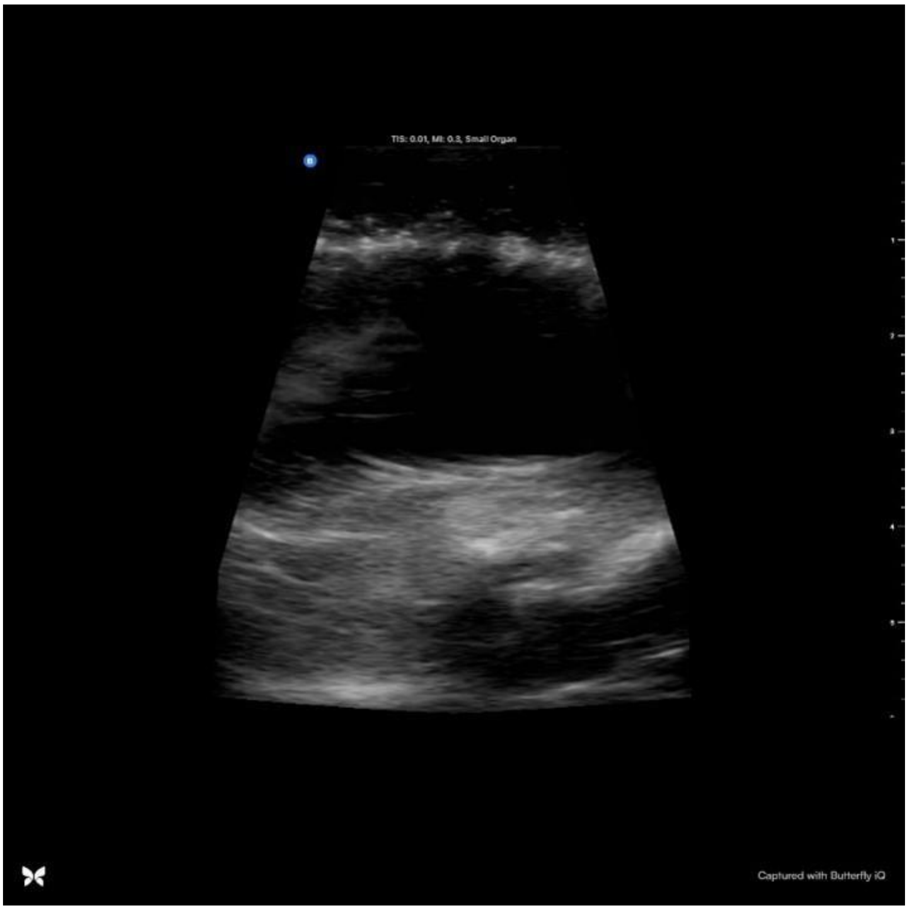


Figure 3 Cancerous lesion seen in the breast phantom tissue using point of care ultrasonic device

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue XI November 2024


Figure 4 Fibroadenomatous lesion in phantom breast tissue using point of care ultrasonic device

Using tissue mimicking materials to create breast phantom tissue in the lab as an inexpensive way to screen breast tissue and breast lesions


Figure 5 Phantom breast tissue created from tissue mimicking materials in the lab

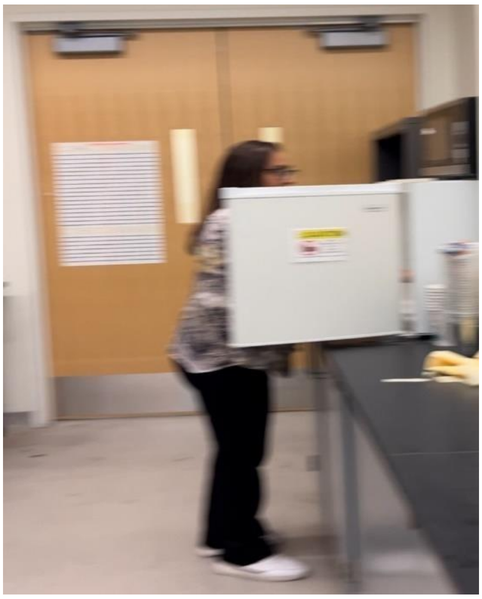

Figure 6 Dr. Majd Oteibi study author and principal investigator screenshot while storing the phantom breast tissue In the fridge

Figure 7 Dr. Majd Oteibi study author and principal investigator screenshot while assessing a phantom breast tissue using point of care ultrasonic device

## PROJECT SUMMARY

This proposal investigates the feasibility and effectiveness of utilizing portable ultrasound devices integrated with artificial intelligence (AI) technology for the early screening and detection of breast lesions in women aged 18 to 75 years, residing in rural and remote areas.

