Towards Personalized Breast Imaging Pathways: Initial Findings from a Learning Health System

Firas Dabbous¹, Zhaohui Su², Gregory Donadio², James Dolan¹, Vandana Menon², Nila Alsheik¹; ¹Advocate Lutheran General Hospital, Park Ridge, IL 60068, ²OM1 Inc., Boston, MA 02199



Introduction

Recall rates represent a key performance metric of breast cancer screening. Higher recall rates are consistently seen in women with heterogeneously or extremely dense breasts. Because of the potential burden of false positive mammograms, the utility of annual screening mammography beginning at age 40 has recently been revisited. In this study, recall rates and clinical outcomes were examined according to index breast screening modality (digital breast tomosynthesis (DBT) vs digital mammography alone (DM)), age, and breast density categories in a large and geographically diverse cohort of women.

Methods

A cloud-based, big data platform and robust technology infrastructure was utilized to integrate and transform data from EMRs, radiology management systems, and tumor registries to create a learning health system. This analysis includes data from 247,431 women (325,729 screening exams) between June 2015 and September 2017 pertaining to 2 large healthcare organizations (39 total facilities). Patients with breast cancer history or implants were excluded. Recall rate (%) included screening exams assessed as BI-RADS category 0, 3, 4 and 5. Cancer rate per 1000 screened was calculated as the number of cancers within 12 months of the screening exams. Cancer detection rate per 1000 screened was restricted to cancers within 12 months of a positive screen. The denominators for cancer outcomes included women with 12 months of clinical follow-up after a screening exam.

Results

This racially diverse study cohort was 64% Caucasian and 25% African American (median age 58 years), consisting of 194,437 (60%) DBT screening mammograms and 131,292 (40%) DM screens. Women in the younger age categories (40-44 and 45-49) were more likely to have heterogeneously or extremely dense breasts, more likely to receive a baseline screening examination as compared to women in the older age categories (50-59 and 60-79) (Table 1) and more likely to be screened with DBT (Figure 1 and Figure 2). Recall rates were consistently lower with DBT than DM across all age categories, with at least 20% reductions in the 40-44 years (25%), 60-79 years (23%) and 45-49 years (22%) (Table 2 and Figure 3). Recall rates were consistently lower with DBT than DM across all breast density categories, with the biggest percent reductions in the almost entirely fatty (37%) and extremely dense (25%) categories (Table 3 and Figure 4). Overall, cancer rates and cancer detection rates were significantly higher with DBT compared to DM and this difference remained significant after adjustment for age and breast density (Table 4).

