Trends in Mammography Over Time for Women With and Without Chronic Disability

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Abstract

Background: Women with disabilities often receive mammograms at lower rates than do nondisabled women, although this disparity varies by disability type and severity. Given the implementation of disability civil rights laws in the early 1990s, we examined whether disability disparities in mammogram use have diminished over time.

Methods: We analyzed National Health Interview Survey responses of civilian, noninstitutionalized United States female residents 50 to 74 years old from selected years between 1998 and 2010. We identified seven chronic disability types using self-reported functional impairments, activity/participation limitations, and expected duration. We conducted bivariable and multivariable logistic regression analyses examining associations of self-reported mammogram use within the previous two years with sociodemographic factors and disability.

Results: Most chronic disability rates rose over time. The most common disability was movement difficulties, with rates increasing from 35.6% (1998) to 39.8% (2010). Mammogram rates for all women remained relatively stable over time, ranging from 72% to 75%. Bivariable analyses generally found statistically significantly lower mammogram rates for women with disability versus nondisabled women. Over time, disparities grew significantly between women with any basic action difficulty or complex activity limitation and nondisabled women ($p < 0.01$). In multivariable logistic analyses, having any difficulty with basic actions was significantly associated with lower adjusted odds of mammography; for example, adjusted odds [95% confidence interval] = 0.5 [0.3–0.8], $p = 0.006$, in the model involving movement disability.

Conclusions: Little has changed since 1998 in mammogram rates for women with versus without disabilities. Women with certain disabilities continue to experience disparities in mammography testing.

Introduction

IN 2000, *HEALTHY PEOPLE 2010*, which set decennial national health priorities, added Americans with disabilities to their list of population subgroups that can experience health and health care disparities.¹ The report observed that common misconceptions about persons with disabilities contribute to an “underemphasis on health promotion and disease prevention activities” for this population. Enactment of the Americans with Disabilities Act (ADA) in 1990, which mandated new civil rights protections to individuals with disabilities, had heightened attention to this population, which previously had not received intensive public health scrutiny.

An early finding of disability disparities involved lower mammogram rates. Data from the 1994 and 1995 National

Health Interview Survey disability supplement (NHIS-D)^{2,3} showed that women with significant mobility difficulties had 30% lower mammogram rates than nondisabled women, even accounting for sociodemographic characteristics.⁴ Subsequent studies using population-based surveys, including later versions of NHIS,⁵ the Medical Expenditure Panel Survey,^{6–8} Medicare Current Beneficiary Survey,⁹ and Behavioral Risk Factor Surveillance System,^{10,11} have usually found that women with disabilities have significantly lower mammogram rates than nondisabled women, although differences have varied by disability type and severity.^{6,12,13}

These population-based surveys are not designed to determine the causes of disparities between women with versus without disabilities. Possible reasons include women's preferences for care; competing health concerns, such as

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coexisting diseases that reduce the priority of mammograms; previous unpleasant experiences with mammography; failures of women's physicians to recommend mammograms because of discriminatory attitudes, such as failure to appreciate the desire of disabled women to maximize their health and wellness; and lack of mammography equipment that is accessible to women with disabilities.^{14–25} Some factors, such as women's competing health risks, are unlikely to have changed since the ADA's implementation. However, other possible barriers, including discriminatory attitudes and inaccessible equipment, might have lessened in the past two decades.

This research examined trends in mammogram use between 1998 and 2010 among women with versus without chronic disabilities. Because some studies have found that mammogram disparities vary by disability type, we analyzed mammography rates using seven different definitions of chronic disability. We hypothesized that (1) mammogram use has increased over time for all U.S. women, including women with disabilities; and (2) disparities in mammography rates between women with versus without chronic disabilities have decreased over time after adjusting for other confounding variables.

Materials and Methods

The Massachusetts General Hospital–Partners HealthCare Institutional Review Board exempted this study from oversight because it used nonidentifiable data.

Data

We downloaded NHIS Public Release data from the National Center for Health Statistics (NCHS) website. We obtained data only from years that included supplemental questionnaires on cancer screening services supported by the U.S. Preventive Services Task Force²⁶: 1998, 2000, 2003, 2005, 2008, and 2010. Because NCHS fundamentally redesigned NHIS in 1997, we could not conduct direct comparisons with 1994–1995 NHIS-D data.

The NHIS Basic Module or Core questionnaire includes the Family Core, Sample Adult Core, and Sample Child Core. The Family Core gathers information on all family members in sampled households, while one randomly selected adult (age ≥18 years) receives the Sample Adult Core questionnaire. This survey asks for details about health and functional status and supplemental questions such as about cancer screening. If the randomly sampled adult is unavailable (e.g., not home) or physically or mentally unable to participate, a knowledgeable adult family member provides proxy responses. NHIS oversamples black and Hispanic populations; since 2006, it has oversampled Asian populations. To produce nationally representative estimates for civilian, noninstitutionalized U.S. residents, analyses use NHIS sampling weights.

