Surveillance Research Program, NCI, Technical Report #2013-02

Appendix - CEBP Focus on Cancer Surveillance: Bias Associated With Self-Report of Prior Screening Mammography

Kathleen A Cronin[1*], Diana L Miglioretti[2], Martin Krapcho[3], Binbing Yu[4], Berta M Geller[5], Patricia A. Carney[6], Tracy Onega[7,8], Eric J Feuer[1], Nancy Breen[9] , Rachel Ballard-Barbash[9]

1. Statistical Research and Applications Branch, Division of Cancer Control and Population Sciences, National Cancer Institute, Suite 504, 6116 Executive Boulevard, Bethesda, MD
2. Group Health Cooperative, Center for Health Studies, 1730 Minor Ave Ste 1600, Seattle WA
3. Information Management Services Inc., 12501 Prosperity Drive, Suite 200, Silver Spring, MD
4. Biometry, National Institute on Aging, 7201 Wisconsin Ave, Bethesda MD
5. Office of Health Promotion Research, University of Vermont, 1 South Prospect Street, Burlington VT
6. Department of Family Medicine and Public Health and Preventive Medicine. Oregon Health & Science University, Portland, OR
7. Department of Community and Family Medicine, Dartmouth Medical School, Hanover and Lebanon, NH
8. Norris Cotton Cancer Center, Dartmouth Medical School, Lebanon, NH
9. Applied Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, EPN 4005, 6130 Executive Boulevard, Bethesda, MD

* Corresponding author

Running title:

Self-Report Of Screening Mammography

Key Words:

breast neoplasms; data collection; mammography; recall; reproducibility of results

Appendix to:

Cronin, K.A., Miglioretti, D.L., Krapcho, M., Yu, B., Geller, B.M., Carney, P.A., Onega, T, Feuer, E.J., Breen, N, Ballard-Barbash, R. Bias Associated With Self-Report of Prior Screening Mammography. Cancer Epidemiol Biomarkers Prev 2009;18:1699-1705.

Appendix: Modeling mammography screening usage by race and ethnicity

To update the mammography dissemination and usage model to produce results by race and ethnicity, we closely followed the model described in Cronin et al. (1)

ESTIMATING THE DISTRIBUTION FOR AGE AT FIRST MAMMOGRAPHY

The time until a woman's first mammography was based on a series of cross-sectional NHIS surveys (1987, 1990, 1992, 1993, 1994, 1998 and 2000 NHIS surveys; http://www.cdc.gov/nchs/nhis.htm links to survey description documentation and data) which asked women if they ever received a mammogram. The series of cross sectional estimates are combined with a diffusion of innovations model as described in Cronin et al (1) to estimate the probability of receiving a first mammogram overall, for non-Hispanic white, African American and Hispanic women.

The basic dissemination model assumed that no screening occurred before 1975 and allowed for a portion of the population to never receive a mammogram. Initial results fit a separate dissemination model for all women by five year birth cohorts. Figure A1 originally appeared as Figure 1a in Cronin et al and shows the cumulative distribution for the time to a first mammography exam by 5-year birth cohort. These results were used directly when simulating the first mammography for all women combined.

The same approach could not be used when modeling by race and ethnicity since there was not enough data to stratify by birth cohort. It was observed that for women born between 1918 and 1952 screening was primarily a period effect instead of a cohort effect, i.e. the percent of women who had a mammography was dependent on calendar year and not on the year they were born. If the dissemination curves shown in Figure A1 were plotted as a function of calendar year they would be similar for women born between 1918 and 1952. For women born after 1953, the dissemination curves are mainly a function of age. These are the first cohorts that had screening widely available when they reached recommended screening age.

To model the distribution for the age at first mammography by race and ethnicity, we combined women born between 1918 and 1952 to estimate one diffusion curve. This curve was used as a function of calendar year for women born before 1953 and a function by age for women born in 1953 and after. Figure A2 shows the distribution for first mammography by race and ethnicity and the NHIS data points used to fit the curves.

