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# Screening Mammography in a Public Hospital Serving Predominantly African-American Women: A Stage–Survival–Cost Model

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A B S T R A C T

*Background:* Ethnic and socioeconomic disparities pervade breast cancer patterns and outcomes. Mammography guidelines reflect the difficulty in optimizing mortality reduction and cost-effectiveness, with controversy still surrounding the 2009 U.S. Preventive Services Task Force (USPSTF) recommendations. This study simulates USPSTF and American Cancer Society (ACS) guidelines' effects on stage, survival, and cost of treatment in an urban public hospital.
*Methods:* Charts of 274 women diagnosed with stage I, II, or III breast cancer (2008–2010) were reviewed. Published tumor doubling times were used to predict size at diagnosis under simulated screening guidelines. Stage distributions under ACS and USPSTF guidelines were compared with those observed. Cohort survival for observed and hypothetical scenarios was estimated using national statistics. Treatment costs by stage, calculated from Georgia Medicaid claims data, were similarly applied.
*Results:* Mean age at diagnosis was 56 years. African Americans predominated (82.5%), with 96% publically insured or uninsured. Simulated stages at diagnosis significantly favored ACS guidelines (43.1% stage 1/38.3% stage 2/9.9% stage 3 vs. USPSTF 23.0%/53.3 %/15.0%), as did 5-year survival and cost of treatment relative to both observed and USPSTF-predicted schema ($p < .0001$). Following USPSTF guidelines predicted lower survival and additional costs.
*Conclusions:* Following ACS guidelines seems to lead to earlier diagnosis for low-income African-American women and increase 5-year survival with lower overall and breast-specific costs. The data suggest that adjusting screening practices for lower socioeconomic status, ethnic minority women may prove essential in addressing cancer disparities.
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The advent of breast cancer screening in the 1970s established that mammography decreases breast cancer mortality (Bjurstam et al., 2003; Hellquist et al., 2011; Miller, To, Baines, & Wall, 2002; Moss et al., 2006; Norman et al., 2007; Shapiro, Strax, & Venet, 1971; Tabár et al., 2011), leading to widespread implementation aimed at earlier detection and treatment. However, in today's era of increasing health care costs (Mariotto, Yabroff, Shao, Feuer, & Brown, 2011) and enhanced consumer autonomy, programs are being reevaluated to weigh financial impact and potential harms against concrete health benefits. The American Cancer Society (ACS) and the U.S. Preventive Services Task Force (USPSTF) both publish screening recommendations based on such investigation, but differences in these statements in 2009 generated considerable controversy. The ACS guidelines endorse mammography starting at age 40 and continuing annually as long as health status and life expectancy allow

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(Smith et al., 2011). In contrast, USPSTF recommendations shifted significantly from 2002, when they roughly matched ACS policies (USPSTF, 2009). The update eliminated routine mammography in women aged 40 to 49 years (instead basing the decision on discussion between the patient and her primary care provider), increased the screening interval from 1 to 2 years, and withheld recommendations for women over 75 years. This policy update was informed by two major studies after years of debate about screening women in their 40s (Green & Taplin, 2003; Salzmann, Kerlikowske, & Phillips, 1997).

The first group, Nelson et al. (2009), used existing data from randomized, controlled trials to compare how mammography impacts the risk of breast cancer death in women of varying ages. The trials that were meta-analyzed by Nelson et al. emerged from the United Kingdom, Sweden, Canada, and New York State. The group found the same reduction in relative risk for breast cancer death (about 15%) for women in the 4th and 5th decades of life, but used mortality rates from the National Cancer Institute's Surveillance Epidemiology and End Results (SEER) database to predict that 1,904 women from the 39 to 49 group would need to be invited to screening to prevent one additional death versus 1,334 from the 50 to 59 group. By comparison, for women 60 to 69 years old (with consensus for screening), mammography offers a 30% risk reduction, and only 377 need to be invited to screening to save one life. The authors stated, however, that data applicability was only fair owing to a lack of U.S.-based studies and that the "number needed to invite to screening could be misleading if…risk for mortality…varied between studies," a mortality variation that occurs in ethnic minority, socioeconomically disadvantaged women. Basing outcomes modeling solely on age-specific variables neglects evidence demonstrating marked ethnic and socioeconomic differences in tumor biology and disease patterns.

The second group, Mandelblatt et al. (2009), modeled various screening schedules and age ranges to determine each models' relative efficiency in decreasing mortality. Although higher screening rates decreased mortality, in each model the benefit for each additional mammogram eventually became marginal. This point was deemed the "efficiency frontier," and the authors concluded that programs that screen biennially from age 50 to 69, 74, or 79 years were among the most efficient. Like Nelson et al., however, the authors acknowledged that "the models…do not capture differences in outcomes among certain risk subgroups, such as women with BRCA1 or BRCA2 genetic susceptibility mutations…or black women who seem to have more disease at younger ages than white women."