**Assessing Feasibility and Effectiveness Objective:** Evaluate the feasibility and effectiveness of AI-assisted 3D ultrasound as a primary investigation method for early breast cancer screening and detection.

**Approach:** Train healthcare professionals to utilize portable ultrasound devices at home, integrating AI for real-time analysis. Evaluate feasibility through a two-year study at Phantom Labs.

**Outcome:**

Determine the viability of AI-assisted portable ultrasound as a cost effective, accessible, and as a reliable screening tool. Enhancing Technology and Implementation. Early breast lesion screening has potential impact to save patients' lives, before it develops into a cancer. This will also help improve patient outcomes and reduce costs of treatment for females due to early detection of breast lesions. The combination of portable ultrasound and AI offers the potential for non-invasive, accessible, and cost-effective screening in diverse healthcare settings, particularly in underserved or rural areas. This is especially useful in females living in remote, and rural places.

**Objective**: Develop and enhance technology for widespread implementation of AI-assisted Portable ultrasound in remote and rural areas

**Approach:** Develop high-fidelity phantom tissue models and simulated images for realistic AI training. Integrate AI findings with patient demographics and medical history. Explore real-time decision support for ultrasound examinations.

**Outcome:** Establish a robust technology framework for accurate breast cancer detection in diverse healthcare settings, including remote and rural areas.

**Evaluation of Long-Term Impact Objective:** Assess the long-term impact of AI-assisted portable ultrasound on patient outcomes, including survival rates and healthcare costs.

**Approach**: Implement the technology in diverse healthcare settings over an extended period. Monitor patient outcomes, referral rates, and treatment costs.

**Outcome**: Provide evidence for the sustained effectiveness and cost-effectiveness of AI-assisted Portable ultrasound in rural and remote areas.

**Innovation:** Integrating AI with portable ultrasound for breast cancer screening represents a cutting-edge approach, enhancing accessibility and accuracy. The development of high-fidelity models and real-time decision support further positions this project at the forefront of technological innovation in healthcare.

## DISCUSSION

AI can analyze breast mass images from low-cost portable ultrasound machines and accurately identify cancer. Research shows that AI correctly identifies 96% to 98% of women with cancer using either portable ultrasound or standard-of-care ultrasound images.

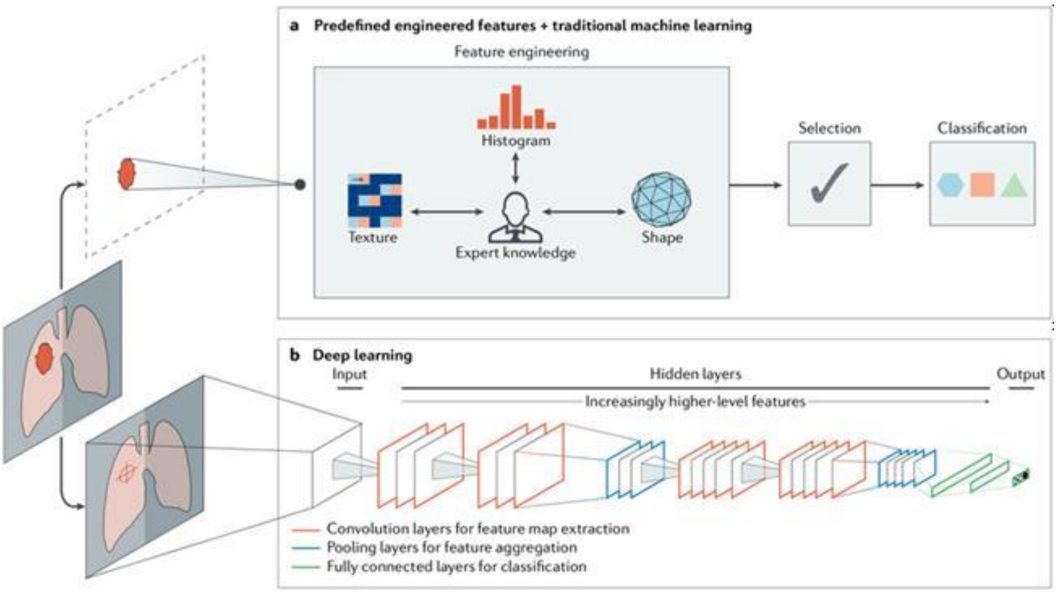


Figure 8 According to the published study on Artificial intelligence incorporates convolutional deep learning algorithms to reach quantitative assessments and recognize complex patterns

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6268174/

In remote and low-resource areas, AI could serve as a valuable tool for identifying breast masses that require urgent attention. Breast lumps are often discovered incidentally during a breast self-exam or a clinical examination by a medical professional.

