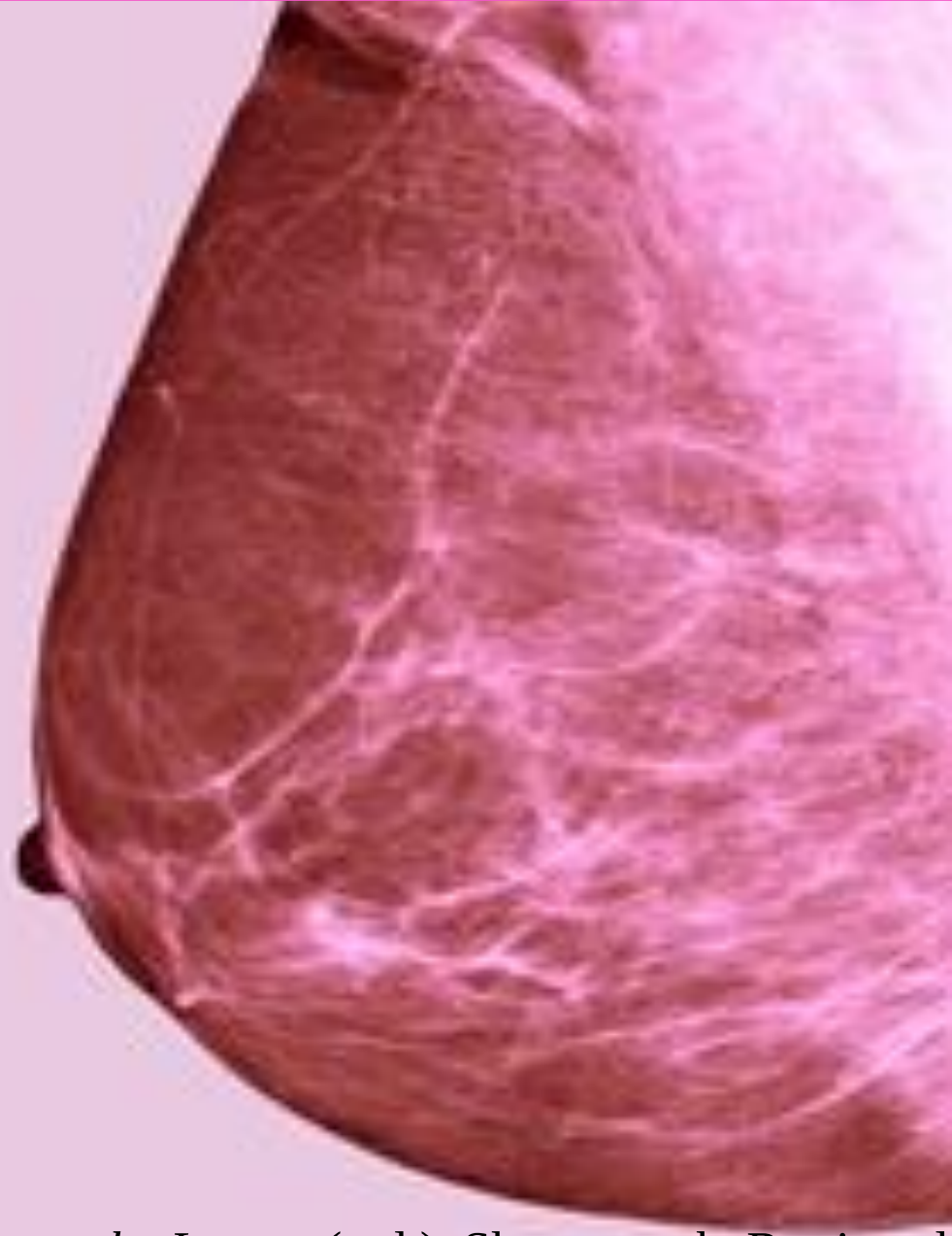
C30 Artificial Intelligence and Human Vision
Differences In Diagnosing Breast Cancer



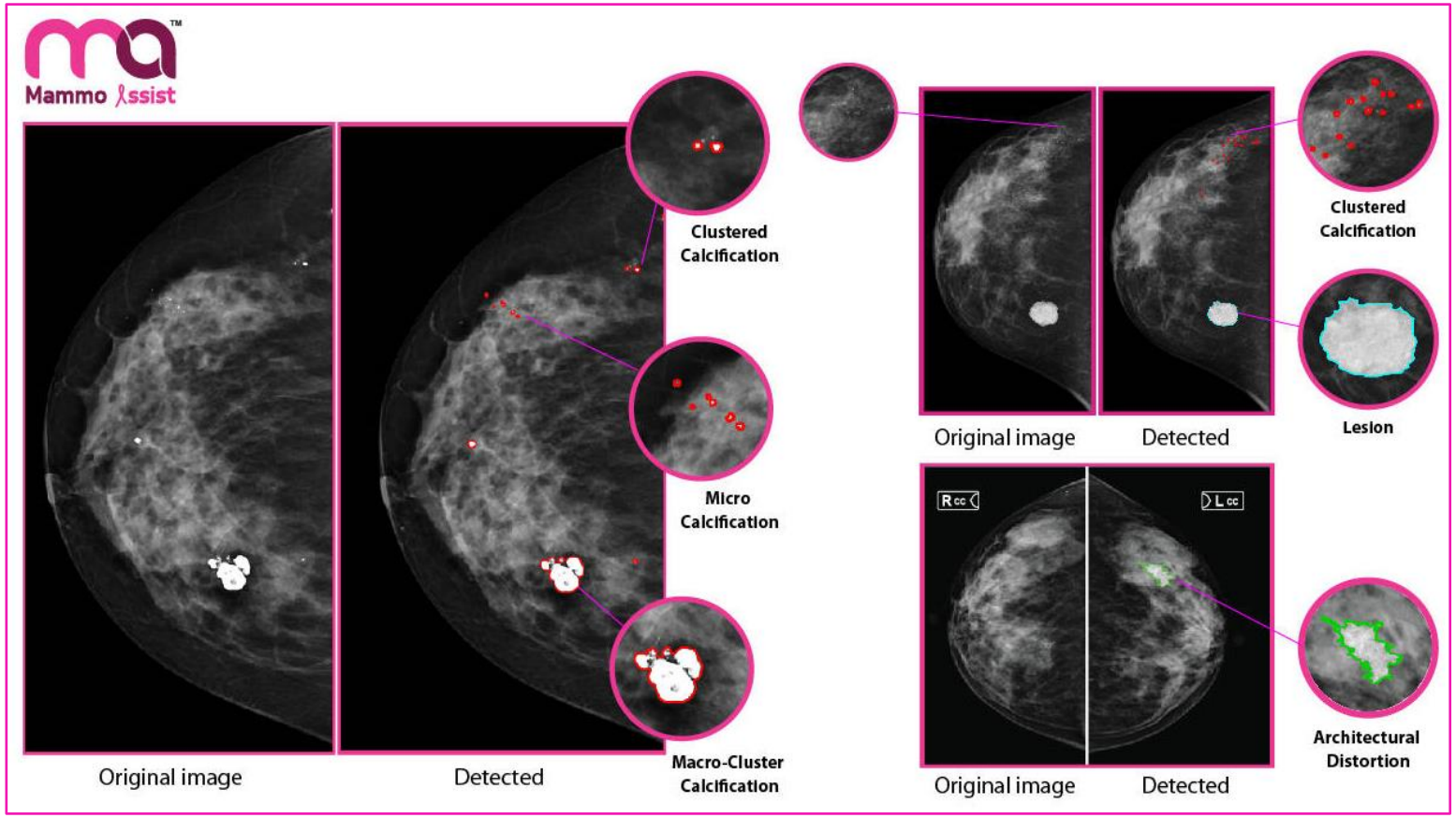
Mammography Image. (n.d.). Shutterstock. Retrieved from https://www.shutterstock.com/image-photo/breast-cancer-screening-xray-offset-1895444080