These analyses focused on age as the primary determinant of cancer risk and concluded that screening biennially, starting at age 50, was most efficient from a national payer perspective. However, both African-American ethnicity and low socioeconomic status have been associated with inferior cancer outcomes, including younger age at diagnosis and increased mortality at the same age and stage (Aragon, Morgan, Wong, & Lum, 2011; Cunningham, Montero, Garrett-Mayer, Berkel, & Ely, 2010; DuBard, Schmid, Yow, Rogers, & Lawrence, 2008; Howlader et al., 2011; Gabram et al., 2008; Klassen & Smith, 2011; Komenaka et al., 2010; Lobb, Ayanian, Allen, & Emmons, 2010; McBride et al., 2007; O'Brien et al., 2010; Smith-Bindman et al., 2006; Ward, Fedewa, Cokkinides, & Virgo, 2010; Yang et al., 2009). Evidence suggests that such factors may leave low-income African-American women at disproportionate risk of negative consequences from later, less frequent screening. Grady Memorial Hospital is a safety net hospital with more than 900 beds in downtown Atlanta, Georgia, serving predominantly lower-income, publically insured African-American patients whose outcomes may provide evidence to address this question. We modeled the potential impact of strict adherence to ACS or USPSTF screening recommendations on stage at diagnosis and expected survival for the women diagnosed with breast cancer at our AVON Foundation Comprehensive Breast Center. Given that previous studies have demonstrated variation in cost of cancer care with stage at diagnosis (Subramanian et al., 2011; Taplin et al., 1995), we also analyzed potential differences in health care costs associated with any overall stage migration.

## Methods

### *Patient Data Collection*

All patients diagnosed with breast cancer in the calendar years 2008 through 2010 were identified from the Grady Memorial Hospital tumor registry (n = 447). Exclusion criteria included in situ disease (n = 73), metastatic disease at diagnosis (n = 49), ipsilateral cancer recurrence (n = 23), duplicate entries of bilateral disease (n = 19), male breast cancer (n = 2), and missing information that prevented confirming the date of diagnosis (n = 7). For women with cancer diagnosed in both breasts during the study period, the earlier diagnosis was included as one occurrence.

The final sample totaled 274 patients. Charts of each patient were reviewed for age at diagnosis, insurance status, ethnic group, clinical tumor stage based on the American Joint Committee on Cancer, 7th edition (AJCC-7), radiographic screening history and reasons for screening, pathologic tumor characteristics, tumor histology, and hormone receptor (estrogen receptor, progesterone receptor, and her2/neu) status. Study variable definitions are clarified below:

#### *Clinical stage ("observed stage")*

Staging was primarily based on radiographic reports at the time of diagnosis and defined using the AJCC-7 TNM classification. Tumor size (T) was the largest single dimension on diagnostic ultrasonography. If not performed, or inaccurate owing to a very large lesion, diagnostic mammogram was used. Nodal status (N) was based on radiology reports from diagnostic mammography and ultrasonography, and confirmed with multidisciplinary conference notes, pathology reports of node aspiration, positron emission tomography scans, and/or physical examination findings (breast, radiation oncology, or medical oncology clinic notes). The clinical stage determined in this manner provided the "observed stage" for each patient.

#### *Screening history and reasons for screening*

The date and type of imaging performed during the screening and diagnosis process were recorded as well as the interval from last imaging to current mammogram. The reason for the patient's current mammogram was abstracted from the radiology report, including routine screening, workup of symptoms, or other.

### *Tumor Growth Model and Predicted Stage Distributions*

Peer, Dijck, Hendriks, Holland, and Verbeek (1993) have previously published tumor doubling times based on measurements from serial mammograms of women in The Netherlands. The results provide the average number of days for a breast

lesion to double in size based on the woman's age. Given that tumor biology is also associated with rate of growth, we further subdivided the doubling times to allow specification based on both age and tumor grade, with older age and lower grade tumors correlating with slower rates of growth (Table 1).

A linear regression model, previously reported by this study's authors (Habtes et al., 2013), was derived from the estimates of doubling times and used to both "rewind" and "fast forward" patterns of tumor growth in each patient based on their lesion's size at the time of diagnosis. Using this equation, tumor size at 1-month intervals was calculated for 4 years retrospectively (predicted sizes had tumor been detected earlier) and prospectively (predicted sizes had tumor been detected later) for each patient. For patients less than 50 years old, the tumor size at age 50 was also separately calculated.

Each patient's documented screening history was compared with that recommended by the ACS and the USPSTF, examining her age, the interval between mammograms, and the reason for testing. This was then used to simulate a 'new time of diagnosis' and in turn, a corresponding stage at diagnosis 'as if' she had followed the ACS or USPSTF guidelines.

