Impact of Population Characteristic on Recall Rates: Initial Finding from a Learning Health System

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Introduction

Several studies have demonstrated the impact of breast density on screening benchmarks, including recall and cancer detection rates. The benefits of digital breast tomosynthesis (DBT) in combination with digital mammography (DM) are well established however, there are limited data on specific outcomes across all density subgroups. We examined recall rates and clinical outcomes according to index breast screening modality (DBT versus DM) across all 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 examinations) between June 2015 and September 2017 arising from 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 the number of cancers within 12 months of the screening exam. 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 follow-up after a screening examination.

Results

This racially diverse study cohort was 64% Caucasian and 25% African American (median age 58 years) and consisted of 194,437 (60%) DBT screening mammograms and 131,292 (40%) DM screens. The majority of the women (~85%) were in either the scattered fibroglandular or heterogeneously dense categories with ~15% in the almost entirely fatty or extremely dense categories. Caucasian and Asian women were more likely to have dense breasts compared to African American women who were more likely to have fatty breasts (**Figure 1**). Women with dense breasts (heterogeneous or extremely dense) were more likely to be younger and screened with DBT whereas women with fatty breasts were older and more likely to be screened with DM (**Table 1** and **Figure 2**). Recall rates were consistently lower with DBT than DM across all breast density categories with the largest reductions in the almost entirely fatty (37%) and extremely dense (25%) categories (**Figure 3** and **Table 2**). Cancer rates and cancer detection rates were consistently higher for DBT compared to DM across all breast density categories. Overall recall rates were significantly lower for DBT compared to DM and adjustment for breast density further magnified the reduction. Overall cancer rates and cancer detection rates were significantly higher with DBT compared to DM and this difference remained significant after adjustment for breast density (**Table 3**).

Figure 1. Distribution of Race by Breast Density

Figure 2. Breast Density Category and Screening Modality

Figure 3. Recall Rates by Screening Modality and Breast Density Category

Table 1. Patient Characteristics by Breast Density Categories

		Almost entirely fatty (N=29,435)	Scattered fibroglandular densities N=151,365	Heterogeneously dense (N=126,784)	Extremely dense (N=18,088)	P-Value
Age (years)	N	29,435	151,365	126,784	18,088	<.001*
	Mean (s.d.)	61.6 (9.3)	60.0 (9.7)	55.9 (10.0)	52.6 (9.2)	
	Median (Q1-Q3)	62 (55-69)	60 (53-68)	55 (48-63)	51 (45-58)	
Age Categories	40-44	1,464 (5.0%)	10,235 (6.8%)	17,714 (14.0%)	3,841 (21.2%)	<.001**
	45-49	2,085 (7.1%)	14,599 (9.6%)	22,120 (17.4%)	4,279 (23.7%)	
	50-59	7,849 (26.7%)	47,784 (31.6%)	42,133 (33.2%)	6,022 (33.3%)	
	60-79	18,037 (61.3%)	78,747 (52.0%)	44,817 (35.3%)	3,946 (21.8%)	
Race	Caucasian	17,197 (61.0%)	88,042 (61.7%)	77,430 (65.6%)	12,576 (73.3%)	<.001**
	African American	9,088 (32.2%)	41,325 (29.0%)	25,246 (21.4%)	1,920 (11.2%)	
	Asian	428 (1.5%)	4,564 (3.2%)	7,521 (6.4%)	1,556 (9.1%)	
	Other	1,488 (5.3%)	8,653 (6.1%)	7,874 (6.7%)	1,111 (6.5%)	
	Unknown	1,234	8,781	8,713	925	
Ethnicity	Hispanic	1,605 (5.8%)	9,653 (7.3%)	8,670 (8.1%)	873 (5.4%)	<.001**
	Non-Hispanic	26,050 (94.2%)	121,948 (92.7%)	98,138 (91.9%)	15,212 (94.6%)	
	Unknown	1,780	19,764	19,976	2,003	
Screening Exam	First Exam	3,705 (14.8%)	15,128 (11.0%)	15,248 (13.2%)	1,869 (11.7%)	<.001**
	Subsequent Exam	21,368 (85.2%)	122,069 (89.0%)	99,852 (86.8%)	14,098 (88.3%)	
	Unknown	4,362	14,168	11,684	2,121	
Center	AHC	16,872 (57.3%)	104,326 (68.9%)	93,856 (74.0%)	12,080 (66.8%)	<.001**
	UPHS	12,563 (42.7%)	47,039 (31.1%)	32,928 (26.0%)	6,008 (33.2%)	
Screening Modality	DBT	16,080 (54.6%)	85,086 (56.2%)	80,470 (63.5%)	12,744 (70.5%)	<.001**
	DM	13,355 (45.4%)	66,279 (43.8%)	46,314 (36.5%)	5,344 (29.5%)	

*Analysis of Variance   **Chi-Square Test

Table 2: Recall Rate and Cancer Outcomes by Breast Density Category and Screening Modality

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

Table 3: 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 breast density only.

Conclusions

This data driven platform enables large scale assessment of screening mammography in a real-world population. We demonstrate significant variations in recall rates based on the underlying population's demographic characteristics and choice of index screening modality. Women with dense breasts were more likely to be recalled and screened with DBT in this cohort. Despite this confounding bias, DBT was associated with lower recall rates overall and higher cancer detection compared to DM, both overall and within each breast density category. DBT may offer a more efficient screening option for women with different breast density phenotypes.