Objectives

- Define Artificial Intelligence (AI)
- Describe current breast cancer diagnostic practices
- Outline the role of AI in diagnosing breast cancer
- List the advantages and disadvantages of using AI
- Compare traditional methods and AI in diagnosing breast cancer

Thesis

The use of AI alongside mammography in detecting breast cancer can help diagnose and predict malignancies earlier, leading to better outcomes.



Detection of breast cancer with AI . (2018). ET Health World. Retrieved from https://health.economictimes.indiatimes.com/news/diagnostics/telerad-tech-launches-ai-product-to-detect-early-stage-breast-cancer/66441819

Abbreviations

- AI: Artificial Intelligence
- BCSC: Breast Cancer Surveillance Consortium
- CAD: Computer-Aided Detection
- DBT: Digital Breast Tomosynthesis
- DCIS: Ductal Carcinoma in Situ
- DM: Diagnostic Mammography
- IBC: Inflammatory Breast Cancer
- IDC: Invasive Ductal Carcinoma
- ILC: Invasive Lobular Cancer
- LCIS: Lobular Carcinoma in Situ
- MBC: Metastatic Breast Cancer
- TNBC: Triple Negative Breast Cancer

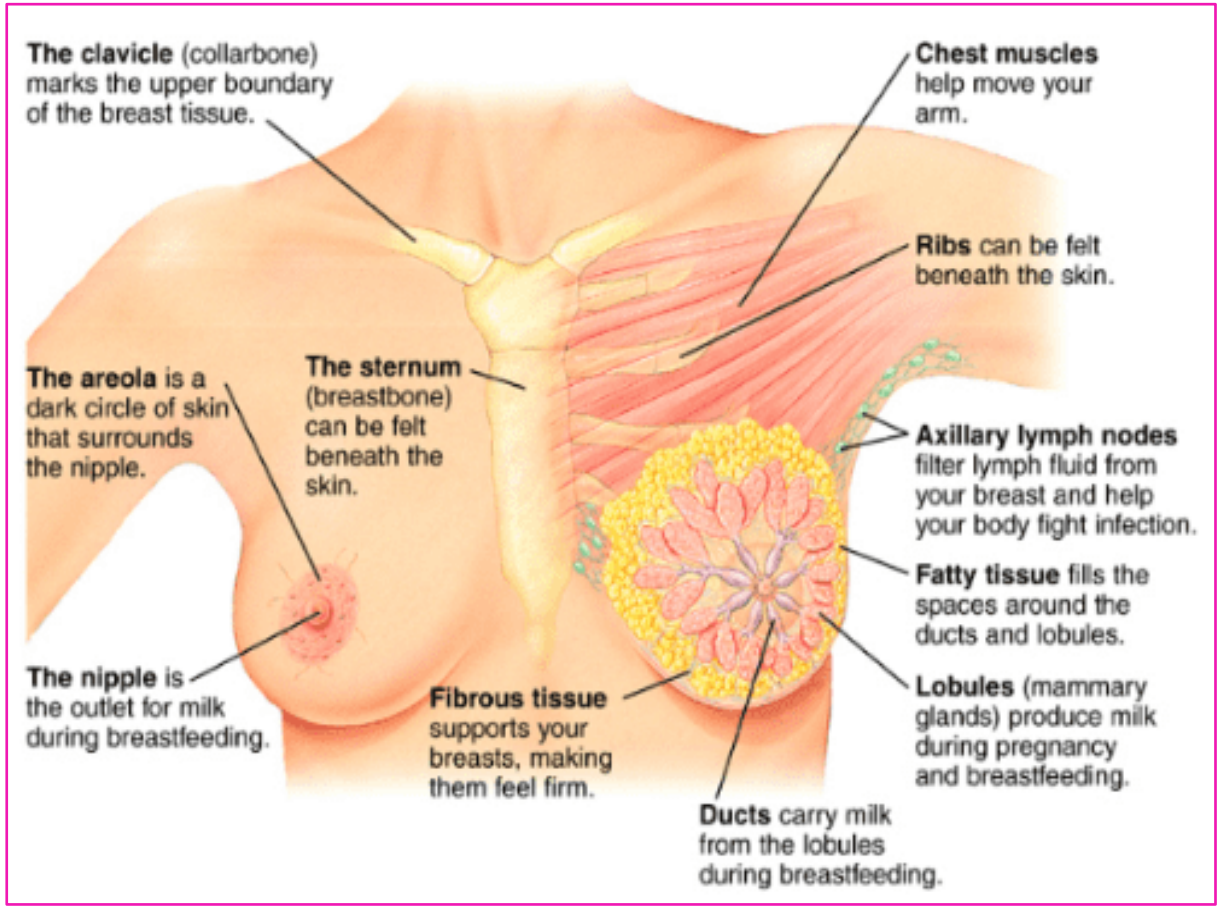
Definitions

- CAD: "mathematical models that can determine whether an imaging feature associated with a disease is present" (Bahl, 2019, pg. 1)
- Convolutional Neural Network: an artificial network used for image recognition and image processing because of its capacity to recognize image patterns (Rodriguez-Ruiz, 2019, pg.917)
- DBT: 3D images formed by 2D images with different tube angles (Fuchsjager & Adelsmayr, 2022, pg. 543)
- Interval Cancers: Cancers that are reported as normal within one year at annual screenings (Bahl, 2019, pg. 1)