For a woman diagnosed with breast cancer between the ages of 50 and 74, when both organizations agree on routine screening, the time since her last mammogram would suggest an advantage for one set of guidelines or the other. If the last screening mammogram occurred, for instance, 19 months before the current one, hypothetical adherence to ACS guidelines would prescribe screening 7 months earlier (at 1 year from the prior mammogram), whereas hypothetical adherence to the USPSTF guidelines would delay screening an additional 5 months (at 2 years from the prior mammogram). Thus, if the lesion was found on the basis of routine screening, the "observed stage" would be the clinical stage at the patient's actual time of diagnosis according to her medical record. Her "ACS stage" would be the stage had she been diagnosed 7 months earlier, and her "USPSTF stage" would be the stage had she been diagnosed 5 months later. If the lesion was found at the same interval owing to symptoms instead, it could hypothetically be diagnosed earlier by ACS guidelines. However, under USPSTF guidelines the time of diagnosis would be unchanged (rather than later), because the symptoms would have led to investigation before the next mammogram was due. In that case, "observed stage" and "USPSTF stage" would be the same, although "ACS stage" might be earlier. In contrast, in a woman diagnosed through either routine screening or symptomatic workup who had not undergone mammography in more than 2 years, adherence to either set of guidelines would be expected to provide an advantage. For women younger than 50 or older than 75, only ACS guidelines recommend routine screening. In these cases, depending on her mammography interval, a woman might be diagnosed earlier based on simulated ACS adherence, at the same time (found on symptoms), or later (found on screening) based on simulated USPSTF adherence. We assumed that there was no provider-recommended earlier screening for women under 40 years old following USPSTF guidelines.

Once the "new time of diagnosis" according to each simulated set of guidelines was determined, expressed as months before or after the observed diagnosis, the calculated tumor size was selected based on the regression model. The threshold for mammographic detection was assumed to be 10 mm (Pisano et al., 2005).

Although some percentage of tumors can be expected to manifest on imaging below this cutoff, it was chosen as a conservative estimation for modeling purposes. If the calculated tumor size at the simulated time of diagnosis was detectable, AJCC-7 T classification was assigned. Because of the inability to predict regional metastasis by this model, the nodal or N classification was set as zero. The threshold at which tumors become palpable, and therefore also assumed to be "symptomatic" and detectable without need for screening mammography, was set at 20 mm (Güth et al., 2008) or stage IIA. These stages were recorded as "ACS stage" or "USPSTF stage" and comprised the two distributions of predicted stages at diagnosis.

**Table 1**
Peer et al. Mean Tumor Doubling Times Adjusted for Tumor Grade (Lund et al., 2008)

| Age (y) | Days, *n* (Range) | | |
|---|---|---|---|
| | Grade 1 | Grade 2 | Grade 3 |
| <50 | 131 (114–147) | 96 (79–113) | 61 (44–78) |
| 50–70 | 190.5 (177–204) | 163 (150–176) | 135 (121–149) |
| >70 | 243.5 (237–250) | 158 (179–237) | 149 (120–178) |

### *Survival, Cost, and Statistical Analyses*

Nationally observed percentages of patients surviving at 1 to 5 years from the time of diagnosis for stages I, II, and III breast cancer were requested from the National Cancer Database (American College of Surgeons, 2011). Each patient's yearly likelihood of survival within each screening scenario was then tabulated based on their observed or predicted stage at diagnosis. The survival estimates for each group of patients was averaged by year to create three 5-year survival curves for the cohort: one each for their observed, ACS-predicted, and USPSTF-predicted distributions of stages at diagnosis.

Cost measurements were derived from Georgia Comprehensive Cancer Registry case files that linked to a woman in the Georgia Medicaid administrative claims data for the study years. Eligibility for inclusion in these calculations was based on 18-month continuous enrollment in Medicaid. Total costs were calculated for breast diagnoses and procedures only as well as for costs including all claims. The estimates were stratified by AJCC-7 stage at diagnosis. As a result, the total cost for all the women in each stage distribution (observed, ACS, and USPSTF) could be obtained by multiplying the average cost of treatment for a given stage of breast cancer by the number of patients diagnosed at that stage within the distribution. This sum was averaged over the number of patients to provide per-patient cost estimates for all screening scenarios, with incremental savings or additional expenses per patient reported.

**Table 2**
Complete Distribution of Observed Stages at Diagnosis in Study Cohort

| AJCC-7 Stage | *n* | % | SEER Stage | *n* | % |
|---|---|---|---|---|---|
| 0 | 73 | 18.4 | In situ | 73 | 18.4 |
| 1 | 94 | 23.7 | Local | 157 | 39.6 |
| 2 | 121 | 30.6 | Regional | 105 | 26.5 |
| 3 | 47 | 11.9 | Distant | 49 | 12.4 |
| 4 | 49 | 12.4 | — | — | — |
| Missing/unknown | 12 | 3.0 | Missing/unknown | 12 | 3.0 |
| Total | 396 | 100 | Total | 396 | 100 |

*Abbreviations:* AJCC-7, American Joint Committee on Cancer, 7th edition; SEER, Surveillance Epidemiology and End Results.