ESTIMATING INTERVAL BETWEEN SCREENING EXAMS

Intervals between subsequent screening exams are based on data from 6 of the BCSC sites for the time period 1994 to 2005. Data from Group Health Center for Health Studies was collected from the Group Health HMO which recommends screening every two years for all but high risk women with a reminder system in place for members. It was felt that data from this site reflected a special population of HMO members and were not representative of the US. Therefore data from Group Health Center for Health Studies were excluded when fitting the model.

Cronin et al. described the methods for modeling repeat screening behavior for all women using data from 1994-2001. For this analysis the model was updated to include data from 1994-2005 and models were fit separately for all women, non-Hispanic white, African American and Hispanic women. We use the same approach and inclusion criterion as presented in Cronin et al. (1)and Yu (2) summarized below.

Gap time was defined as the time between subsequent screening exams. If a women appears multiple time in the data set (i.e., she has more than two mammograms in the data set), she will contribute multiple gap times to the analysis. *A priori*, three classes of women were defined; annual, biennial and irregular screeners. Each woman was categorized as either annual screeners (mean gap time of <1.5 years), biennial screeners (mean gap time ≥1.5 years and < 2.5 years) or irregular screeners (mean gap time ≥2.5 years). A gamma frailty survival analysis was performed separately for each screening group for all women combined and by race/ethnicity. Covariates included in the model were age (18-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90+) and whether or not the mammogram at the beginning of the interval was a first mammogram. A frailty model was used to capture the correlation introduced by multiple observations from the same women. Table A1 shows parameter estimates for each of the 12 stratified survival models fit to the data. Figure A3 shows a sample of modeled survival distribution for the time between successive screening mammograms for all women and by race/ethnicity.

The curves by race/ethnicity look very similar for each category of screener because the same criterion was used to classify women into annual, biennial and irregular screening categories. Differences between the race/ethnicity groups in estimating gap time are characterized in the percent of the population that falls into each of the defined categories. Table A2 shows the percentage of women that were classified into the three screening categories by age and race/ethnicity.

COMBINING THE COMPONENTS THROUGH SIMULATION

Simulation was used to combine the two components of the mammography dissemination and usage model and generate a population of women that have screening histories representative of the US population.

The following steps were used:

1. Generate a date of first mammogram based on the cumulative distribution for the time to first exam conditioned on year of birth.
2. Generate a frailty parameter that a woman keeps throughout her lifetime.
3. Generate a random number that defines her screening category (annual, biennial or irregular) conditioned on her current age, see Cronin et al for details.
4. At each mammography exam generate the gap time until the next exam conditioned on age, whether or not it was her first screening exam, category of screening, and frailty parameter.

Screening histories for women born between the year 1919 and 1960 were simulated over time to estimate screening rates in the simulated population for ages 40 to 89 in the years 1999 and 2000.

Table A1 Survival model parameters for time between subsequent mammograms

Annual	All Women	White Non-Hispanic	African American	Hispanic
Age (reference 50-59)				
18-39	-0.311	-0.324	-0.194	-0.299
40-49	-0.125	-0.132	-0.089	-0.116
60-69	-0.003	-0.004	0.025	-0.013
70-79	-0.037	-0.358	-0.0557	-0.101
80-89	-0.238	-0.256	-0.183	-0.306
90+	-0.584	-0.599	-0.336	-0.981
First mammogram (reference no)				
Yes	-0.099	-0.246	-0.180	-0.293
Missing	-0.099	-0.116	-0.056	-0.07
Variance of Gamma frailty	0.013	0.019	0	0.002

Biennial	All Women	White Non-Hispanic	African American	Hispanic
Age (reference 50-59)				
18-39	-0.361	-0.364	-0.286	-0.376
40-49	-0.047	-0.041	-0.061	-0.075
60-69	-0.024	-0.237	0.012	-0.046
70-79	-0.056	-0.050	-0.013	-0.126
80-89	-0.279	-0.277	-0.170	-0.408
90+	-0.658	-0.697	-0.511	-0.832
First mammogram (reference no)				
Yes	-0.115	-0.096	0.073	-0.167
Missing	0.226	0.192	0.301	0.155
Variance of Gamma frailty	0.0004	.0005	0	0