Breast Anatomy

- Adipose tissue is a collection of fat cells that extends from the collarbone to the underarm and across the mid-area of the rib cage
- A female's breast contains lobes, lobules, and milk ducts
  - About 12-20 lobes
  - Lobes are made up of smaller parts called lobules
  - Milk ducts connect lobes and lobules
  - The above three structures are where the cancer usually starts to develop in the breast

(National Breast Cancer Foundation, 2023, Breast Anatomy Section, para. 3)



Breast Anatomy. (n.d.). Platinum Women's Health. Retrieved from https://www.platinumwomenshealth.com/contents/breast-anatomy

Breast Cancer Overview

- Cancer is a group of abnormal malignant cells growing in the breast tissue that can metastasize throughout the body
- Breast cancer often presents in the breast tissue as a lump, growth, or mass
- Breast cancer occurs more frequently in women
  - Affects about 297,790 women & 2,800 men (National Breast Cancer Foundation, 2023)
  - "1 in 8 women in the United States will be diagnosed with cancer in their lifetime" (National Breast Cancer Foundation, 2023)
  - Advancements in technology and screening have helped with early detection, further causing an increase in survival rates

(National Breast Cancer Foundation, 2023, What Is Cancer Section, para. 1)

Pink Breast Cancer Ribbon. (2014). Vector Shock. Retrieved from https://www.vectorstock.com/royalty-free-vector/breast-cancer-awareness-pink-ribbon-vector-2482668

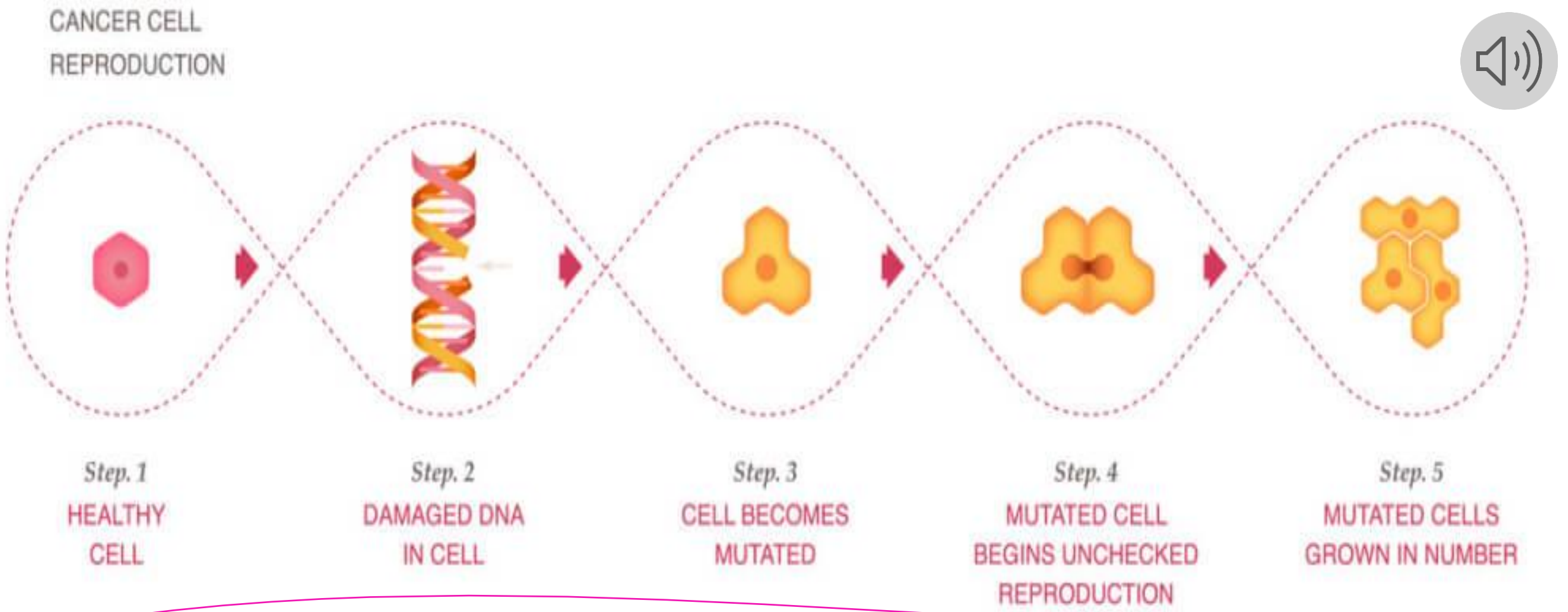
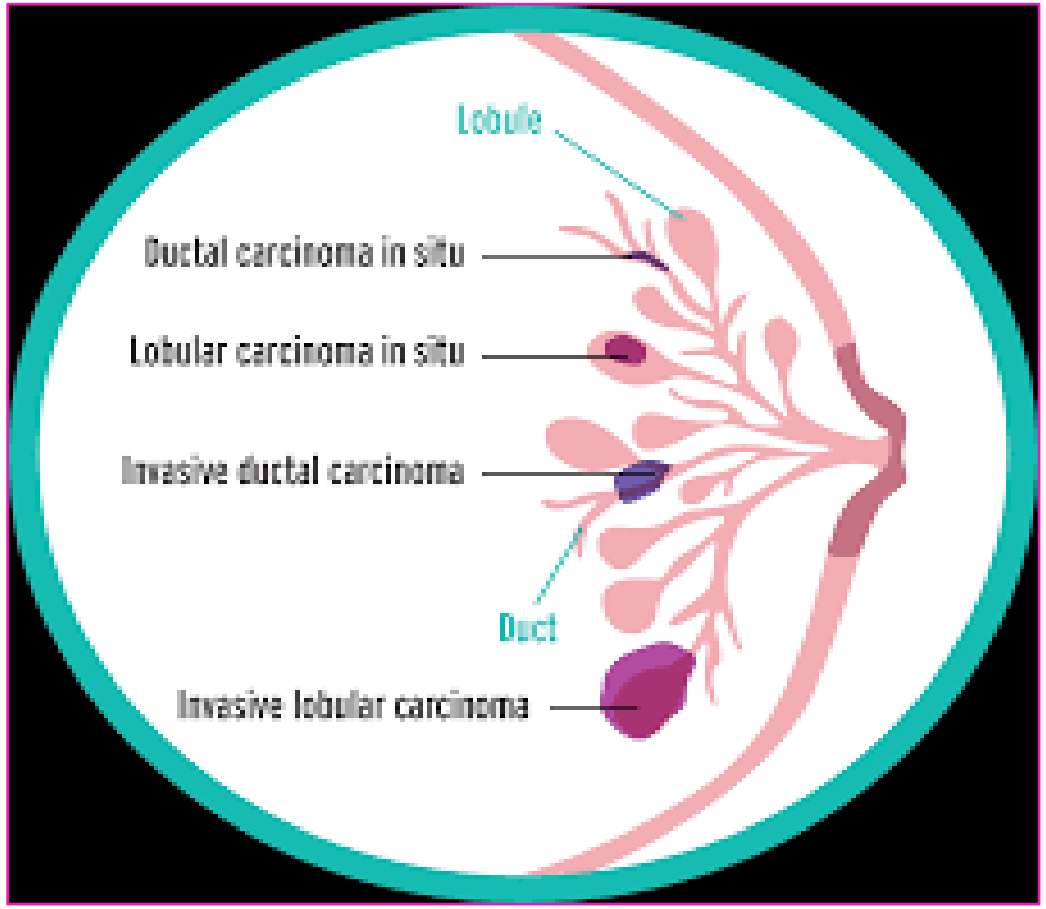