Chronic disability indicators

As described elsewhere,²⁷ we build our chronic disability algorithms around methods developed by NCHS analysts.⁵ Their algorithms use responses from the Sample Adult Core “Adult Health Status and Limitations” section, which asks about “difficulties” in performing various functions “with-

out using any special equipment” because of “any physical, mental, or emotional problem or illness (not including pregnancy).” By combining responses from different questions, we created seven disability indicators (yes/no variables) within two broad categories, as follows:

Basic action difficulties (BADs).

- **Movement difficulty:** yes if person reports that walking, standing, stair climbing, sitting, stooping, reaching, grasping, or carrying is “somewhat difficult,” “very difficult,” or “can’t do at all”
- **Sensory (hearing or seeing) difficulty:** yes if person reports trouble seeing even when wearing glasses or contact lenses or blind/unable to see at all, or if person reports being deaf or having a “lot of trouble” hearing without a hearing aid
- **Emotional difficulty:** yes if person reports feelings of being sad, nervous, restless, hopeless, “everything was an effort,” or worthless in the past 30 days
- **Cognitive difficulty:** yes if person reports being limited in any way because of difficulty remembering or because of periods of confusion

Complex activities limitations (CALs).

- **Self-care limitation:** yes if person reports difficulty with any component of activities of daily living or instrumental activities of daily living
- **Social limitation:** yes if person reports that going out, participating in social activities, or relaxing is “somewhat difficult,” “very difficult,” or they “can’t do at all”
- **Work limitation:** yes if person cannot work at a job or business or is limited in the kind or amount of work because of a physical, mental, or emotional problem

The seven disability indicators are not clinically mutually exclusive. For instance, individual BADs might contribute to persons having CAL problems. We further combined the four individual BAD and three individual CAL variables to create new indicators (yes/no variables) as follows: “any BAD” if a person had any one of the four BAD indicators described above; “any CAL” if a person had any one of the three CAL indicators; and “any disability” if a person had any one of the three BAD or any one of the four CAL indicators.

We subdivided movement difficulties into five mutually exclusive severity levels (level 1 = “least severe” to level 5 = “most severe”) using methods described elsewhere.^{1,5} This approach, developed by NCHS analysts, assigns weights to the eight movement items based on “how important a particular function would be to maintaining an independent lifestyle.”^{1,5} We refined all seven disability indicators by including only those difficulties that respondents described as chronic, defined by NHIS as lasting for 3 months or longer. We combined participants who reported nonchronic (temporary) conditions with those without the particular disability.²⁷

Mammogram indicator

Mammogram use come from a supplemental questionnaire administered to Sample Adult Core female participants 50 to 74 years old. The same definition was used over the years as follows: mammogram within the prior 2 years for women

who did not have a history of breast cancer. Across the study years, from 3.9% to 5.0% of women reported histories of breast cancer; these women were excluded from the bivariable and multivariable analyses.

Other variable definitions

We used information from Sample Adult Core responses to create the sociodemographic variables except for income, which we obtained from the Family Core survey. We grouped age into categories. Because NHIS is cross-sectional, we could not look at these factors longitudinally for individual women.

Analysis

NHIS changed its sampling design in 2006. Therefore, all analyses and statistical tests for trends over time accounted for correlations that might exist among data collected within the same design period (years 1998–2005 and 2008–2010).²⁸

We calculated standardized mammography rates among women with different disability indicators using population age distributions from the 2010 U.S. Census (www.census.gov/prod/cen2010/briefs/c2010br-03.pdf) as weights in the analyses. For example, in 2010, 30,246,432 women (72.25%) were 50–64 years of age and 11,616,910 women (27.75%) were aged 65–74 years. We therefore used 0.7225 and 0.2775 as weights in our analyses to obtain the mammogram rates. For each of the 6 years, we then compared mammogram use within each disability type with use among women without any of the seven disabilities. We tested whether these rates differed significantly within each year and also across the years. For this later analysis, we combined data across years and obtained the adjusted percentages from separate logistic regression models with mammogram use as the outcome variable and disability type, survey year, and an interaction term between disability status and survey year as predictor variables. The interaction term tested whether the association of mammogram use and disability varied over time (Hypothesis 1). We looked at 15 interaction terms between disability and year (adjusting for age), including the 7 disability indicators, the 5 movement severity levels, and whether individuals had any BAD, any CAL, or any BAD or CAL.

We conducted separate multivariable logistic regressions for each year to evaluate predictors of receiving mammograms. Before we finalized the multivariable models, we assessed how to enter the seven disability indicators by examining correlation coefficients among BADs and among CALs separately within each of the study years. BADs and CALs were moderately correlated (correlation coefficients from 0.2 to 0.5), and correlations remained similar across the study years. We performed two sets of multivariable logistic regressions, including the sociodemographic variables specified below and either: (1) each BAD or CAL separately in seven individual models, along with an indicator of whether the person had any BAD or any CAL, as appropriate; or (2) all BAD and CAL indicators simultaneously in the model. We show only results from the first model (1) for 2010.

