New artificial intelligence method predicts future risk of breast cancer

A new tool has been developed using advanced AI methods to predict a woman's future risk of breast cancer [1].

To develop the model, researchers used almost 90,000 screening mammograms from about 40,000 women to train, validate and test the new breast cancer risk-assessment model.

It was found that the model performs equally well across diverse races, ages and family histories.

Researchers from two major institutions have developed a new tool with advanced artificial intelligence (AI) methods to predict a woman's future risk of breast cancer. The reslts of their work have recently been published [1].

Identifying women at risk for breast cancer is a critical component of effective early disease detection. However, available models that use factors such as family history and genetics fall far short in predicting an individual woman's likelihood of being diagnosed with the disease.

As Yala *et al* report [1], mammographic breast density, which relates to the amount of fibroglandular tissue in a woman's breast, is a risk factor that has received substantial attention. Mammographic breast density was incorporated into the Gail risk model and the Tyrer-Cuzick models (TC), improving their areas under the receiver operating characteristic curve (AUCs) from 0.55 and 0.57 to 0.59 and 0.61, respectively [2]

The use of breast density as a proxy for the detailed information embedded on the mammogram is limited because breast density assessment is a subjective assessment and varies widely across radiologists, and breast density summarizes the information contained in the digital images into a single value. Same-age patients who are assigned the same density score can have drastically different mammography with vastly different outcomes. Whereas previous studies explored automated methods to assess breast density, these efforts reduced the mammographic input into a few statistics, largely related to volume of glandular tissue, that are not sufficient to distinguish patients who will and will not develop breast cancer.

Yala et al. hypothesized that there are subtle but informative cues contained in mammograms that may not be discernible by humans or simple volume-of-density measurements,

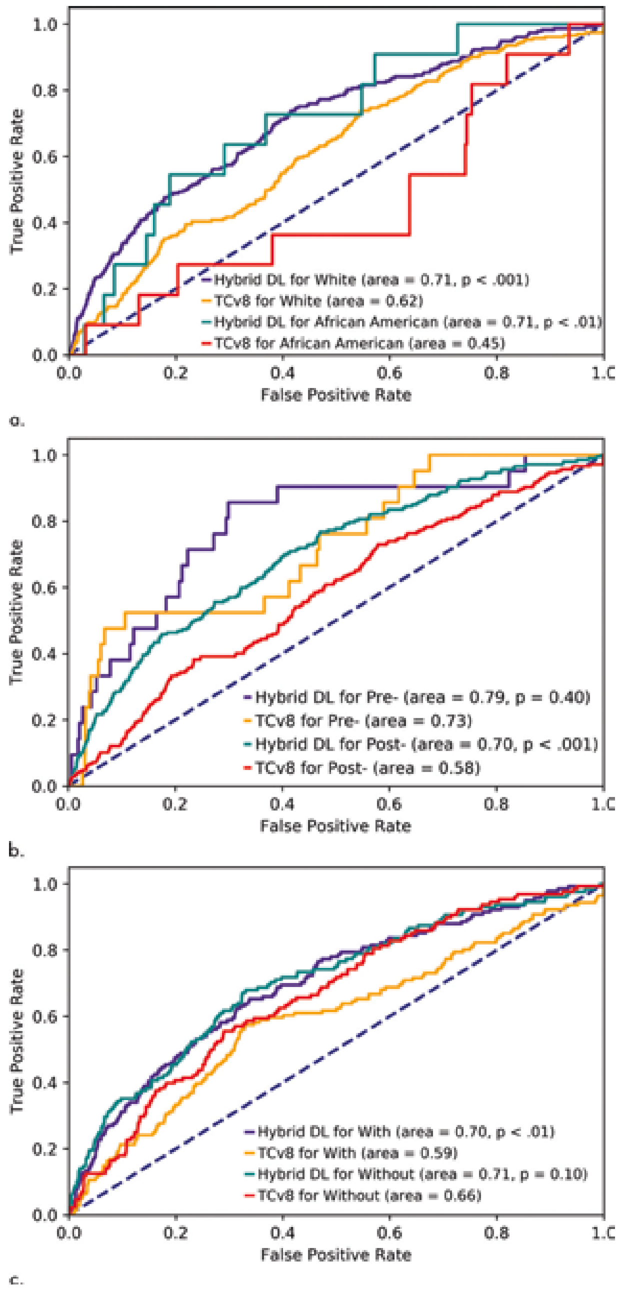

Figure 1. Receiver operating characteristic curve for Tyrer-Cuzick version 8 (TCv8) and hybrid deep learning (DL) for different subgroups of patients: (a) patients who are white and African American, (b) pre- and postmenopausal women, and (c) women with and without any family history of breast or ovarian cancer. All P values are relative to TCv8 for the same subgroup.. Image from [1] , courtesy of Radiological Society of North America.