Irregular	All Women	White Non-Hispanic	African American	Hispanic
Age (reference 50-59)				
18-39	-0.478	-0.476	-0.475	-0.418
40-49	-0.068	-0.050	-0.078	-0.078
60-69	0.012	0.019	0.016	0.017
70-79	-0.027	-0.006	-0.039	-0.100
80-89	-0.227	-0.205	-0.155	-0.397
90+	-0.583	-0.594	-0.427	-0.979
First mammogram (reference no)				
Yes	-0.431	-0.282	-0.368	-0.447
Missing	1.116	1.038	1.096	0.885
Variance of Gamma frailty	0.002	0.002	0	0

Table A2. Proportion of women who have had at least one screening mammogram between 1994-2005 that are classified as annual, biennial or irregular screeners by age, race and ethnicity.

Age	**All Women**	**White Non-Hispanic**	**African American**	**Hispanic**
18-39				
Annual	**12.1**	**12.4**	**9.8**	**12.8**
Biennial	**23.3**	**24.0**	**23.2**	**22.5**
Irregular	**64.6**	**63.7**	**67.1**	**64.7**
40-49				
Annual	**24.6**	**26.4**	**17.7**	**21.6**
Biennial	**33.2**	**33.6**	**34.8**	**33.5**
Irregular	**42.2**	**40.0**	**47.5**	**44.9**
50-59				
Annual	**36.5**	**39.4**	**29.2**	**30.3**
Biennial	**31.8**	**31.4**	**34.9**	**34.1**
Irregular	**31.7**	**29.2**	**35.9**	**35.6**
60-69				
Annual	**38.1**	**41.7**	**31.9**	**31.4**
Biennial	**29.8**	**29.1**	**33.2**	**32.3**
Irregular	**32.1**	**29.2**	**34.9**	**36.3**
70-79				
Annual	**33.0**	**35.9**	**28.1**	**26.9**
Biennial	**30.3**	**30.1**	**32.5**	**32.6**
Irregular	**36.8**	**33.9**	**39.4**	**40.5**

Appendix Figures

Figure A1. Cumulative distribution for the time until first mammogram for all women by birth cohort.