Breast cancer screening is essential, as it can detect cancers in the breast before a lump is palpable. While cancer screening has been a primary focus in Western countries, rural areas and low to middle income countries frequently lack access to organized screening programs and the necessary technology.

In low resource areas, breast cancer most commonly presents as a palpable lump in the breast. Ultrasound can play a critical role in early detection, leading to more effective and less invasive treatment options, as well as improved patient outcomes.

Unfortunately, women in these regions often face significant barriers to accessing breast healthcare. Many cannot receive the necessary care for several months, even when they detect a lump that may be cancerous.

**Timeline**

Use this portable ultrasound and integrate AI and follow up the patients' findings for two years in phantom labs. These findings show that integrating AI with portable ultrasound for breast cancer screening and early detection holds promise and is more convenient to use. Also make this technology widely available to females in rural and remote areas. Further research and development are needed to enhance the feasibility and effectiveness of using AI assisted point of care ultrasonography for early detection of breast disorders.

## CONCLUSIONS

The integration of portable ultrasound and AI presents a promising opportunity for non-invasive, accessible, and cost-effective screening across a wide range of healthcare environments. This approach is particularly advantageous in underserved or rural areas, where access to traditional healthcare facilities may be limited. In these regions, portable ultrasound devices can be deployed to reach women who might otherwise face significant barriers to screening.

This technology is especially beneficial for women living in rural and remote areas, where healthcare resources are often scarce and disparities in access to medical care are prevalent. By providing a reliable and efficient screening method, portable ultrasound combined with AI can help bridge the gap in breast cancer detection, ensuring that women receive timely and effective care.

Early detection of breast cancer is crucial, as it has the potential to save lives and dramatically improve patient outcomes. When cancer is identified at an early stage, treatment options are generally more effective and less invasive, which can lead to higher survival rates and a better quality of life for patients. Furthermore, early detection can significantly reduce treatment costs, as managing cancer in its initial stages typically requires fewer resources than addressing advanced disease.

In summary, the combination of portable ultrasound and AI not only enhances access to essential healthcare services but also plays a critical role in improving public health outcomes. By making early breast cancer screening more widely available, this innovative approach has the potential to transform the landscape of women's health, particularly in regions that need it the most.

## ACKNOWLEDGMENT

I would like to express my gratitude to everyone who contributed to this manuscript and to all those who supported us on this project. Special thanks to all my team members and collaborators at Validus Institute Inc. Special thanks to all the team members and collaborators at Portland State University and mainly Dr. Faryar Etesami for all his kind support and guidance. Thank you all for your support.

# REFERENCES

1. Tabár, L. et al. Swedish two-county trial: impact of mammographic screening on breast cancer mortality during 3 decades. Radiology 260, 658–663 (2011).
2. Lehman, C. D. et al. National performance benchmarks for modern screening digital mammography: update from the Breast Cancer Surveillance Consortium. Radiology 283, 49–58 (2017).
3. Bray, F. et al. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J. Clin. 68, 394–424 (2018).
4. The Canadian Task Force on Preventive Health Care. Recommendations on screening for breast cancer in average-risk women aged 40–74 years. CMAJ 183, 1991–2001 (2011).
5. Marmot, M. G. et al. The benefits and harms of breast cancer screening: an independent review. Br. J. Cancer 108, 2205–2240 (2013).
6. Lee, C. H. et al. Breast cancer screening with imaging: recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of clinically occult breast cancer. J. Am. Coll. Radiol.
7. 18–27 (2010). 7. Oefringer, K. C. et al. Breast cancer screening for women at average risk: 2015 guideline update from the American Cancer Society. J. Am. Med. Assoc. 314, 1599–1614 (2015).
8. Siu, A. L. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. Ann. Intern. Med. 164, 279–296 (2016).
9. Center for Devices & Radiological Health. MQSA National Statistics (US Food and Drug Administration, 2019; accessed 16 July 2019); http://www.fda.gov/radiation-emitting-products/mqsa-insights/mqsanational-statistics.
10. Cancer Research UK. Breast Screening (CRUK, 2017; accessed 26 July 2019); https://www.cancerresearchuk.org/about-cancer/breastcancer/screening/breast-screening.
11. Elmore, J. G. et al. Variability in interpretive performance at screening mammography and radiologists' characteristics associated with accuracy. Radiology 253, 641–651 (2009).
12. Lehman, C. D. et al. Diagnostic accuracy of digital screening mammography with and without computer-aided detection. JAMA Intern. Med. 175, 1828–1837 (2015).
13. Tosteson, A. N. A. et al. Consequences of false-positive screening mammograms. JAMA Intern. Med. 174, 954–961 (2014).
14. Houssami, N. & Hunter, K. The epidemiology, radiology and biological characteristics of interval breast cancers in population mammography screening. NPJ Breast Cancer 3, 12 (2017).
15. Gulshan, V. et al. Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. J. Am. Med. Assoc. 316, 2402–2410 (2016).
16. Esteva, A. et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature 542, 115–118 (2017).
17. De Fauw, J. et al. Clinically applicable deep learning for diagnosis and referral in retinal disease. Nat. Med. 24, 1342–1350 (2018).
18. Ardila, D. et al. End-to-end lung cancer screening with three-dimensional deep learning on low-dose chest computed tomography. Nat. Med. 25, 954–961 (2019).
19. Topol, E. J. High-performance medicine: the convergence of human and artificial intelligence. Nat. Med. 25, 44–56 (2019).
20. Moran, S. & Warren-Forward, H. The Australian Breast Screen workforce: a snapshot. Radiographer 59, 26–30 (2012).
21. Wing, P. & Langelier, M. H. Workforce shortages in breast imaging: impact on mammography utilization. AJR Am. J. Roentgenol. 192, 370–378 (2009).
22. Rimmer, A. Radiologist shortage leaves patient care at risk, warns royal college. BMJ 359, j4683 (2017).
23. Nakajima, Y., Yamada, K., Imamura, K. & Kobayashi, K. Radiologist supply and workload: international comparison. Radiat. Med. 26, 455–465 (2008).
24. Rao, V. M. et al. How widely is computer-aided detection used in screening and diagnostic mammography? J. Am. Coll. Radiol. 7, 802–805 (2010).