**Table 3**
Demographic, Social, and Clinical Characteristics of Study Cohort

| Characteristic | Entire Cohort | | Ethnic Group | | | |
|---|---|---|---|---|---|---|
| | *n* | % | African-American (%) | Caucasian (%) | Hispanic/Latina (%) | Other (%) |
| Age at diagnosis (y) | | | | | | |
| Mean | 56 | — | 57 | 57.6 | 46.9 | 51.1 |
| <50 | 88 | 32.1 | 28.8 | 27.3 | 72.2 | 36.8 |
| 50–74 | 158 | 57.7 | 61.5 | 72.7 | 22.2 | 36.8 |
| ≥75 | 22 | 8.0 | 9.3 | — | 5.6 | |
| Missing | 6 | 2.2 | 0.4 | — | — | 26.4 |
| Total | 274 | 100 | 100 | 100 | 100.0 | 100.0 |
| Ethnic group | | | | | | |
| African American | 226 | 82.5 | — | — | — | — |
| Caucasian | 11 | 4.0 | — | — | — | — |
| Hispanic/Latina | 18 | 6.6 | — | — | — | — |
| Other | 19 | 6.9 | — | — | — | — |
| Total | 274 | 100 | — | — | — | — |
| Insurance status | | | | | | |
| Private | 8 | 2.9 | 3.1 | 9.1 | — | — |
| Medicare | 66 | 24.1 | 27.9 | 18.2 | 5.6 | — |
| Medicaid | 92 | 33.6 | 35.8 | 27.3 | 5.6 | 36.8 |
| None/self-pay | 105 | 38.3 | 33.2 | 45.5 | 88.9 | 47.4 |
| Unknown/missing | 3 | 1.1 | — | — | — | 15.8 |
| Total | 274 | 100 | 100 | 100 | 100 | 100 |
| Tumor size | | | | | | |
| Mean size at diagnosis (mm) | 30.6 | | 30.2 | 22.7 | 36.1 | 21.9 |
| <2 cm | 108 | 39.4 | 42.9 | 54.5 | 16.7 | 22.2 |
| 2–5 cm | 107 | 39.1 | 38.9 | 45.5 | 61.1 | 22.2 |
| >5 cm | 39 | 14.2 | 14.2 | — | 16.7 | |
| Missing/unknown | 20 | 7.3 | 4.0 | — | 5.6 | 55.6 |
| Total | 274 | 100.0 | 100 | 100 | 100 | 100 |
| Tumor stage | | | | | | |
| AJCC-7 | | | | | | |
| 1 | 94 | 34.3 | 35.8 | 45.5 | 22.2 | 15.0 |
| 2 | 121 | 44.2 | 43.8 | 54.5 | 61.1 | 20.0 |
| 3 | 47 | 17.2 | 16.8 | — | 16.7 | 5.0 |
| Missing/unknown | 12 | 4.4 | 3.5 | — | — | 60.0 |
| Total | 274 | 100 | 100 | 100 | 100 | 100 |
| SEER | | | | | | |
| Local | 157 | 57.3 | 58.0 | 63.6 | 61.1 | 30.0 |
| Regional | 105 | 38.3 | 38.5 | 36.4 | 38.9 | 10.0 |
| Missing/unknown | 12 | 4.4 | 3.5 | — | — | 60.0 |
| Total | 274 | 100 | 100 | 100 | 100 | 100 |
| Tumor grade | | | | | | |
| 1 | 31 | 11.3 | 11.9 | 9.1 | 16.7 | |
| 2 | 136 | 49.6 | 50.9 | 36.4 | 55.6 | 41.7 |
| 3 | 93 | 33.9 | 34.1 | 54.5 | 27.8 | 25.0 |
| Missing/unknown | 14 | 5.1 | 3.1 | — | — | 33.3 |
| Total | 274 | 100 | 100 | 100 | 100 | 100 |
| Hormone receptor status | | | | | | |
| ER and/or PR+ | 152 | 55.5 | 54.4 | 72.7 | 66.7 | 41.7 |
| Her2/neu + only | 18 | 6.6 | 7.1 | 9.1 | — | 8.3 |
| Triple negative | 86 | 31.4 | 33.2 | 18.2 | 27.8 | 8.3 |
| Unknown/missing | 18 | 6.6 | 5.3 | — | 5.6 | 41.7 |
| Total | 274 | 100 | 100 | 100 | 100 | 100 |

*Abbreviations:* AJCC-7, American Joint Committee on Cancer, 7th edition; ER, estrogen receptor; PR, progesterone receptor; SEER, Surveillance Epidemiology and End Results.

Significance of the differences between comparison groups for stage at diagnosis, survival by year, and per-patient costs was assessed using Pearson $\chi^2$ contingency statistics.