Multivariable logistic regression models included sociodemographic variables as follows: age category (50–64 years, 65–74 years); race (white, black, Asian, and other/multiple race); Hispanic ethnicity (yes/no); education (less than high school, high school, some college/associates degree, college graduate and advanced degrees); income less

than 100% of federal poverty level (yes/no); has health insurance (yes/no); and has a usual source of health care (yes/no). We used likelihood ratio tests to assess the effect of adding each sociodemographic variable to initial models that included only the specific disability indicator or set of seven disability indicators. We also examined the effect of adding individual disability indicators (or set of seven indicators) to a model that included all sociodemographic variables.

We conducted all analysis in SAS 9.2 and SUDAAN 11.0 and considered a two-sided p -value < 0.05 to be statistically significant. Analyses accounted for the complex sampling design and use NHIS sampling weights to produce nationally representative estimates for civilian, noninstitutionalized U.S. residents.

Results

Table 1 shows demographic characteristics and chronic disability rates among women ages 50 to 74 years across the study years. The proportion of women ages 50 to 64 years grew from 66.5% in 1998 to 72.2% in 2010. The most prominent racial and ethnic changes involved increasing percentages of Asian and Hispanic women, although these absolute percentages remained relatively low. Educational attainment increased over time, as did lack of health insurance.

Table 1 also presents rates of each chronic disability type over time among women ages 50 to 74 without histories of breast cancer. With a few exceptions, chronic disability rates increased over time. In 1998, 39.7% of women reported some chronic disability, rising to 43.1% in 2010. Movement difficulties were the most common disability type, affecting 39.8% of women in 2010. Over time, the percentage of women with the most severe movement difficulties fluctuated around 3% and 4%.

Mammogram use over time

Our first hypothesis was that mammography rates would rise over time. However, as shown in Table 2 and Figures 1 and 2, mammogram use did not vary significantly over time. Rates fluctuated somewhat across years, staying around 75% for all women in 2008 and 2010. Mammogram use did not change significantly across the years for any subgroup of women, including women within each of the seven chronic disability types. Of the 17 different interaction terms we computed between disability status and year, only five were statistically significant as follows: movement difficulty ($p = 0.02$); work limitation ($p = 0.01$); any BAD ($p = 0.02$); any CAL ($p = 0.04$); and any BAD or CAL ($p = 0.01$).

Mammogram use by disability status

We also hypothesized (Hypothesis 2) that differences in mammogram rates between women with versus without chronic disabilities would lessen over time, after accounting for other covariates including other disability types. This hypothesis assumes that disability disparities did exist. As shown in Table 2 and Figures 1 and 2, bivariable analyses found lower mammogram rates between women with various disabilities and nondisabled women, with most (although not all) differences being statistically significant. One exception involved women with the least severe movement difficulties, who had slightly higher mammogram rates than other women; these findings were not statistically significant. Women with more severe movement difficulties, chronic emotional difficulty, or self-care