Figure 1. Breast Density Category and Screening Modality

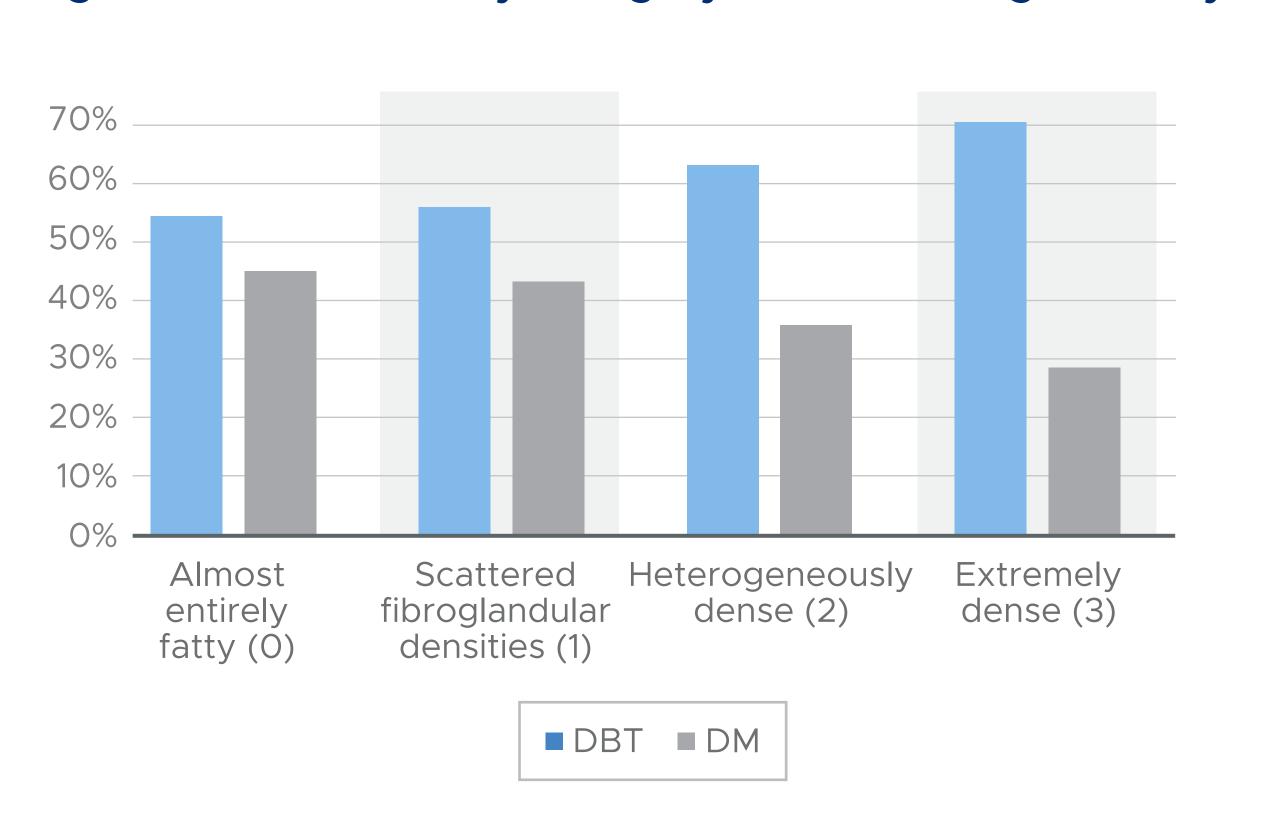


Table 1: Patient Characteristics by Age Category

White

Hispanic

AHC**

UPHS

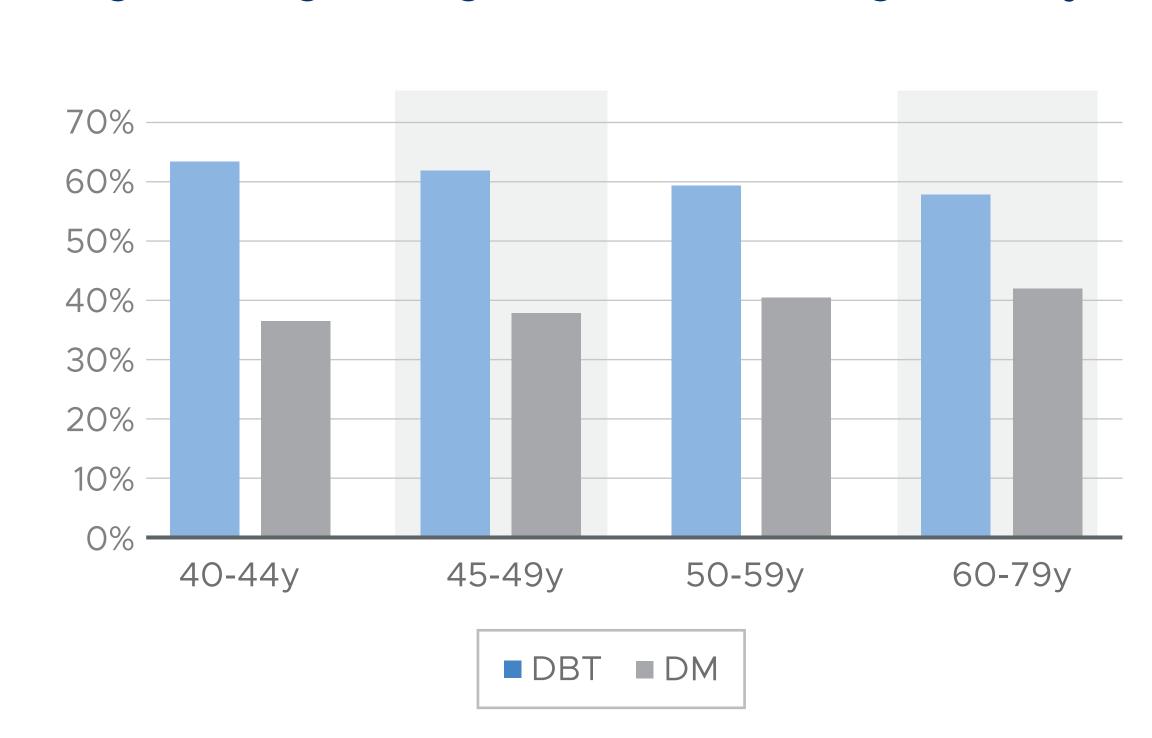
DBT

Almost entirely fatty (0)

Extremely dense (3)

Heterogeneously dense (2)

Figure 2: Age Categories and Screening Modality



(N=145,567)

36,546 (26.5%)

5,458 (4.0%)

6,427 (4.7%)

78,747 (54.1%)

44,817 (30.8%)

3,946 (2.7%)