## Results

The observed distribution of stage at diagnosis among the initial group of 396 women is shown in Table 2. Stages excluded in the main analysis are presented for comparison with national statistics. Demographic, socioeconomic, and clinical characteristics of the included cohort (n = 274) are shown in Table 3. The average age at diagnosis was 56 years (range, 28–99 years). The cohort was predominantly African American (n = 226/274; 82.5%) and most were publically insured (Medicaid 33.6%/Medicare 24.1%) or uninsured (38.3%). Overall, about 32% of women were diagnosed before the age of 50. Hispanic/Latina women seem more likely to present before the 5th decade (72.2%) and to be uninsured (88.9%); however, the sample size is very small (n = 18).

The average size of lesions at presentation was approximately 3 cm. Again, Hispanic/Latina women seemed to be at a disadvantage, with more 2- to 5-cm tumors (61.1% of lesions) than

**Table 4**
Screening History and Reasons for Workup

| Prior Screens | Entire Cohort | | Ethnic Group | | | |
|---|---|---|---|---|---|---|
| | *n* | % | African American (%) | Caucasian (%) | Hispanic/Latina (%) | Other |
| Mammogram >30 mo ago | 47 | 17.2 | 17.7 | 27.3 | 22.2 | — |
| Mammogram in the last 2 years (18–29 mo) | 28 | 10.2 | 10.6 | 9.1 | 5.6 | 16.7 |
| Mammogram in the last year (0–17 mo) | 56 | 20.4 | 22.6 | 27.3 | 5.6 | 8.3 |
| No prior mammography | 80 | 29.2 | 27.9 | 36.4 | 27.8 | 41.7 |
| Not documented | 63 | 23.0 | 21.2 | | 38.9 | 33.3 |
| Total | 274 | 100 | 100 | 100 | 100 | 100 |
| Average interval since last mammogram (mo) | 33.2 | | 32.4 | 39.1/25.7* | 47.7/33.2* | 13.7 |
| Reason for imaging | | | | | | |
| Routine screening | 88 | 32.1 | 35.8 | 27.3 | 22.2 | 8.3 |
| Symptoms | 146 | 53.3 | 53.5 | 54.5 | 61.1 | 58.3 |
| Other reason | 17 | 6.2 | 7.1 | 9.1 | — | — |
| Unknown | 23 | 8.4 | 3.5 | 9.1 | 16.7 | 33.3 |
| Total | 274 | 100 | 100 | 100 | 100 | 100 |

* Alternate value when one outlier of 120 mo excluded.

other ethnic groups (22.2%–45.5%). Most tumors presented at AJCC-7 stage 2 (44.2%) and demonstrated intermediate grade (49.6%). African-American women showed the smallest proportion of estrogen or progesterone receptor positivity (54.4% vs. 72.7% of Caucasian women and 66.7% of Hispanic/Latina women) as well as the heaviest burden of triple negative (estrogen, progesterone, and her2/neu receptor negative) disease (33.2% vs. 27.8% for Hispanic/Latina women and 18.2% in Caucasian women).

Unfortunately, the most common screening history across all ethnicities (Table 4) was "no prior mammography" (29.2% overall); only 30.6% of women had a documented mammogram within the last 2.5 years. Most women were diagnosed after symptom onset (53.3% overall) rather than routine screening, a trend consistent across all ethnicities.

### *Tumor Growth Model and Predicted Stage Distributions*

When the tumor growth model and predicted stage algorithms were applied to the observed stages at diagnosis, significant stage migrations resulted (Figure 1; Table 5). Simulating ACS guidelines yielded the highest proportion of stage I tumors (43.1%) versus the proportion of stage I tumors observed (34.3%) and predicted by simulating the USPSTF guidelines (23.0%), as well as decreased stage II and III disease. Hypothetically following USPSTF guidelines resulted in a substantial increase in predicted stage II disease (53.3%) compared with ACS (38.3% stage II) and observed (44.2% stage II).

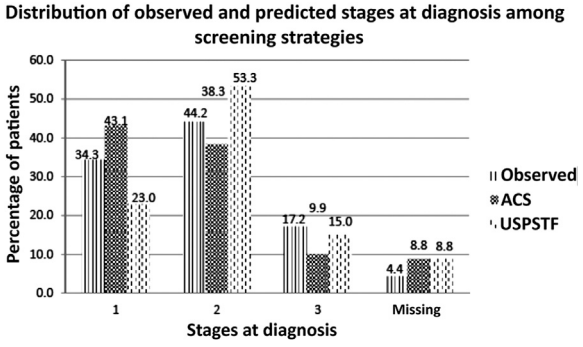


**Figure 1.** Stage migrations by alternative simulated mammography schedules. ACS, American Cancer Society; USPSTF, U.S. Preventive Services Task Force.

### *Survival Analysis*

Five-year survival estimations based on each strategy are presented in Figure 2. The ACS simulation predicted the highest survival at each of the first 5 years after diagnosis relative to both the observed stages at diagnosis (intermediate survival estimates) and the USPSTF stages (lowest survival estimates). Differences between scenarios were small (0.4%–2.3%) but significant.