Figure 4a. (2023b). National Breast Cancer Foundation. Retrieved from https://www.nationalbreastcancer.org/what-is-cancer/

Common Types of Breast Cancer

- Ductal Carcinoma in Situ (DCIS)
- Invasive Ductal Carcinoma (IDC)
- Lobular Carcinoma in Situ (LCIS)
- Invasive Lobular Cancer (ILC)
- Triple Negative Breast Cancer (TNBC)
- Inflammatory Breast Cancer (IBC)
- Metastatic Breast Cancer (MBC)

(National Breast Cancer Foundation, 2023, Types of Breast Cancer Section)



Types of Breast Cancer. (2023). beBRCAware. Retrieved from https://www.bebrcaware.com/breast-cancer-the-brca-link/what-is-breast-cancer.html

Breast Cancer Risk Factors

Genetic:	Environmental:
• Gender • Age • Race • Family history • Personal health history • Menstruation/reproductive history • Gene mutations (BRCA1/BRCA2) • Dense breast tissue	• Poor diet • Physical inactivity • Being overweight/obese • Alcohol consumption • Radiation to chest • Hormone replacement therapy

(National Breast Cancer Foundation, 2023, Risk Factors Section, para. 3-4)

Stages & Symptoms of Breast Cancer

The CDC states that symptoms include:

- New lump(s) in the breast or underarm
- Thickening or swelling of part of the breast
- Irritation or dimpling of breast skin
- Redness or flaky skin on the nipple or the breast
- Pulling in of the nipple or pain in the nipple area
- Nipple discharge other than breast milk, including blood
- Any change in the size or the shape of the breast
- Pain in any area of the breast

(CDC, 2023, Symptom Section, para. 1)

Breast cancer is evaluated by:

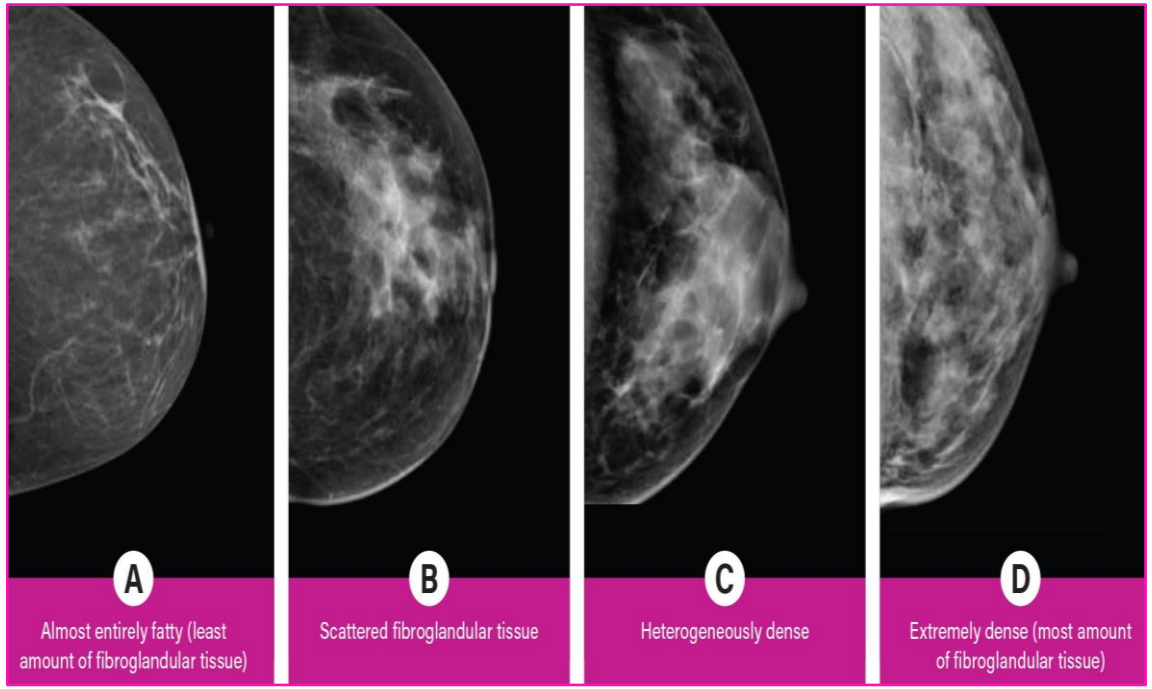
- Stages 0, I, II, III, IV
  - Graded by the spread of the cancer
- TNM is another system used to determine the stage of the cancer
  - T = Tumor
  - N = Number of Lymph Nodes
  - M = Metastasis

(National Cancer Institution, 2022, Stages of Breast Cancer Section, para. 1)

Diagnosing Breast Cancer

- The screening process for breast cancer is the same for most women; however, this is a problem because no woman, or breast, is identical
- Combining mammography with AI improves risk assessment for the future prediction of breast cancer
- Several risk models are being used to assess for breast cancer and associated future risks

(Lauritzen, 2023, pg. 2)