TABLE 1. DEMOGRAPHIC AND DISABILITY CHARACTERISTICS OVER TIME AMONG WOMEN AGED 50–74 YEARS

Variables	Year					
	1998	2000	2003	2005	2008	2010
NHIS respondents: <i>n</i>	5,539	5,477	5,512	5,827	4,237	5,336
Age in years: mean (SE)	60.6 (0.1)	60.3 (0.1)	60.0 (0.1)	59.9 (0.1)	59.9 (0.1)	60.1 (0.1)
<i>Column percent (standard error)</i>						
Age category						
50–64 years	66.5 (0.7)	68.4 (0.7)	71.0 (0.8)	72.1 (0.7)	72.6 (0.8)	72.2 (0.7)
65–74 years	33.5 (0.7)	31.6 (0.7)	29.0 (0.8)	27.9 (0.7)	27.4 (0.8)	27.8 (0.7)
Race						
White	85.3 (0.5)	84.8 (0.6)	86.0 (0.6)	84.6 (0.6)	82.5 (0.7)	81.7 (0.6)
Black	10.4 (0.5)	10.3 (0.5)	10.4 (0.5)	10.8 (0.5)	11.5 (0.6)	11.7 (0.5)
Asian	2.3 (0.3)	2.3 (0.3)	2.4 (0.3)	3.1 (0.3)	4.1 (0.3)	4.2 (0.3)
Other, multiple races	1.9 (0.2)	2.7 (0.2)	1.2 (0.1)	1.5 (0.2)	1.9 (0.2)	2.3 (0.2)
Hispanic ethnicity	7.0 (0.3)	7.5 (0.4)	8.2 (0.4)	8.3 (0.5)	8.5 (0.5)	9.0 (0.4)
Education						
Less than high school	22.7 (0.7)	20.3 (0.7)	17.8 (0.6)	16.0 (0.6)	15.0 (0.6)	13.8 (0.6)
High school	37.3 (0.8)	36.3 (0.8)	34.7 (0.8)	33.4 (0.8)	31.3 (0.9)	29.0 (0.8)
Some college/associates degree	23.9 (0.7)	24.3 (0.7)	27.1 (0.7)	26.6 (0.6)	29.3 (0.9)	29.7 (0.7)
College and advanced degrees	16.1 (0.6)	19.1 (0.6)	20.3 (0.7)	24.0 (0.7)	24.4 (0.8)	27.5 (0.9)
Income less than poverty threshold	11.6 (0.6)	10.7 (0.6)	11.1 (0.6)	8.8 (0.4)	9.8 (0.6)	11.1 (0.5)
No health insurance	8.7 (0.4)	8.5 (0.4)	9.4 (0.5)	9.4 (0.5)	9.3 (0.6)	10.1 (0.5)
No usual source of health care	7.0 (0.4)	5.7 (0.4)	5.5 (0.3)	6.0 (0.4)	6.1 (0.5)	7.3 (0.4)
No disability*	60.3 (0.8)	62.6 (0.8)	59.7 (0.8)	59.5 (0.7)	60.6 (0.9)	56.9 (0.9)
Basic action difficulties (BAD)*						
Movement difficulty	35.6 (0.7)	34.2 (0.8)	37.0 (0.8)	37.2 (0.7)	35.6 (0.9)	39.8 (0.9)
Least severe	7.3 (0.4)	7.8 (0.4)	8.8 (0.5)	8.5 (0.4)	7.6 (0.5)	10.0 (0.5)
Level 2	9.7 (0.4)	8.7 (0.4)	9.0 (0.4)	10.1 (0.5)	9.5 (0.6)	10.5 (0.5)
Level 3	8.8 (0.4)	9.0 (0.4)	8.9 (0.5)	8.7 (0.4)	10.0 (0.6)	9.6 (0.5)
Level 4	5.6 (0.3)	5.4 (0.3)	6.0 (0.4)	5.8 (0.3)	5.2 (0.4)	5.7 (0.4)
Most severe	4.2 (0.3)	3.3 (0.3)	4.3 (0.3)	4.1 (0.3)	3.3 (0.3)	4.0 (0.3)
Sensory difficulty	11.3 (0.5)	11.0 (0.5)	11.2 (0.5)	11.4 (0.5)	11.5 (0.6)	12.1 (0.6)
Emotional difficulty	3.0 (0.2)	3.0 (0.3)	3.9 (0.3)	3.5 (0.3)	3.4 (0.3)	4.1 (0.3)
Cognitive difficulty	3.0 (0.3)	2.5 (0.2)	3.2 (0.3)	3.4 (0.2)	3.5 (0.4)	3.9 (0.3)
Any BAD ^b	38.3 (0.7)	36.3 (0.8)	39.3 (0.8)	39.5 (0.7)	38.2 (0.9)	42.1 (0.9)
Complex action limitations (CAL)*						
Self-care limitation	6.0 (0.3)	5.0 (0.3)	6.0 (0.4)	6.1 (0.4)	5.8 (0.5)	6.7 (0.4)
Social limitation	11.3 (0.5)	10.7 (0.5)	13.0 (0.6)	12.0 (0.5)	11.2 (0.6)	13.4 (0.6)
Work limitation	17.7 (0.6)	15.2 (0.6)	16.9 (0.6)	16.8 (0.6)	17.4 (0.7)	17.4 (0.7)
Any CAL ^c	21.4 (0.6)	18.8 (0.6)	21.2 (0.7)	20.6 (0.6)	20.6 (0.8)	21.9 (0.7)
Any disability ^d	39.7 (0.8)	37.4 (0.8)	40.3 (0.8)	40.5 (0.7)	39.4 (0.9)	43.1 (0.9)

*Excludes women with breast cancer.

^aAll analyses accounted for the complex sampling design and use National Health Interview Survey (NHIS) sampling weights to produce nationally representative estimates for civilian, noninstitutionalized United States residents

^b“Yes” if has any one of the four BADs.

^c“Yes” if has any one of the three CALs.

^d“Yes” if has either any BAD or any CAL.

limitations had particularly low mammogram rates compared with nondisabled women. Significance levels varied, which might relate to fluctuating and sometimes small sample sizes.

For several subgroups of disabled women, disparities grew significantly across the years. Differences in mammogram rates between disabled and nondisabled women increased over time with statistical significance as follows: movement difficulties ($p=0.02$); any BAD ($p=0.02$); work limitations ($p=0.01$); any CAL ($p=0.04$); and any disability ($p=0.01$).

Multivariable regression results

Table 3 presents adjusted odds ratios from multivariable logistic regression models using 2010 data to predict mam-

mogram use based on sociodemographic characteristics, whether the woman had one of the seven disability types, and whether she had any BAD or CAL, as appropriate. According to likelihood ratio tests, all sociodemographic characteristics were substantially more important predictors of mammogram receipt than the disability indicators. Across all seven models, younger age, black race, Hispanic ethnicity, high school and greater education, higher income, having health insurance, and having a usual source of care had significant associations with receiving mammograms.