### *Cost Analysis*

Calculated costs by stage are presented in Table 6. Both breast-related and all-claims costs were found to increase by $20,000 to $25,000 with each increasing stage of disease. When stage-specific costs were applied over distributions of stages according to observed, ACS-predicted, and USPSTF-predicted schema, simulated ACS guideline outcomes showed significant per-patient savings relative to both observed (savings of $3,745 per patient) and USPSTF costs (savings of $5,528 per patient). Simulating following the USPSTF guidelines generated the highest costs.

## Discussion

This modeling approach has been validated by the same authors in an initial study examining only changes to stage at diagnosis in women diagnosed at Grady Memorial Hospital in 2008 (Habtes et al., 2013). The current analyses and conclusions are significantly different and support recommendations outside the scope of our previous work. The initial manuscript modeled data for 84 patients; the endpoint was stage at diagnosis and a significant advantage was found for ACS guidelines. We published this fragment both to validate the model and to provide the backing of the peer review process to the recommendations included in the text, which we wished to apply in our institution. Conclusions emphasized the importance of screening discussions with a primary care provider for lower socioeconomic status, African-American women. However, this manuscript builds on the previous in both power and scope, increasing to 274 patients and applying the survival and cost analyses. Not only do these data add insight from a national payer perspective, but allow us to give specific recommendations for populations similar to ours (rather than patient–provider discussion alone).

**Table 5**
Stages and Statistical Comparison of Observed Versus Simulated Mammography Schedules

| AJCC-7 Stage | Screening Schedules | | | | | |
|---|---|---|---|---|---|---|
| | Observed | | ACS | | USPSTF | |
| | *n* | % | *n* | % | *n* | % |
| 1 | 94 | 34.3 | 118 | 43.1 | 63 | 23.0 |
| 2 | 121 | 44.2 | 105 | 38.3 | 146 | 53.3 |
| 3 | 47 | 17.2 | 27 | 9.9 | 41 | 15.0 |
| Missing | 12 | 4.4 | 24 | 8.8 | 24 | 8.8 |
| Total | 274 | 100 | 274 | 100 | 274 | 100 |

| Comparison | Chi Square | *p* Value |
|---|---|---|
| Observed vs. ACS | 261.1 | <.0001 |
| Observed vs. USPSTF | 303.3 | <.0001 |
| ACS vs. USPSTF | 230.9 | <.0001 |

*Abbreviations:* ACS, American Cancer Society; AJCC-7, American Joint Committee on Cancer, 7th edition.

Substantial evidence supports wide ethnic and socioeconomic variations in breast cancer patterns. Despite lower incidence, African-American women are more likely than Caucasian women to be diagnosed at younger ages (Howlader et al., 2011; Yang et al., 2009). They present with more advanced-stage disease, and are more likely to die from breast cancer when matched for age and stage (Howlader et al., 2011; Komenaka et al., 2010; Yang et al., 2009). Part of the disadvantage may be owing to increased hormone receptor-negative and triple-negative tumors (Cunningham et al., 2010; Komenaka et al., 2010; O'Brien et al., 2010) or larger, more lymph node–positive tumors (McBride et al., 2007). Some effects have been reproduced in low-income populations demonstrating higher breast cancer risk in the 4th decade of life (Lobb et al., 2010), cancers of worse prognosis (Klassen & Smith, 2011), and more advanced disease at diagnosis (Ward et al., 2010). Finally, differences in mammography utilization may affect profoundly the calculation of numbers invited to screening versus lives saved in women of minority ethnic groups or lower socioeconomic strata (Aragon et al., 2011; DuBard et al., 2008; Gabram et al., 2008; Smith-Bindman et al., 2006).

Although breast cancer screening may be moving toward a more personalized model based on individual risk (Schousboe, Kerlikowske, Loh, & Cummings, 2011), our findings reiterate the importance of integrating existing knowledge of ethnic and socioeconomic disease patterns into any national screening recommendations. They also support the continued use of ACS

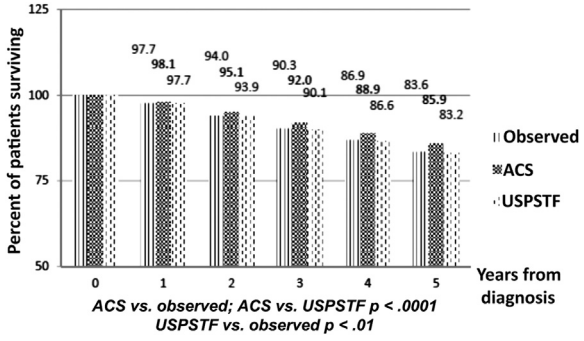


**Figure 2.** Predicted 5-year survival of observed and simulated cohorts. ACS, American Cancer Society; USPSTF, U.S. Preventive Services Task Force.