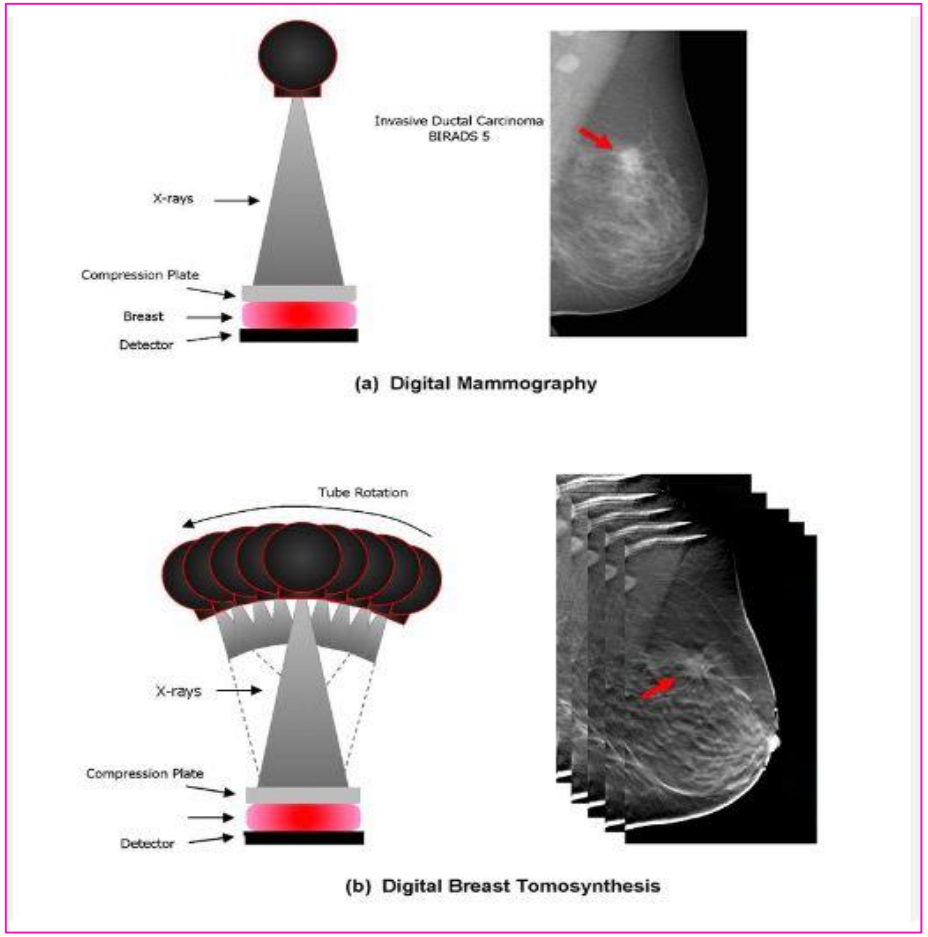
Categories of breast density. (2020). Imaging Technology News. Retrieved from https://www.itnonline.com/article/breast-density-explained

Current Risk Models Used

- Gail and Tyrer-Cuzick model uses breast cancer factors to screen high-risk patients
- The Breast and Ovarian Analysis of Disease Incidence and Carrier Estimation Algorithm is used to predict variations in breast cancer genes
- Mammography-based models
- BSCS model is used to predict a patient's 5-year risk factor of developing breast cancer
- AI models that are being tested use algorithms to predict and detect breast cancer

(Lauritzen, 2023, pg. 2)

Human Eye Detection of Breast Cancer

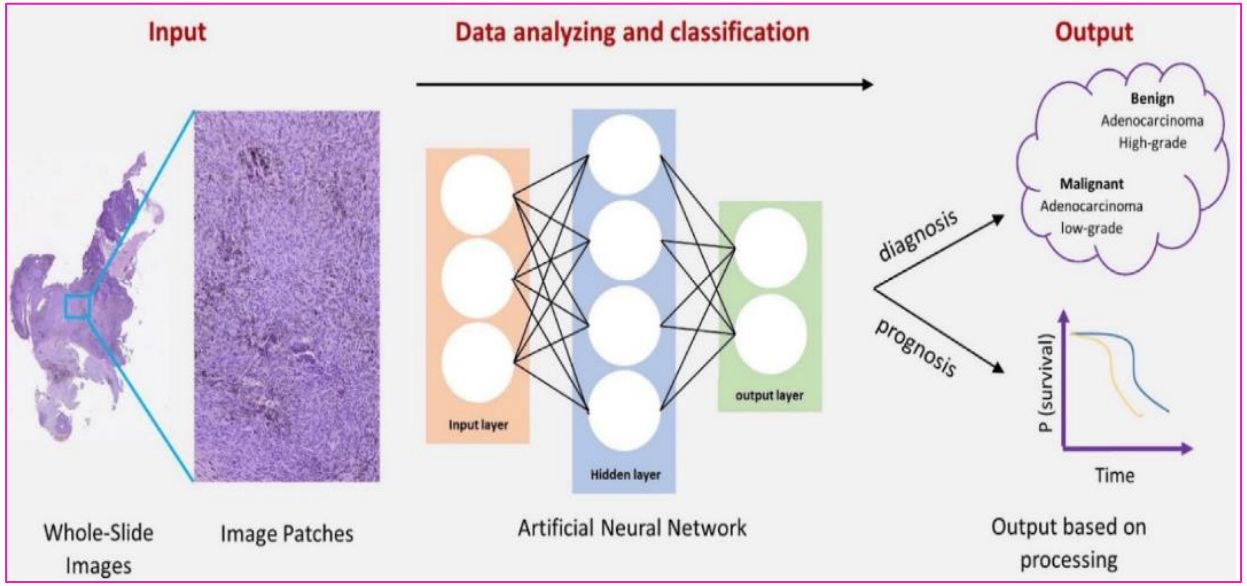


- Radiologists evaluate DM images looking for lesions in breast tissue
  - Limited to screening lower density breast tissue
  - Superimposition of dense breast tissue increases the difficulty of detecting breast cancer (Fuchsjager & Adelsmayr, 2022, pg. 543)
- DBT is used for a more accurate diagnosis for women with dense breast tissue, but takes more time to read
  - Longer reading times can lead to fatigue which can cause missed lesions when reviewing an image (Philpotts, 2022, pg. 78)
- Breast cancer can be missed due to the misinterpretation of dense breast tissue (Bahl, 2019, pg. 1)

Figure 1. (2008). ResearchGate. Retrieved from https://www.researchgate.net/figure/maging-geometry-and-lesion-conspicuity-with-a-DM-and-b-DBT_fig1_252425925