After accounting for these sociodemographic characteristics, movement difficulty severity was the only individual disability type significantly associated with mammogram use

TABLE 2. MAMMOGRAM RATES BY DISABILITY TYPE AMONG WOMEN AGED 50–74 YEARS AND NO BREAST CANCER

Disability Type	Year					
	1998	2000	2003	2005	2008	2010
	Row percent (SE) ^{a,b}					
All women	72.1 (0.7)	76.7 (0.7)	75.3 (0.7)	73.5 (0.7)	74.8 (0.9)	74.7 (0.8)
No disability	73.1 (0.9)	78.4 (0.9)	76.3 (0.8)	75.3 (0.9)	78.5 (1.0)	77.3 (1.0)
BAD						
Movement difficulty	71.3 (1.3)	74.1 (1.2) [†]	73.9 (1.2)	71.5 (1.2) [†]	69.4 (1.5) [*]	71.8 (1.3) [†]
Least severe	75.5 (2.4)	76.1 (2.5)	80.8 (2.3)	78.0 (2.3)	73.1 (3.2)	78.3 (2.5)
Level 2	75.2 (2.2)	77.2 (2.3)	72.0 (2.4)	72.8 (2.4)	71.2 (2.8) [§]	71.8 (2.6) [§]
Level 3	69.6 (2.4)	70.2 (2.3) [†]	76.5 (2.3)	70.4 (2.3) [§]	69.9 (2.7) [†]	72.4 (2.6)
Level 4	71.7 (2.8)	76.9 (2.9)	69.9 (3.0) [§]	64.2 (3.4) [†]	67.4 (4.3) [†]	66.1 (3.3) [†]
Most severe	59.1 (4.3) [†]	67.0 (4.3) [†]	64.3 (3.6) [†]	67.2 (3.5) [§]	58.0 (4.9) [*]	60.4 (4.4) [*]
Sensory difficulty	68.4 (2.2) [§]	73.6 (2.0) [§]	72.4 (2.1)	64.6 (2.3) [*]	67.2 (2.9) [†]	68.8 (2.3) [†]
Emotional difficulty	58.0 (4.2) [†]	60.7 (4.0) [*]	64.3 (3.4) [†]	62.1 (3.8) [†]	61.2 (5.5) [†]	65.1 (4.1) [†]
Cognitive difficulty	63.4 (3.9) [§]	75.1 (3.8)	67.6 (4.3) [§]	62.7 (3.9) [†]	65.9 (4.8) [†]	63.0 (4.0) [†]
Any BAD ^b	71.1 (1.2)	74.1 (1.1) [†]	73.8 (1.2)	71.2 (1.1) [†]	69.9 (1.5) [*]	71.4 (1.2) [*]
CAL						
Self-care limitation	65.9 (3.0) [§]	74.0 (3.0)	65.3 (3.0) [†]	61.8 (3.1) [*]	60.6 (4.4) [*]	62.8 (3.6) [*]
Social limitation	65.7 (2.2) [†]	69.9 (2.1) [*]	67.2 (2.1) [*]	68.5 (2.0) [†]	66.8 (2.9) [*]	64.8 (2.5) [*]
Work limitation	70.0 (1.6)	70.0 (1.7) [*]	71.2 (1.7) [†]	67.6 (1.8) [†]	67.3 (2.2) [*]	66.5 (1.9) [*]
Any CAL ^c	69.0 (1.5) [§]	70.8 (1.5) [*]	70.4 (1.5) [†]	69.5 (1.6) [†]	67.6 (2.1) [*]	66.7 (1.8) [*]
Any disability ^d	71.2 (1.2)	74.1 (1.1) [†]	74.0 (1.1)	71.4 (1.1) [†]	69.8 (1.4) [*]	71.4 (1.2) [*]

Percentages adjusted by age distribution from the 2010 US Census.

p-Values for comparison with women without disability: ^{*}*p* ≤ 0.0001, [†]*p* ≤ 0.001, [‡]*p* ≤ 0.01, [§]*p* ≤ 0.05.

Screening rates did not change substantially over time. However, there was a statistically significant trend over time in the differences in screening rates between those with no disability and women with movement disability (*p* = 0.02), any BAD (*p* = 0.02), with work limitations (*p* = 0.01), any CAL (*p* = 0.04), and any disability (*p* = 0.01). The *p*-values for other interactions ranged from 0.10 to 0.77.

^aAll analyses accounted for the complex sampling design and use NHIS sampling weights to produce nationally representative estimates for civilian, noninstitutionalized U.S. residents.

^b“Yes” if having any one of the four BADs.

^c“Yes” if having any one of the three CALs.

^d“Yes” if having either any BAD or any CAL.

FIG. 1. Basic actions disabilities mammogram screening rates by year. BAD, basic actions disabilities; CAL, complex actions limitations; MAM, mammogram.

FIG. 2. Complex actions limitations mammogram screening rates by year.