**Table 6**
Observed Costs by Stage and Predicted Incremental Costs by Screening Cohort

| | Breast Procedures, Diagnoses Only | All Claims | *p* Value |
|---|---|---|---|
| AJCC-7 stage ($USD per patient) | | | |
| 1 | 22,959 | 38,104 | — |
| 2 | 41,799 | 59,217 | — |
| 3 | 66,190 | 86,148 | — |
| Scenario comparison (Net $USD per patient) | | | |
| ACS vs. observed | −37,45 | −4,171 | <.0001 |
| USPSTF vs. observed | 1,952 | 2,188 | .0002 |
| ACS vs. USPSTF | −5,528 | −6,173 | <.0001 |

*Abbreviations:* ACS, American Cancer Society; USPSTF, U.S. Preventive Services Task Force.

screening schedules in low-income African-American women treated in urban public hospitals, and in that regard, may inform patient navigation programs for similar populations.

Our study cohort has a much greater proportion of African-American women than the major randomized, controlled trials and national statistical databases. The ages at diagnosis fall between two studies examining ethnic breakdown in large cancer registries. One Massachusetts group (McBride et al., 2007) reported 45% of patients diagnosed before age 50; however, this population had a larger percentage of Hispanic/Latina women (45%), who seemed to be diagnosed earlier in our population as well and, if better represented, may have increased under-50 diagnosis. In another study from the Florida Cancer Registry (Yang et al., 2009), subset analysis showed that 22.4% of African-American patients were diagnosed before age 50, which is similar to the 28.8% of our patients. Furthermore, that study found a younger average age at diagnosis, 56.6 years, for African-American women compared with Caucasian women. This closely approximates our average age of diagnosis, although we found no Black–White disparity (57 years in African-Americans vs. 57.6 years in Caucasians). However, our Caucasian subset is too small (n = 11) to truly analyze. The similarity in presentation of our patients and the Florida registry patients may be owing to their roughly equivalent socioeconomic status and access to care, a fact that has eliminated outcomes disparities in other studies (Chu et al., 2009). Patients in our study were, however, much more likely to be uninsured (vs. receiving Medicaid or Medicare) than the Florida cohort (only 8.8% of African-American women).

Tumor characteristics in our population were worse compared with the Florida study overall (Yang et al., 2009). We found fewer tumors less than 2 cm (39.4% in our population vs. 58%) and a lower proportion of local disease (Table 2). However, compared with Florida's African-American patients alone, the relationships among tumor size categories are similar (42.9% less than 2 cm/38.9% 2–5 cm/14.2% greater than 5 cm our population vs. 47.3%/38.8%/13.9% Florida), whereas those among local, regional, and distant disease are worse (50.5% local/33.8% regional/15.8% distant vs. 52.4%/41.7%/5.9%). Our population also has a greater shift toward distant disease compared with national averages for African-American women in SEER (51.9%/37.0%/8.1%; Howlader et al., 2011). Our stages are very similar to those presented by Komenaka et al., who examined stage at diagnosis among underinsured African-American women. Our findings for the proportion of triple-negative tumors also match Komenaka's (31.9% our population vs. 32%), as do percentages of estrogen receptor–negative tumors (38.9% our population vs. 41%). Triple-negative disease comparisons between ethnicities match previously published studies in which African-American

women face the highest burden, Hispanic/Latina women the next highest, and Caucasian women the lowest (Ray & Polite, 2010). They are also consistent with previously published data by these authors on the high prevalence of triple-negative tumors in the Grady Memorial Hospital population (Lund et al., 2008).

Compared with the Komenaka et al. study, our population was less likely to have undergone screening mammography in the 2 years before diagnosis (30.6% our population vs. 51%). Our percentage undergoing mammography in the last year is also substantially less than the 60.6% of African-American women reported in 2007 from the U.S. Medical Expenditure Panel Survey (Miranda, Tarraf, & González, 2011), but those data were self-reported and thus subject to recall and social acceptability biases. Only 32.1% of lesions in our population were found on routine screening, in contrast with 59% nationally (Breen, Yabroff, & Meissner, 2007). That so few tumors were detected on mammography may bear strongly on our outcomes given differences in behavior between mammography-detected tumors and tumors detected by symptoms or self-examination (Shen, Hammonds, Madsen, & Dale, 2011). We are not able to ascertain, however, whether these are missed or true interval tumors (Kirsh et al., 2011).

Our cost findings are similar to those reported by Barron, Quimbo, Nikam, and Amonkar (2008) and Janjan et al. (1993) and feature increments between stages similar to previous reports in comparable populations (Subramanian et al., 2011). Overall, the data suggest that although cost effectiveness is an important national goal, using variables specific to a low-income minority population may yield modified guidelines on which to base 'best' screening practices. There have been numerous proponents to reevaluate the interpretation of the data behind the 2009 USPSTF recommendations (Helvie, Petitti, Calonge, Melnyk, & Wilt, 2011; Hendrick & Helvie, 2011). One study tested the idea of incorporating disparity-specific variables into outcome models for cervical cancer. The authors found that different scenarios provided reductions in disparities among ethnic groups at increased or equal cost effectiveness (Goldie & Daniels, 2011).