AI Overview

- AI uses an algorithm called deep learning where the system is provided with data, and then uses it to further uncover details or combinations of details that are used in classifying that data
- The algorithm is developed only by the data provided
  - No other information is entered or added to the system (Bahl, 2019, pg.1)
- "The many layers in deep learning algorithms are used to detect simple features (ex. lines and edges) and complex features (ex. shapes)" (Bahl, 2019, pg.1)
- AI uses this data to train its neural networks and advance its knowledge and capabilities



A diagram of the deep learning process. (2022). MDPI. Retrieved from https://www.mdpi.com/2072-6694/14/21/5264

Figure 2. (2023b). RSNA. Retrieved from https://pubs.rsna.org/doi/10.1148/radiol.222733

Types of AI Systems Used for Breast Cancer Readings

- Mirai
- Globally-Aware Multiple Instance Classifier
- MammoScreen
- ProFound AI
- Mia
- Transpara

(Arasu, 2023, pg. 5)

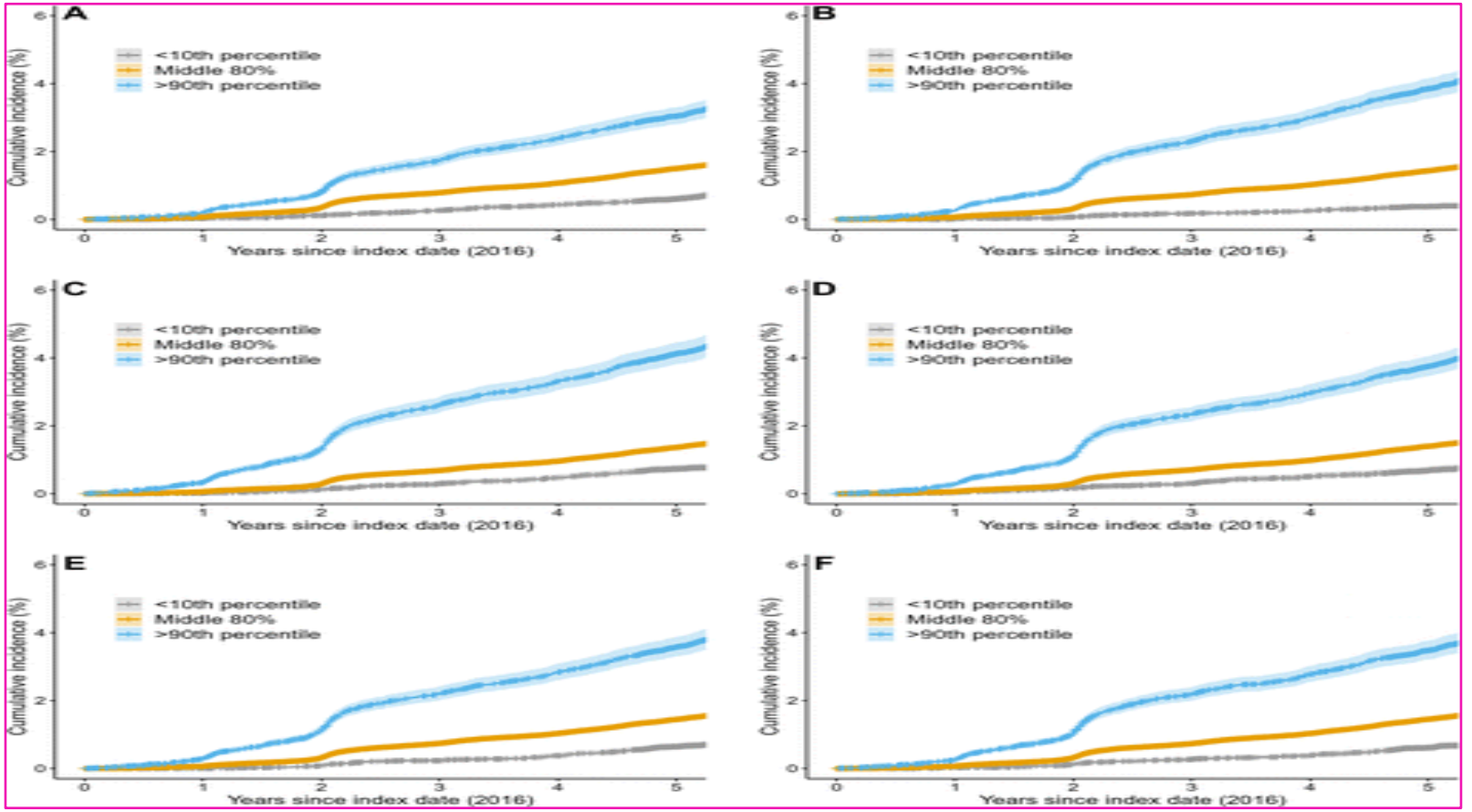


Figure 2: Cumulative risk of breast cancer by risk model type at 5 years. Kaplan-Meier curves for (**A**) the clinical Breast Cancer Surveillance Consortium (BCSC) risk model and for the mammography-trained artificial intelligence (AI) risk models, (**B**) Mirai, (**C**) MammoScreen, (**D**) ProFound, (**E**) Mia, and (**F**) Globally-Aware Multiple Instance Classifier (Arasu, 2023, pg. 5)

Current AI Detection of Breast Cancer

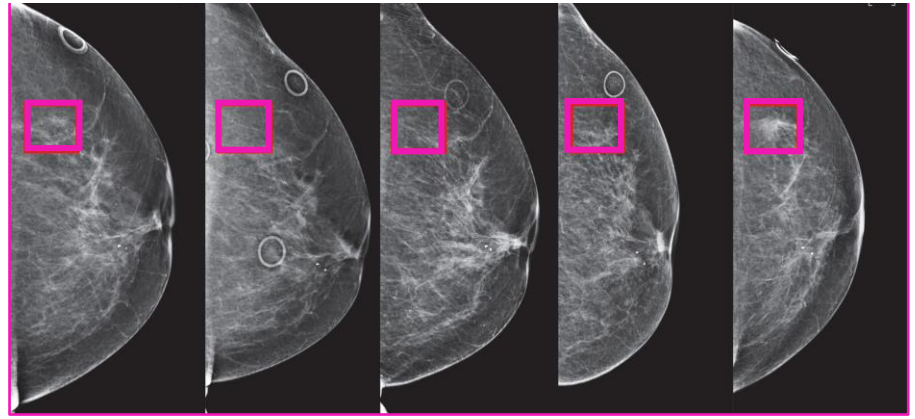
- "The system uses deep learning convolutional neural networks, feature classifiers, and image analysis algorithms to detect calcifications and soft tissue lesions..." (Rodriguez-Ruiz, 2019, pg. 917)
- AI reviews images and gives a score of 1-10 based on any suspicion of cancer
    - Images with a high score are flagged by AI and reviewed by Radiologists
- Accuracy of AI is determined by comparing its results with Radiologists' readings (Rodriguez-Ruiz, 2019, pg. 917)
- AI is currently used to aid Radiologists in reading digital mammography and DBT images
    - Meaning a dual-read system instead of a stand-alone system
- It is used to complement the Radiologists' role instead of overtaking it