TABLE 3. ADJUSTED ODDS OF RECEIVING A MAMMOGRAM IN 2010 ACCOUNTING FOR SOCIODEMOGRAPHIC FACTORS AND DISABILITY STATUS

Variables	Models						
	Movement	Sensory	Emotional	Cognitive	Self-care	Social	Work
NHIS sample (<i>n</i>)	4,036	4,035	4,026	3,908	3,992	3,918	3,992
<i>Sociodemographic</i>							
Age category (<i>p</i> -values)	0.0113	0.0121	0.0073	0.0141	0.0184	0.0132	0.0130
50–64 years	1.0	1.0	1.0	1.0	1.0	1.0	1.0
65–74 years	0.8 [0.6–0.9]	0.8 [0.6–0.9]	0.8 [0.6–0.9]	0.8 [0.6–0.9]	0.8 [0.6–1.0]	0.8 [0.6–0.9]	0.8 [0.6–0.9]
Race (<i>p</i> -values)	0.0080	0.0147	0.0160	0.0122	0.0079	0.0124	0.0083
White	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Black	1.3 [1.0–1.7]	1.3 [1.0–1.6]	1.3 [1.0–1.6]	1.3 [1.0–1.7]	1.3 [1.1–1.7]	1.3 [1.0–1.7]	1.3 [1.0–1.7]
Asian	0.6 [0.4–1.0]	0.7 [0.4–1.0]	0.7 [0.4–1.0]	0.7 [0.4–1.0]	0.7 [0.4–1.0]	0.7 [0.4–1.0]	0.7 [0.4–1.0]
Other, multiple races	1.0 [0.6–1.9]	1.0 [0.6–1.8]	1.0 [0.5–1.7]	1.1 [0.6–2.0]	1.1 [0.6–2.0]	1.1 [0.6–2.2]	1.1 [0.6–1.9]
Hispanic ethnicity (<i>p</i> -values)	0.0006	0.0007	0.0009	0.0008	0.0011	0.0011	0.0014
Yes	1.7 [1.3–2.3]	1.7 [1.3–2.3]	1.7 [1.2–2.3]	1.7 [1.3–2.4]	1.7 [1.2–2.3]	1.7 [1.2–2.3]	1.7 [1.2–2.3]
No	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Education (<i>p</i> -values)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Less than high school	1.0	1.0	1.0	1.0	1.0	1.0	1.0
High school	1.5 [1.1–2.0]	1.5 [1.2–2.0]	1.5 [1.2–2.0]	1.5 [1.2–2.0]	1.5 [1.2–2.0]	1.5 [1.1–2.0]	1.5 [1.1–2.0]
Some college/associates degree	1.7 [1.3–2.2]	1.7 [1.3–2.3]	1.7 [1.3–2.3]	1.8 [1.4–2.4]	1.8 [1.3–2.3]	1.8 [1.3–2.4]	1.7 [1.3–2.3]
College and advanced degrees	2.3 [1.7–3.1]	2.4 [1.8–3.2]	2.3 [1.7–3.1]	2.4 [1.8–3.2]	2.3 [1.7–3.1]	2.3 [1.7–3.1]	2.3 [1.7–3.1]
Income less than poverty threshold (<i>p</i> -values)	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	0.0006	0.0003
Yes	0.6 [0.5–0.8]	0.6 [0.5–0.7]	0.6 [0.5–0.7]	0.6 [0.5–0.8]	0.6 [0.5–0.8]	0.6 [0.5–0.8]	0.6 [0.5–0.8]
No	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Health insurance (<i>p</i> -values)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Yes	1.0	1.0	1.0	1.0	1.0	1.0	1.0
No	0.3 [0.2–0.4]	0.3 [0.2–0.4]	0.3 [0.2–0.4]	0.3 [0.2–0.3]	0.3 [0.2–0.3]	0.3 [0.2–0.3]	0.3 [0.2–0.3]
Has usual source of care (<i>p</i> -values)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Yes	1.0	1.0	1.0	1.0	1.0	1.0	1.0
No	0.3 [0.2–0.4]	0.3 [0.2–0.4]	0.3 [0.2–0.4]	0.3 [0.2–0.4]	0.3 [0.2–0.4]	0.3 [0.2–0.4]	0.3 [0.2–0.4]
<i>Basic action difficulties (BAD)</i>							
Severity of Movement difficulty (<i>p</i> -values)	0.0011						
Least Severe	2.1 [1.2–3.7]						
Level Two	1.6 [0.9–2.7]						
Level Three	1.7 [1.0–2.9]						
Level Four	1.2 [0.6–2.1]						
Most Severe	0.9 [0.5–1.7]						
No	1.0						
Sensory difficulty (<i>p</i> -values)		0.8540					
Yes		1.0 [0.7–1.3]					
No		1.0					
Emotional difficulty (<i>p</i> -values)			0.9309				
Yes			1.0 [0.7–1.5]				
No			1.0				
Cognitive difficulty (<i>p</i> -values)				0.1489			
Yes				0.7 [0.5–1.1]			
No				1.0			
Any BAD ^b	0.0060	0.0218	0.0093	0.0532			
Yes	0.5 [0.3–0.8]	0.8 [0.6–1.0]	0.8 [0.6–0.9]	0.8 [0.7–1.0]			
No	1.0	1.0	1.0	1.0			
<i>Complex action limitations (CAL)</i>							
Self-care limitation (<i>p</i> -values)					0.1188		
Yes					0.7 [0.5–1.1]		
No					1.0		
Social limitation (<i>p</i> -values)						0.0744	
Yes						0.7 [0.5–1.0]	
No						1.0	
Work limitation (<i>p</i> -values)							0.4022
Yes							0.8 [0.6–1.3]
No							1.0
Any CAL ^c					0.0034	0.2535	0.1003
Yes					0.7 [0.5–0.9]	0.8 [0.6–1.2]	0.7 [0.5–1.1]
No					1.0	1.0	1.0

Data presented as adjusted odds ratio [95% confidence interval]; *p*-value (where indicated).