25. Gilbert, F. J. et al. Single reading with computer-aided detection for screening mammography. N. Engl. J. Med. 359, 1675–1684 (2008).
26. Giger, M. L., Chan, H.-P. & Boone, J. Anniversary paper: history and status of CAD and quantitative image analysis: the role of Medical Physics and AAPM. Med. Phys. 35, 5799–5820 (2008).
27. Fenton, J. J. et al. Influence of computer-aided detection on performance of screening mammography. N. Engl. J. Med. 356, 1399–1409 (2007).
28. Kohli, A. & Jha, S. Why CAD failed in mammography. J. Am. Coll. Radiol. 15, 535– 537 (2018).
29. Rodriguez-Ruiz, A. et al. Stand-alone artificial intelligence for breast cancer detection in mammography: comparison with 101 radiologists. J. Natl. Cancer Inst. 111, 916–922 (2019).
30. Wu, N. et al. Deep neural networks improve radiologists' performance in breast cancer screening. IEEE Trans. Med. Imaging https://doi.org/10.1109/TMI.2019.2945514 (2019).
31. Zech, J. R. et al. Variable generalization performance of a deep learning model to detect pneumonia in chest radiographs: a cross-sectional study. PLoS Med. 15, e1002683 (2018).
32. Becker, A. S. et al. Deep learning in mammography: diagnostic accuracy of a multipurpose image analysis software in the detection of breast cancer. Invest. Radiol. 52, 434–440 (2017).
33. Ribli, D., Horváth, A., Unger, Z., Pollner, P. & Csabai, I. Detecting and classifying lesions in mammograms with deep learning. Sci. Rep. 8, 4165 (2018).
34. McKinney, S.M., Sieniek, M., Godbole, V. et al. international evaluation of an AI system for breast cancer screening. Nature 577, 89–94 (2020). https://doi.org/10.1038/s41586-019-1799-6.
35. Lutz, Stephen, Edward Chow, and Peter Hoskin. "Radiation Oncology in Palliative Cancer Care." https://onlinelibrary.wiley.com/doi/epdf/10.1002/9781118607152.fmatter
36. Silva, Helbert Eustáquio Cardoso da, Glaucia Nize Martins Santos, André Ferreira Leite, Carla Ruffeil Moreira Mesquita, Paulo Tadeu de Souza Figueiredo, Cristine Miron Stefani, and Nilce Santos de Melo. "The use of artificial intelligence tools in cancer detection compared to the traditional diagnostic imaging methods: An overview of the systematic reviews." Plos one 18, no. 10 (2023): e0292063.
37. Hosny, Ahmed, Chintan Parmar, John Quackenbush, Lawrence H. Schwartz, and Hugo JWL Aerts. "Artificial intelligence in radiology." Nature Reviews Cancer 18, no. 8 (2018): 500-510.
38. Unveiling the Future: Convergence of Engineering, Medicine, and Technology in Biomedical and Biotechnology, Hadi Khazaei, Danesh Khazaei, Faryar Etesami(Emeritus Professor, Department of Mechanical Engineering/Portland State University).
39. Lipor, John, et al. "Eye biometry prediction from ultrasound images using convolutional neural networks." Open J Clin Med Images 3.2 (2023): 1142.