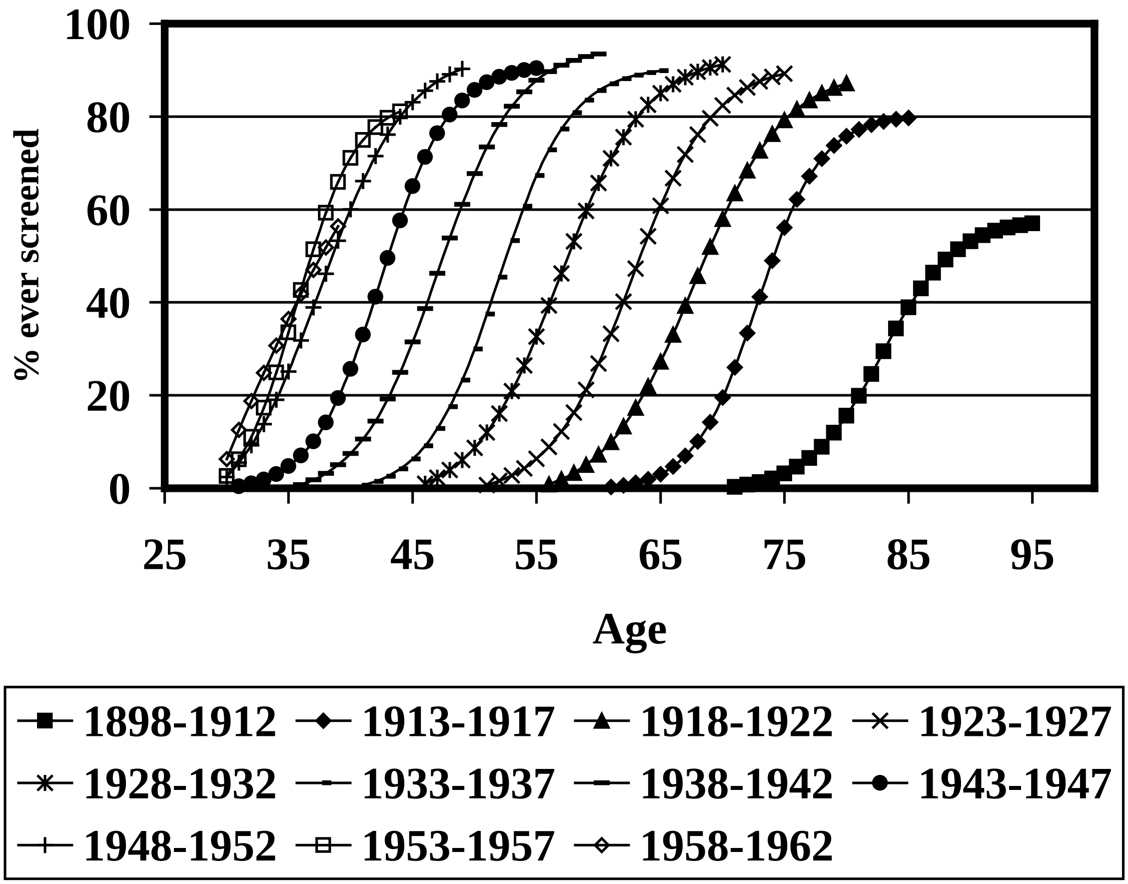
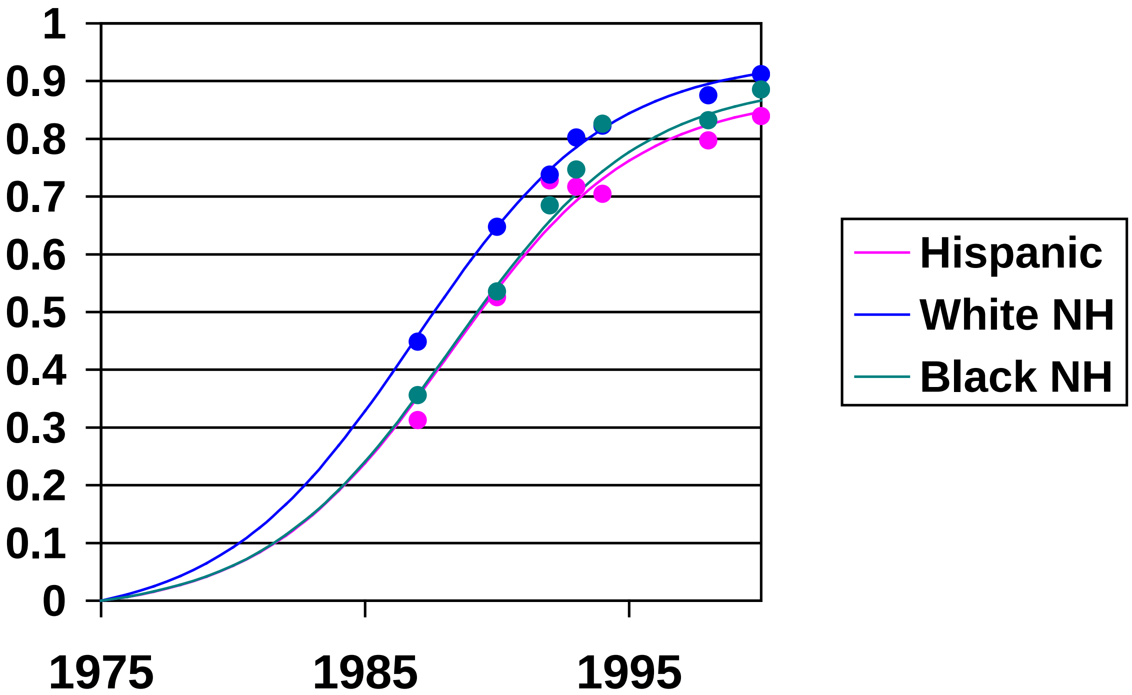
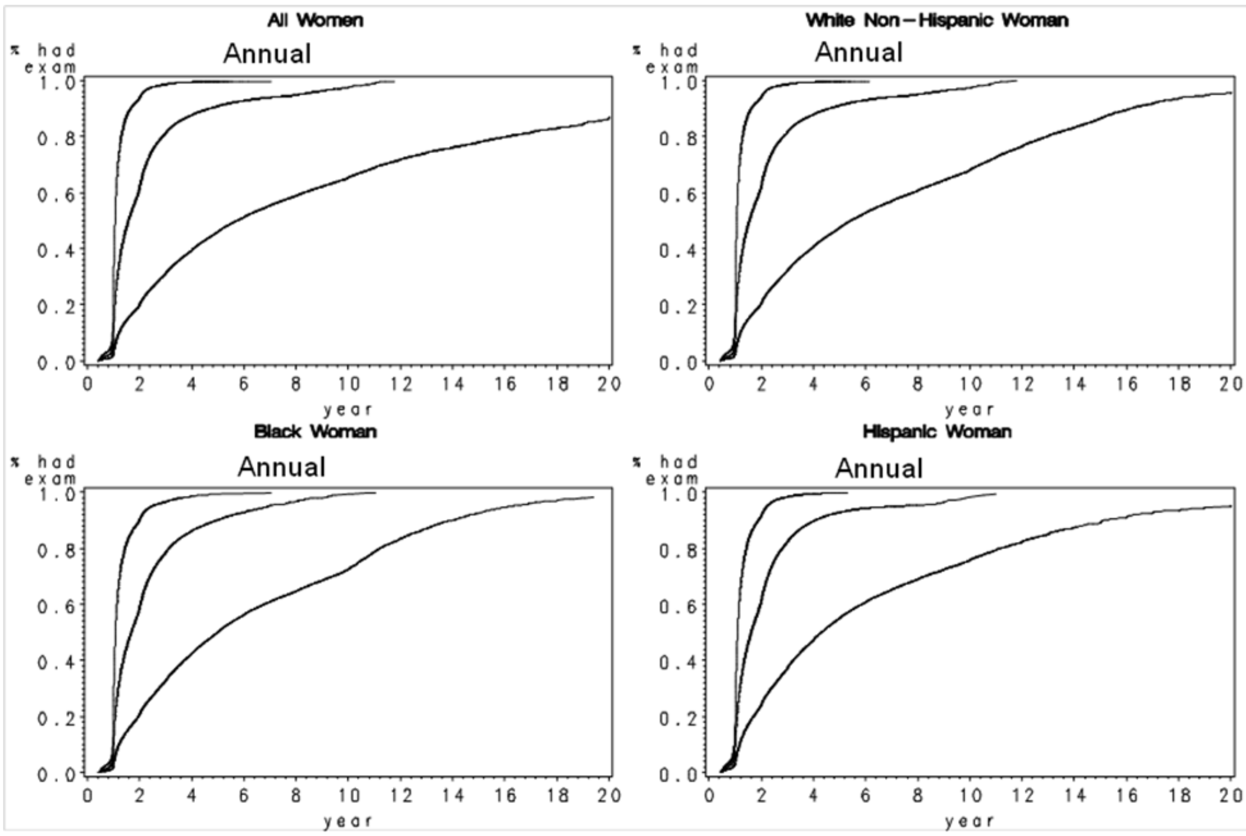


Figure A2. Cumulative distribution for time until first mammogram by race and ethnicity.



If born before1945, first mammogram based on calendar year.
If born in 1945 or after, first mammogram based on women's age

Figure A3. Modeled survival curves for the time between subsequent mammography exams for women age 50-59 when the exam at the beginning of the interval is a second or later mammogram.



Reference List

(1) Cronin KA, Yu B, Krapcho M, Miglioretti DL, Fay MP, Izmirlian G et al. Modeling the dissemination of mammography in the United States. Cancer Causes and Control 2005; 16:701-712.

(2) Yu B. Estimation of shared Gamma frailty models by a modified EM algorithm. Computational Statistics & Data Analysis 2006; 50:463-474.