^aAll analyses accounted for the complex sampling design and use NHIS sampling weights to produce nationally representative estimates for civilian, noninstitutionalized U.S. residents.

^b“Yes” if has any one of the four BADs.

^c“Yes” if has any one of the three CALs.

($p=0.0011$). We did not find a dose-response: that is, the adjusted odds of receiving mammogram did not increase or decrease monotonically with the severity level. However, the findings by movement difficulty severity level seem paradoxical: compared with women without movement difficulties, women with the least severe movement difficulties had adjusted odds ratio [95% confidence intervals]=2.1 [1.2–3.7] of receiving mammograms. The wide confidence interval suggests more variability in this group. To further investigate this result, we recognized that the reference group included women with “disabilities other than movement difficulties.” When we made this the reference group, we found that the likelihood of receiving mammogram among women with no BADs was similar to those with least severe movement difficulties: 1.9 [1.2–3.1]. The odds of receiving a mammogram decreased as the severity of movement difficulty increased, with the most severe difficulty level being very similar to the reference group.

However, for all four BAD analyses, the variable “any BAD” was statistically significantly associated with lower mammography use compared with women without BADs: $p=0.006$ in the movement difficulty analysis, 0.02 for sensory, 0.009 for emotional, and 0.05 for cognitive difficulties. The lowest adjusted odds ratio for any BAD occurred in the movement difficulty analysis: 0.5 [0.3–0.8]. Confidence intervals for these analyses were relatively tight. “Any CAL” was statistically significant ($p=0.003$) only for the self-care analysis.

In models where all seven disability indicators were entered at once in each of the study years (data not shown), sociodemographic variables again were the most important predictors according to likelihood ratio tests. In several instances, disability indicators were statistically significant predictors, with adjusted odds ratios ranging from 0.5 (emotional disability in 2000; self-care limitation 2008) to 1.7 (cognitive difficulty in 2000). Statistical significance was as follows: emotional disability in 2000 ($p=0.006$); self-care limitations in 2003 ($p=0.045$) and 2008 ($p=0.009$); and social limitations in 1998 ($p=0.047$) and 2010 ($p=0.026$). Across the years, movement, sensory, cognitive difficulties, and work limitation always had insignificant associations with receiving mammogram in these models. Although severity of movement disability was not significantly associated with receiving mammogram except in 2010 ($p=0.0011$), women with the most severe movement difficulties generally had lower adjusted odds of receiving mammogram (0.8 in 1998–2003, 1.2 in 2005, 0.4 in 2008, and 0.9 in 2010).

Discussion

Almost 25 years after passage of the ADA, women with disabilities continue to have lower mammogram rates than nondisabled women, and in certain subgroups of disabled women, this gap has grown over time. The magnitude and significance of this disparity varies by disability type, as others have found.^{6,12,13} Approximately 20 years ago, analyses of 1994–1995 NHIS-D data found that, after adjusting for sociodemographic factors, women with major mobility difficulties had 30% lower mammogram rates than other women.⁴ We cannot precisely replicate those NHIS-D analyses because of fundamental NHIS redesign; furthermore, NHIS-D contained details about mobility aid use (i.e., specific assistive technologies, such as wheelchairs and walk-

ers), which allowed more refined definitions of movement disability than have subsequent surveys.^{2,3} Nonetheless, our longitudinal analyses found that movement difficulty is one of several disability categories where disparities have significantly widened between 1998 and 2010.

These longitudinal analyses also suggest that mammogram rates for U.S. women overall have not changed from 1998 to 2010, hovering around 74% to 75% since 2003. NHIS asks questions about self-reported mammogram use among women without histories of breast cancer, and only in age ranges supported by the U.S. Preventive Health Services Task Force, starting at age 50 years.²⁶ Numerous reasons could explain why 25% of women fail to report mammogram receipt, and it is unclear what an optimal and feasible population-level mammogram rate would be. NHIS gives no insight into why women fail to obtain—or report—mammography testing.

Interview studies have suggested reasons that women with different disabilities fail to receive mammograms.^{14–25} One overarching consideration is competing health priorities: women’s health conditions underlying their disabilities, comorbid health problems, or combinations of both could lessen the apparent benefits of mammography. Disability-specific reasons include physical or communication barriers to obtaining the test and extremely negative previous experiences, which make women unlikely to return for periodic testing. For example, women who are deaf have reported difficulties knowing when to hold their breath during the test (i.e., to prevent motion artifact), especially when they are not provided adequate sign language interpretation or other communication support.¹⁷ As a result, some women have described mammography technicians taking multiple images, bruising women’s breasts, causing pain and distress, and decreasing their willingness for periodic testing. Often because of inadequate explanations, women with intellectual disabilities may not understand the value or physical requirements of mammography testing and thus be afraid or unwilling to undergo testing.²⁷ Very low grade-level language, pictures, or models, as well as clinicians’ time and patience, can assist in educating these women about this important test.