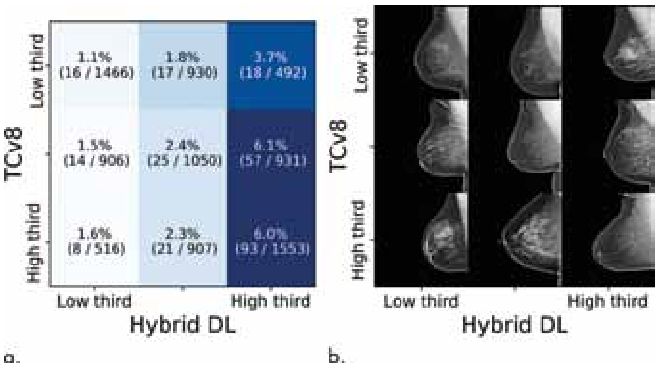

Figure 2: Cancer incidences partitioned by Tyrer-Cuzick risk assessment model (TCv8) and hybrid deep learning (DL) risk assessment. (a) Each tile shows the percent and numerators/denominators of women with examinations within a specific risk range that developed cancer within 5 years. (b) Examples of screenings, sampled randomly from all examinations in that group. Image from [1], courtesy of Radiological Society of North America.

and that deep learning (DL) could leverage these cues to yield improved risk models. Therefore, they developed a DL model that operates over a full-field mammographic image to assess a patient's future breast cancer risk.

"...There's much more information in a mammogram than just the four categories of breast density, By using the deep learning model, we learn subtle cues that are indicative of future cancer....."

- A Yala, MIT

Rather than manually identifying discriminative image patterns, the group relied on their machine learning model to discover these patterns directly from the data. Specifically, their model is provided with full-field mammograms and the outcome of interest, namely whether or not the patient developed breast cancer within 5 years from the date of the examination. In addition to their image-only model, the group developed two other models in the same cohort: a logistic regression model that operates on the basis of traditional risk factors and that provides a strong baseline for our population, and a hybrid model that operates on both the full-field mammogram and traditional risk factors. Yala, in collaboration with Dr. Regina Barzilay an AI expert and professor at MIT, and Dr. Constance Lehman, chief of breast imaging at Massachusetts General Hospital (MGH) in Boston and professor of radiology at Harvard Medical School, then compared all three models to the Tyrer-Cuzick model that includes breast density and is routinely used in clinical practice.

.

"*There's much more information in a mammogram than just the four categories of breast density,*" said study lead author Adam Yala, Ph.D. candidate at the Massachusetts Institute of Technology (MIT) in Cambridge, Mass. "*By using the deep learning model, we learn subtle cues that are indicative of future cancer.*"

The researchers used almost 90,000 full-resolution screening mammograms from about 40,000 women to train, validate and test the deep learning model. They were able to obtain cancer outcomes through linkage to a regional tumor registry.

The found that deep learning models yielded substantially improved risk discrimination over the Tyrer-Cuzick model, the current clinical standard that uses breast density in factoring risk. When comparing the hybrid deep learning model against breast density, the researchers found that patients with non-dense breasts and model-assessed high risk had 3.9 times the cancer incidence of patients with dense breasts and model-assessed low risk. The advantages held across different subgroups of women.

"*Unlike traditional models, our deep learning model performs equally well across diverse races, ages and family histories,*" Dr. Barzilay said. "*Until now, African-American women were at a distinct disadvantage in having accurate risk assessment of future breast cancer. Our AI model has changed that.*"

"*There's a very large amount of information in a full-resolution mammogram that breast cancer risk models have not been able to use until recently,*" Yala added. "*Using deep learning, we can learn to leverage that information directly from the data and create models that are significantly more accurate across diverse populations.*"

AI-assisted breast density measurements are already in use for screening mammograms performed at MGH. The researchers are tracking its performance in the clinic while working on refining the ways to communicate risk information to women and their primary care doctors.

"*A missing element to support more effective, more personalized screening programs has been risk assessment tools that are easy to implement and that work across the full diversity of women whom we serve,*" Dr. Lehman said. "*We are thrilled with our results and eager to work closely with our health care systems, our providers and, most importantly, our patients to incorporate this discovery into improved outcomes for all women.*"

CONCLUSION

The authors conclude that their deep learning (DL) model that directly leverages full-field mammograms in addition to traditional risk factors, outperforms the Tyrer-Cuzick model (version 8) by a large margin; this improvement is consistent across demographic subgroups.

These results support the hypothesis that mammography contains informative indicators of risk not captured by traditional risk factors, and DL models can deduce these patterns from the data. These models have the potential to replace conventional risk prediction models.

Further research is required to validate the model across institutions and vendors before it can be broadly implemented, To this end, the authors have made their trained model and code available for research (*learningtocure.csail.mit.edu).*

REFERENCES

1. Yala A, Lehman C, Schuster T, Portnoi T & Barzilay R. A Deep Learning Mammography-based Model for Improved Breast Cancer Risk Prediction. Radiology. 2019 May 7:182716. doi: 10.1148/radiol.2019182716.

2. Brentnall AR, Harkness EF, Astley SM, et al. Mammographic density adds accuracy to both the Tyrer-Cuzick and Gail breast cancer risk models in a prospective UK screening cohort. Breast Cancer Res 2015;17(1):147.