The study is limited by restrictions to the tumor model. Because we cannot predict local invasion or metastasis, stages 0 and 4 were excluded. Similarly, we were unable to assign an "N" status to the predicted TNM staging, which may have underestimated simulated stage 3 and 4 disease and led to a bias toward screening. In contrast, our threshold mammographic detection was purposefully conservative at 10 mm; any bias caused by this decision would point away from the benefits of screening, as would the assumption that all tumors become palpable at 20 mm. Additionally, there is a potential for significant variation in tumor biology among the Peer et al. population of White, non-Hispanic, European women and our studied population of African-American women. However, the doubling time values published in the Peer et al. paper are roughly in accordance with the estimates of breast cancer growth found in a number of other published studies relying on serial mammographic measurements (Kuroishi et al., 1990; Lundgren, 1977; Michaelson et al., 2002; Peer et al., 1993; Spratt, von Fournier, Spratt, & Weber, 1993; Spratt Jr. & Spratt, 1964; von Fournier et al., 1980).

The tumor model focuses on a small sample size of lower socioeconomic status, African-American women in an urban public hospital. Although the results are significant in that subset, they cannot be generalized to the overall United States population or to all African-American women across socioeconomic boundaries. We further focused on specific tumor characteristics within that population (age of patient and size and grade of tumor) as a reasonable but limited model of behavior. Additional information, such as family history or hormone receptor status, would admittedly influence tumor behavior as well, but falls outside the scope of this model.

Finally, some evidence suggests that earlier screening results in lead time bias rather than actual reduction of advanced stage disease, and that other factors are responsible for reducing mortality after widespread screening (Autier et al., 2011). Because we cannot measure these effects directly in our hypothetical cohort, we cannot conclusively rule out this possibility. However, other papers in similarly underserved populations (Elting et al., 2009; Norman et al., 2007) and indirect observations in the Grady Memorial Hospital population (Gabram et al., 2008) suggest that screening in such women may indeed result in a decreased incidence of advanced stage presentation as a mechanism for decreased mortality. Adjustment of the model for age and grade of tumor should further mitigate against lead time bias.

Although USPSTF guidelines allow for high-risk women to be screened before age 50 and after age 75 based on discussions with their primary care provider, we did not attempt to account for these scenarios in the model. Data from the University of Pennsylvania in 2005 suggest that African-American women at risk of BRCA 1 or 2 mutations are almost five times less likely than Caucasian women to receive counseling about genetic testing, even though all patients had seen a primary care physician within the 3 years before the study period (Armstrong, Micco, Carney, Stopfer, & Putt, 2005). The researchers pointed out the concentration of African-American patients among relatively few primary care physicians; moreover, these providers are less likely to be board certified and report more difficulty in delivering high-quality care relative to primary care physicians seen by Caucasian patients (Bach, Pham, Schrag, Tate, & Hargraves, 2004). In addition, Medicaid recipients have been shown to have lower rates of cancer screening compared with the general population. In one study of those aged 50 and over eligible for cancer screening, only 60% of women were referred for mammography by their primary care provider (Smith-Bindman et al., 2006). Finally, the success at Grady Memorial Hospital of direct community outreach and patient navigation programs in increasing mammography utilization and schedule adherence (Gabram et al., 2007; Gabram et al., 2008) suggests that many of our patients may be guided more strongly by information received outside of the primary care context. These factors provide evidence that for underinsured African-American women, a provision leaving extended screening at the discretion of a patient–provider conversation may not be sufficient to ensure screening outside of the routine recommendation.

Directions for future research include analysis of serial mammograms within our population to better understand tumor growth within this subset of women. Also, given the striking pattern of screening behavior and age at diagnosis observed among Hispanic/Latina women, directed inquiry in a larger sample size might elucidate whether these women are truly at such a diagnostic disadvantage.

## Conclusion

Our data support the substantial body of evidence that African-American and lower socioeconomic status women present with markedly different patterns of screening behavior and

breast cancer characteristics than those represented by population-wide averages. Awareness of such issues is even more critical in underserved populations, where patient navigator programs provide a large degree of influence in helping women to access and utilize screening and diagnostic services, and when changes to national guidelines may impact the services covered by public insurance.

## Implications for Practice and/or Policy

Although further research is needed to validate our findings and determine whether our data can be generalized on a more national and/or global level, we believe that low-income African-American women and any navigation programs that serve them, should be encouraged to continue to follow the ACS recommendations for annual mammography beginning at 40 years and continuing as long as life expectancy and functional status allow. Not only could considering alternative screening strategies provide cost-effective means of reducing late-stage disease burden, but reinvestigating the microsimulation models specific to lower income and ethnic minority women may provide valuable insight into reducing the cancer disparities that present from diagnosis to death in this population.

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