Women with movement difficulties have obvious impediments to mammography, especially when women cannot stand and facilities have not accommodated them through wheelchair accessible equipment, specialized mammography chairs, additional technician support, or other adaptations. Women with movement disabilities have described difficulties being positioned properly, problems holding these positions for sufficient periods, unintended movements triggering switches and causing equipment malfunction, and husbands holding them up to equipment without appropriate radiation protection.^{17,23} Some women have refused to return for additional mammograms.

We could not test this hypothesis with NHIS data; nonetheless, we had conjectured that physical access to medical equipment might have improved since the ADA’s enactment. This coincided with the advent of digital mammography machines and many facilities replacing their equipment. These changes could have lessened disparities. However, as suggested by our finding of widening disparities from 1998 through 2010 for women with movement difficulties, this expectation was overly optimistic. While ADA physical accessibility regulations encompass physical structures and attached items (e.g., toilets, grab bars), no regulations govern

accessibility of medical diagnostic equipment, such as mammogram machines. To address this deficiency, Section 4203 of the 2010 Patient Protection and Affordable Care Act amends Title V of the Rehabilitation Act and requires the U.S. Access Board, with Food and Drug Administration consultation, to issue technical standards for accessibility of medical diagnostic equipment, including mammogram machines. An advisory committee to the Access Board has issued recommendations specifically for mammography, which aim for women with disabilities to participate in mammography as independently as possible (e.g., without technicians holding women's positions).²⁹ Although Section 4203 required promulgation of these standards by 2012, they have not yet been finalized. Even when regulations are in place, it may take many years for equipment manufacturers to design and produce accessible equipment and for facilities to purchase and install this new equipment.

Although not the focus of this report, our study found that sociodemographic characteristics were the strongest predictors of reporting mammogram use. In particular, women with less than high school educations and incomes below the federal poverty level were significantly less likely to report receiving mammograms than are other women. In general, individuals with disabilities are substantially more likely than others to be disadvantaged in their education and income levels.²⁷ Such sociodemographic disadvantages might exacerbate disability-specific factors, such as transportation problems and inaccessibility of health care facilities, which impede mammogram use.

One finding from the multivariable analyses was paradoxical: women with the least severe movement difficulties had an adjusted odds of 2.1 [1.2–3.7] of reporting mammograms compared with women with no movement difficulties. However, the adjusted odds decreased as the level of severity increased, with women with the most severe movement difficulties having odds similar to those in the reference group (women with BADs other than movement difficulties). Women with any BAD were less likely have a mammogram compared with women who had no disability. A variety of factors could affect mammogram use by women with movement difficulties, in particular, but the NHIS data offer limited opportunity for exploring these possibilities. Although our analyses adjusted for women having a usual source of care and health insurance, we could not adjust for long-term relationships with clinicians. Compared with nondisabled women, it is possible that women with the least severe movement difficulties have sought care over years for these problems and therefore have visits with practitioners where mammograms are recommended. Furthermore, compared with women having more severe movement difficulties, these women may not have the competing health risks that make mammograms lower priority. More investigation is needed to understand this unexpected finding.

Our study shares the limitations of research using cross-sectional survey data. Analyses can identify only associations, not determine causal links. The NHIS data represent respondents' self-reports, which could be distorted by memory lapses, cultural biases, or other factors. Unlike many studies using NHIS data, we considered only disabilities reported as chronic, rather than including temporary disabilities or conditions ignoring time frame.⁵ NHIS's measure of chronicity is relatively short: conditions self-reported to last

at least 3 months. Finally, as acknowledged above, we cannot explain reasons for disparities in mammogram use between women with and without disability.

Conclusions

The ADA requires that persons with disabilities have equal access to services, such as health care, as nondisabled individuals. The U.S. Preventive Health Services Task Force judges mammograms to be a useful screening study to detect breast cancer among women of the ages studied here. The numbers of women in this age range with various disabilities will grow substantially in the United States in coming years as "baby boomers" age. These women must receive equal quality screening services as other women, and our finding that the disparities gap may be growing for some disabilities is very troubling. More research is needed to understand fully what is causing this worrisome trend. Numerous factors might affect this disparity, thus requiring a range of responses. Equipment manufacturers, health care facilities, primary care practitioners, and women with disabilities themselves will likely need to join forces to erase this disability disparity in mammogram use.

Acknowledgments

This work was funded by the National Cancer Institute, 5 R01 CA160286-02.

The opinions expressed in this manuscript do not necessarily represent the official views of the Department of Veterans Affairs.

Author Disclosure Statement

No competing financial interests exist.

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