Figure 3. Recall Rates by Screening Modality and Age Category

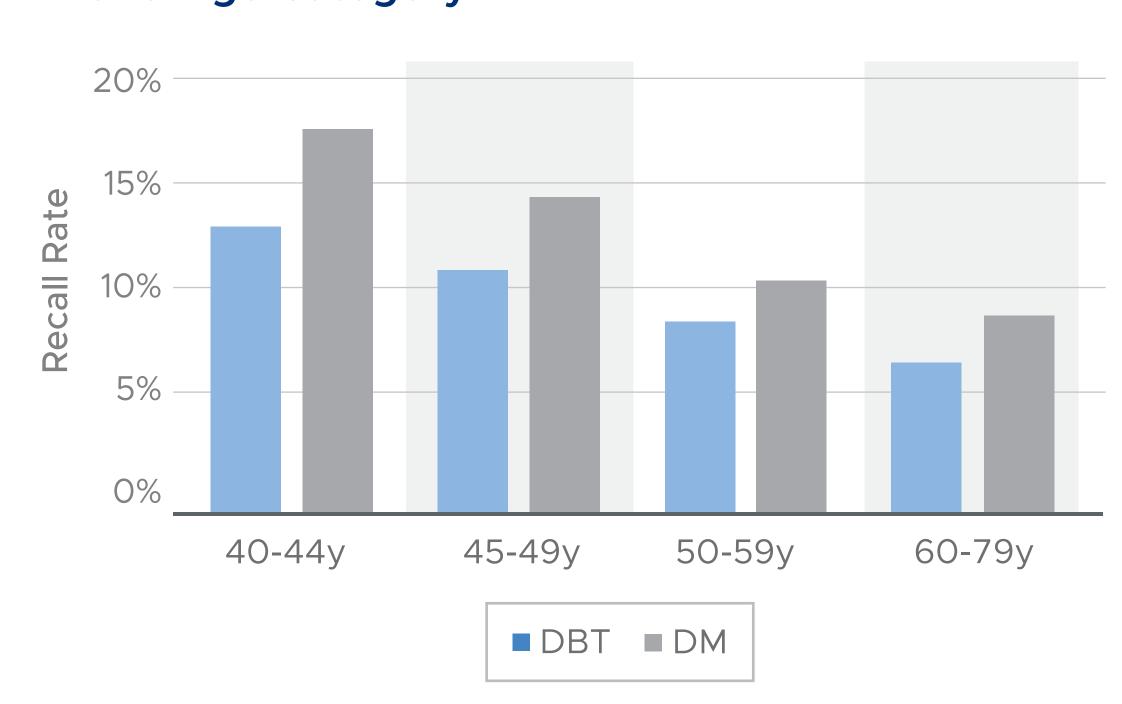


Table 2: Recall Rate and Cancer Detection Rate* by

Age Category and Screening Modality

	DBT n=194,437	DM n=131,292	p value
Recall rate			
40-44 years	2,777 (13.1%)	2,096 (17.4%)	<0.001
45-49 years	3,004 (11.2%)	2,317 (14.3%)	<0.001
50-59 years	5,482 (8.8%)	4,415 (10.5%)	<0.001
60-79 years	5,902 (7.0%)	5,587 (9.1%)	<0.001
Cancer detection rate			
40-44 years	27 (2.6 per 1000)	17 (1.8 per 1000)	0.27
45-49 years	39 (2.9 per 1000)	27 (2.2 per 1000)	0.22
50-59 years	128 (4.2 per 1000)	103 (3.2 per 1000)	0.047
60-79 years	264 (6.4 per 1000)	232 (5.0 per 1000)	0.007

Table 3: Recall Rate and Cancer Outcomes* by Breast Density Category and Screening Modality

45-49yrs

(N=43,095)

9,472 (23.6%)

2,443 (6.1%)

4,279 (9.9%)

40-44yrs

(N=33,266)

18,654 (60.3%)

7,210 (23.3%)

2,033 (6.6%)

3,036 (9.8%)

3,198 (11.2%)

1,464 (4.4%)

10,235 (30.8%)

17,714 (53.3%)

3,841 (11.6%)

9,722 (32.4%)

11,080 (33.3%)

12,068 (36.3%)

25,435 (88.8%)

2333

50-59yrs

(N=103,801)

24,353 (25.1%)

83,096 (92.4%)

47,784 (46.0%)

42,133 (40.6%)

6,022 (5.8%)

4,135 (4.3%)

6,201 (6.4%)

OUTCOMES	Almost entirely fatty (N=29,435)		Scattered fibroglandular densities (N=151,365)		Heterogeneously dense (N=126,784)		Extremely dense (N=18,088)	
	DBT	DM	DBT	DM	DBT	DM	DBT	DM
N	16,080	13,355	85,086	66,279	80,470	46,314	12,744	5,344
Recall Rates	5.16%	8.20%	7.57%	9.79%	10.69%	13.23%	9.89%	13.21%
N with One Year of Follow-Up Post Screen	6,832	9,821	40,329	50,016	41,470	35,627	6,737	4,196
Number of Cancers	36	50	192	205	241	159	31	17
Number of Invasive Cancers	27	43	139	159	169	117	19	11