Advantages of AI

- AI vision has a quicker processing speed and object recognition than human vision (Mehta, 2023, pg. 1)
- Lacks the ability of getting fatigued
- Some current imaging systems have difficulty differentiating "between benign calcifications and those seen in" DCIS (Bahl, 2019, pg. 1)
    - After data exposure, AI learns how to identify image features and combinations of image features that can be associated with and/or predictive of DCIS (Bahl, 2019, pg. 1)
- AI reduces Radiologists' workload by about 70% for DM and DBT (Philpotts, 2022, pg. 1)
    - Also found a large decrease in flagged images per examination (Philpotts, 2022, pg. 2)

Current Concerns With Using AI

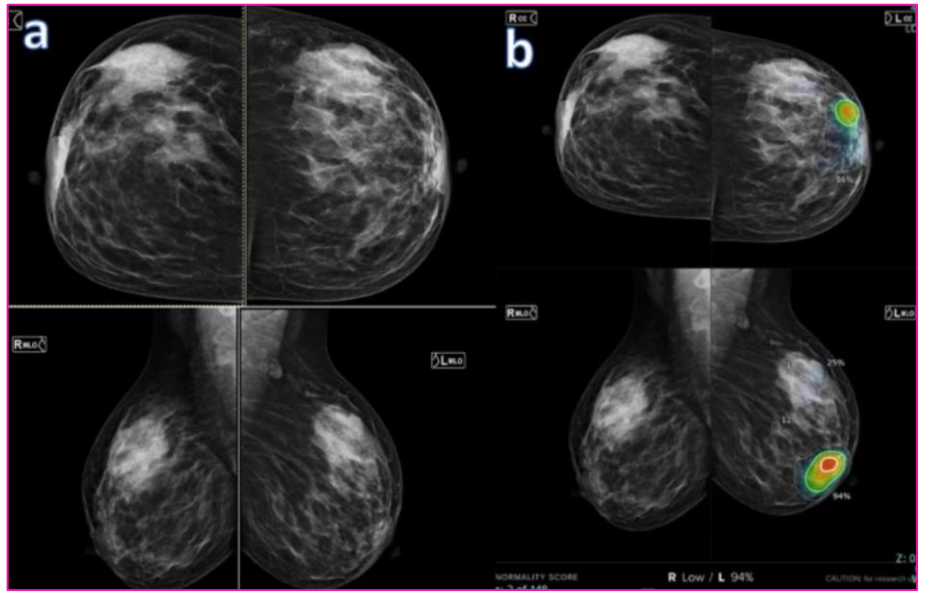
- We must expect errors in image interpretation because AI is far from perfect, which could lead to possible legal issues
- AI uses large quantities of patient data, leaving the need for data protection
    - Anonymization and preventing unwarranted third-party access
- Radiologists could develop an "automation bias" if they learn to depend too heavily on the AI's breast imaging interpretations (Philpotts, 2022, pg. 1)
- There is documentation of AI missing cancer cases that were after detected by the Radiologists (Philpotts, 2022, pg. 2)
- AI has difficulties with more dense breast tissue, meaning AI is more effective at non-dense cases
- If AI removes all suspicion free, non-dense cases for Radiologists, they could quickly become fatigued, as less-dense cases offer the Radiologists a bit of relief (Philpotts, 2022, pg. 2)



AI Screening for Breast Cancer. (2021). Wired. Retrieved from https://www.wired.com/story/doctors-using-ai-screen-breast-cancer/

A Peak Into the Future of AI and Breast Imaging

- Potential for AI to be used as an independent first or second reader in breast cancer screenings (Bahl, 2019, pg. 2)
    - This would substantially reduce Radiologist workload if further review of AI results was no longer needed
- AI has the possibility of eventually replacing the need for Radiologists in interpreting DM breast images (Fuchsjager & Adelsmayr, 2022, pg. 2)
    - Radiologists' help will still be needed to resolve discrepancies in AI-based findings, as well as providing patient consultations (Fuchsjager & Adelsmayr, 2022, pg. 2)

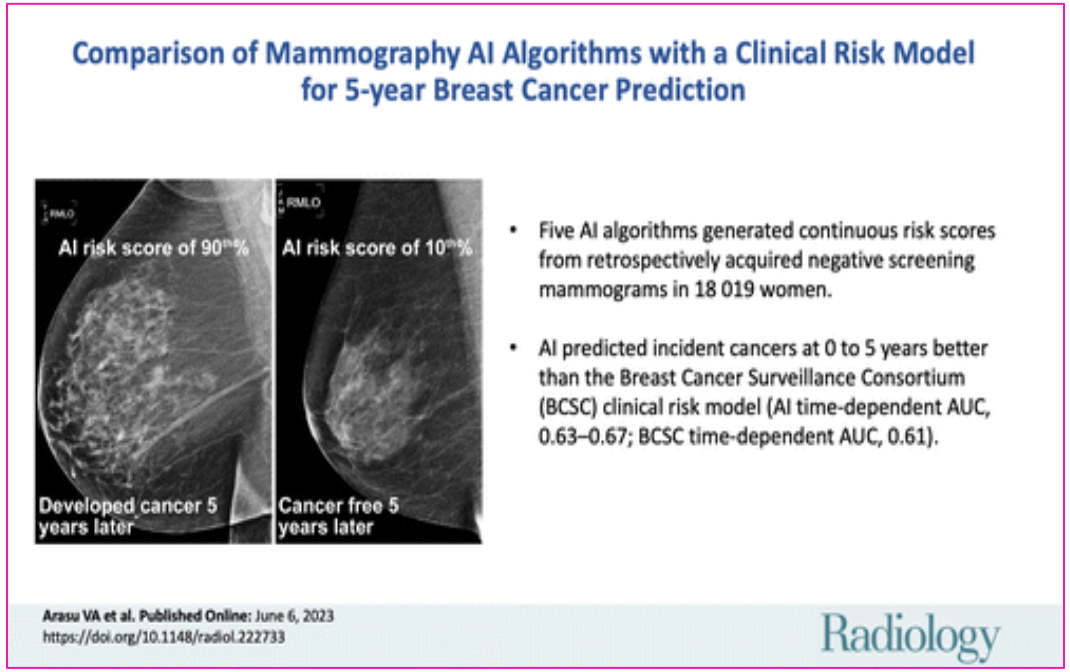


Digital mammography vs AI in detecting a suspicious mass in the breast. (2023). Springer Open. Retrieved from https://ejrnm.springeropen.com/articles/10.1186/s43055-023-01129-3