Cancer Rate per 1000 Screens	5.3	5.1	4.8	4.1	5.8	4.5	4.6	4.1
Cancer Detection Rate per 1000 Screens	5.0	4.6	4.4	3.8	5.3	3.6	4.2	3.3

^{*}Restricted to patients with 12 months of follow up

Table 4. Overall Unadjusted and Adjusted Recall Rate and Cancer Detection Rate* by Screening Modality

	DBT n=194,437	DM n=131,292	p-value	Unadjusted Odds Ratio	95% CI	Adjusted** Odds Ratio	95% CI
Total recalled	17,165	14,415					
Recall Rate	8.83%	10.98%	<0.001	0.79	(0.77-0.80)	0.76	(0.74-0.77)
Total cancers (n)	500	431					
Cancer rate per 1000	5.2	4.3	0.004	1.21	(1.07- 1.38)	1.21	(1.06-1.37)
Cancer detection rate per 1000	4.8	3.8	0.001	1.27	(1.11-1.45)	1.26	(1.10-1.45)

^{*}Restricted to women who had at least 12 months of follow-up. **Adjusted for age and breast density category

and Breast Density Category

Figure 4. Recall Rates by Screening Modality

■ DBT ■ DM

Conclusions

This data driven platform enables large scale assessment of screening mammography in a real-world population. Significant reduction in recall rates across all ages and breast densities coupled with improved cancer detection rate and specificity was demonstrated in the DBT cohort. Because false positive screening mammograms have been linked to altered future screening behavior in recalled women, the importance of recall rate reduction in the DBT cohort cannot be overstated. DBT may therefore offer a more efficient screening option for all women regardless of age and breast density and engender increased compliance with national mammographic screening guidelines.

^{*}Chi-Square Test; **AHC=Advocate Health Care and UPHS=University of Pennsylvania Health Services