Conclusion

- Using AI along with mammography texture models improves the detection of interval and long-term cancers, as well as the prediction of women at high-risk (Lauritzen, 2023, pg. 2)
- AI systems perform better than BCSC systems for predicting breast cancer risk over a 5-year period (Arasu, 2023, pg. 2)

- <u>Our thoughts:</u>
  - AI systems used along with Radiologists' interpretations help detect and predict future breast cancer
  - AI systems lessen Radiologists' workload and are more time efficient
  - AI systems, along with Radiologist interpretation, will reduce the number of callbacks because it is more precise and accurate compared to other screening methods alone



Comparison of AI Algorithms with a Clinical Risk Model for 5-year Breast Cancer Prediction. (2023). RSNA. Retrieved from https://pubs.rsna.org/doi/10.1148/radiol.222733

Article References

- Arasu, V. A., Habel, L. A., Achacoso, N. S., Buist, D. S., Cord, J. B., Esserman, L. J., Hylton, N. M., Glymour, M. M., Kornak, J., Kushi, L. H., Lewis, D. A., Liu, V. X., Lydon, C. M., Miglioretti, D. L., Navarro, D. A., Pu, A., Shen, L., Sieh, W., Yoon, H.-C., & Lee, C. (2023). Comparison of mammography AI algorithms with a clinical risk model for 5-year breast cancer risk prediction: An observational study. *Radiology*, *307*(5). https://doi.org/10.1148/radiol.222733
- Bahl, M. (2018). Detecting Breast Cancers with Mammography: Will AI Succeed Where Traditional CAD Failed? *Radiology.* 290 (2), 1-2. https://doi.org/10.1148/radiol.2018182404
- Centers for Disease Control and Prevention. (2023, July 25). *Breast cancer*. Centers for Disease Control and Prevention. https://www.cdc.gov/cancer/breast/index.htm
- Fuchsjäger, M. H., & Adelsmayr, G. (2022). Artificial Intelligence as an assistant in breast cancer screening. *Radiology*, *302*(3), 543–544. https://doi.org/10.1148/radiol.212675
- Lauritzen, A. D., von Euler-Chelpin, M. C., Lynge, E., Vejborg, I., Nielsen, M., Karssemeijer, N., & Lillholm, M. (2023). Assessing breast cancer risk by combining AI for lesion detection and mammographic texture. *Radiology*, *308*(2). https://doi.org/10.1148/radiol.230227
- Mehta, T. S. (2023). Leveraging differences in AI and human “Vision” to improve breast cancer detection. *Radiology*, *309*(1), 1–3. https://doi.org/10.1148/radiol.232520
- National Breast Cancer Foundation. (2023). *What is cancer?* https://www.nationalbreastcancer.org/what-is-cancer/
- Philpotts, L. E. (2022). Advancing artificial intelligence to meet breast imaging needs. *Radiology*, *303*(1), 78–79. https://doi.org/10.1148/radiol.213101
- Rodriguez-Ruiz, A., Lång, K., Gubern-Merida, A., Broeders, M., Gennaro, G., Clauser, P., Helbich, T. H., Chevalier, M., Tan, T., Mertelmeier, T., Wallis, M. G., Andersson, I., Zackrisson, S., Mann, R. M., & Sechopoulos, I. (2019). Stand-alone artificial intelligence for breast cancer detection in mammography: Comparison with 101 radiologists. *JNCI: Journal of the National Cancer Institute*, *111*(9), 916–922. https://doi.org/10.1093/jnci/djy222

Image References

- *A diagram of the deep learning process.* (2022). MDPI. Retrieved from https://www.mdpi.com/2072-6694/14/21/5264
- *AI Screening for Breast Cancer*. (2021). Wired. Retrieved from https://www.wired.com/story/doctors-using-ai-screen-breast-cancer/
- *Breast Anatomy*. (n.d.). Platinum Women's Health. Retrieved from https://www.platinumwomenshealth.com/contents/breast-anatomy
- *Categories of breast density*. (2020). Imaging Technology News. Retrieved from https://www.itnonline.com/article/breast-density-explained
- *Comparison of AI Algorithms with a Clinical Risk Model for 5-year Breast Cancer Prediction*. (2023). RSNA. Retrieved from https://pubs.rsna.org/doi/10.1148/radiol.222733
- *Detection of breast cancer with AI* . (2018). ET Health World. Retrieved from https://health.economictimes.indiatimes.com/news/diagnostics/telerad-tech-launches-ai-product-to-detect-early-stage-breast-cancer/66441819
- *Digital mammography vs AI in detecting a suspicious mass in the breast.* (2023). Springer Open. Retrieved from https://ejrnm.springeropen.com/articles/10.1186/s43055-023-01129-3
- *Figure 1*. (2008). ResearchGate. Retrieved from https://www.researchgate.net/figure/maging-geometry-and-lesion-conspicuity-with-a-DM-and-b-DBT_fig1_252425925
- *Figure 2*. (2023b). RSNA. Retrieved from https://pubs.rsna.org/doi/10.1148/radiol.222733
- *Figure 4a*. (2023b). National Breast Cancer Foundation. Retrieved from https://www.nationalbreastcancer.org/what-is-cancer/
- *Mammography Image*. (n.d.). Shutterstock. Retrieved from https://www.shutterstock.com/image-photo/breast-cancer-screening-xray-offset-1895444080
- *Pink Breast Cancer Ribbon*. (2014). Vector Shock. Retrieved from https://www.vectorstock.com/royalty-free-vector/breast-cancer-awareness-pink-ribbon-vector-2482668
- *Types of Breast Cancer*. (2023). beBRCAware. Retrieved from https://www.bebrcaware.com/breast-cancer-the-brca-link/what-is-breast-cancer.html