Distance And Mammogram Utilization Among Unmarried Middle-Aged and Older Women

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ABSTRACT [NOTE: LIMIT IS 300 WORDS]

This study assessed the relationship between distance to mammography facilities and mammography utilization, using data from the Cancer Screening Project for Women (CSPW). The CSPW was a study about the experiences of legally unmarried women undergoing breast, cervical, and colorectal cancer screening in Rhode Island. Women aged 40-75 were recruited, stratified by marital status (previously vs. never-married) and partnership gender (women who partner with men exclusively or prefer no partner [WPM] vs. women who partner with women or with women and men [WPW]). ARC/GIS was used to calculate distance between participants' home addresses and the nearest mammography facility (N=568). All women lived within 10 miles of a mammography facility. Logistic regression models were computed for recent mammography (received in the past 2 years) against distance to the nearest mammography facility. Distance was split into tertiles to facilitate interpretation of results. Models were computed in three stages: (model 1) distance variables only; (model 2), adding individual-level control variables; and (model 3), adding neighborhood-level control variables. Greater distance from a facility was positively associated with recent mammography in all three models, but achieved statistical significance only in model 1 (tertile 2 OR=1.76, CI=1.00–3.09; tertile 3 OR=2.37, CI=1.29–4.33). Three individual-level variables were negatively associated with recent mammography ($p<0.05$): age, an index of avoidance behaviors, and an index of structural barriers to care. Neighborhood-level variables were not significantly associated with recent mammography. Results suggest that barriers to mammography were greatest for women living in the immediate vicinity of facilities. In small, densely populated areas such as Rhode Island, greater distance may not in and of itself represent a barrier to mammography. In these areas, GIS may be best used as a tool to assess the compositional differences affecting underserved areas, thereby facilitating the deployment of tailored outreach interventions.

Keywords: Utilization; mammography; marital status; proximity

INTRODUCTION

Despite recent improvements in breast cancer screening rates in the United States, there remain underserved populations that are less likely to receive timely mammograms, and more likely to be diagnosed with advanced stages of breast cancer. Research suggests that unmarried middle-aged and older women are one such group (Taplin, Ichikawa, Yood, Manos, Geiger, Weinmann et al., 2004; Gorin & Heck, 2005). There are currently over 18 million unmarried women between the ages of 40 and 75 in the United States, representing 33% of women in this age-range (U.S. Census Bureau 2005).

Pooled data from national samples drawn in 2002 and 2004 show that among non-Hispanic Whites and non-Hispanic Blacks, 81% of married women had received a mammogram in the past two years, compared to 79% of previously-married (widowed or divorced) women, and 74% of never-married women. Among Hispanics, 75% of married women had received a mammogram in the past two years, compared to 72% of previously-married women and 65% of never-married women (Wasserman, Clark, Rakowski, & Truchil, 2006). The present study aimed to assess whether distance between women's homes and mammography facilities was a barrier to timely mammography among unmarried middle-aged and older women living in Rhode Island.

Distance and health care utilization.

There has been a long-standing tradition in health services research of studying the geographic distribution of disease, health care delivery, and resource allocation (Ricketts, 2003). Traditionally, studies of geographic disparities in access to care have focused on differences between "small areas" defined by political boundaries or zip codes (Paul-Shaheen, Clark, & Williams, 1987; Ricketts, 2003). However, using pre-defined areas as the unit of analysis provides only a rough indication of geographic disparities because the populations within them may be heterogeneous and mobile, and underserved populations may extend beyond pre-defined boundaries.

In recent years, GIS (geographic information systems) has become widely available and accepted as a tool for health services research (Ricketts, 2003). GIS can link spatial information, such as the location of health care facilities, with health, social, and environmental data (McLafferty, 2003). Of particular interest for this study is the ease with which current GIS programs can now produce estimates of exact travel distances (McLafferty, 2003).

Due to the limitations of data sharing, confidentiality and privacy protection laws (HIPAA) and the extensive use of secondary data, many studies of distance and mammography utilization still rely on imprecise estimates of respondent locations. Generally, these studies use the center of a geographic area, or centroid, as a measure of respondent location. Calculating respondent location in this way may be a significant misrepresentation, because the size of many geographic subdivisions varies vastly.

Travel distance significantly affects the utilization of health care in general (LaVela, Smith, Weaver, & Miskevics, 2004), and has been a determinant of mammography

among women living in disadvantaged areas (Downs & Stea, 1977; Hyndman & Holman, 2000). However, the relationship between distance and utilization of mammograms may vary with the characteristics of different geographic areas. For example, a relatively short distance may represent a large obstacle in heavy traffic. Further, the relationship between distance and utilization of mammograms may vary with the characteristics of eligible women. Distance may be a greater barrier for persons who do not have access to transportation (Martin, Wrigley, Barnett, & Roderick, 2002; McLafferty, 2003). Distance has also been shown to be a greater barrier to care for older persons (Burgess & DeFiore, 1994). This may relate to older persons' generally more limited options for transportation.

Distance is not only a physical reality, but also a social and psychological construct (Nemet & Bailey, 2000). Research suggests that each person operates within an activity space, or the confines of a territory sufficient to provide for the necessities of life (Shannon, 1980). In their study of elderly persons living in rural Vermont, Nemet & Bailey (2000) showed that, while a linear measure of distance to facilities was related to utilization of care, a better predictor was whether physicians were located within study participants' daily activity spaces.

By extension, we hypothesize that some variables may modify the effect of distance on mammography utilization by changing the size of the activity space. For example, being employed may require a commute, which would expand an individual's activity space. Then again, an employee may have no time off work, which might limit activity space. Since the present study focuses on unmarried middle-aged and older women, one interesting factor that theoretically could expand or contract the activity space is whether a woman is a member of a sexual minority group (i.e. lesbian or bisexual). On the one hand, the perception that health care providers lack respect for sexual minority women may make women who partner with women (WPW) reluctant to travel for a mammogram (Clark, Bonacore, Wright, Armstrong, & Rakowski, 2003). On the other hand, they may be willing to travel a greater distance for a provider who will provide respectful care. Indeed, most people are prepared to travel farther to obtain specialized or higher-quality care (Folland, 1983; Haynes & Fotheringham, 1984; McLafferty, 2003). Other variables which could affect the size of a woman's activity space may include older age, medical problems, lack of insurance, lack of time or transportation and psycho-social barriers.

An alternate view of distance and utilization is that the association can be due to compositional factors rather than causal effects. As McLafferty (2003) observed, people are not distributed evenly across the earth's surface, and populations differ along many dimensions – including age, gender, culture, and economic status – that affect their need for health care, their ability to travel to obtain health care, and the types of services they are willing and able to utilize. While greater distance from facilities might, in and of itself, constitute a barrier to care, it may also be a "marker" for other variables, such as socio-economic status and race, which simultaneously affect where women live and whether they use mammograms.

Regardless of whether these other control variables are hypothesized to precede or follow distance in the causal chain, in multivariable models, they would be expected to reduce the coefficient on the distance variable. For example, in a study of Medicare beneficiaries in Kansas, Engelman, Hawley, Gazaway, Mosier, Ahluwalia, & Ellerbeck (2002) showed that greater distance from facilities was negatively associated with utilization of mammograms. However, distance had only a marginally significant effect in multivariable models adjusting for age, race, and county education level (OR=0.97, CI=0.95–0.99).

Marital status, health care utilization, and distance to facilities

Travel distance to facilities has not previously been studied as a determinant of mammography among middle-aged and older unmarried women. Marital status is often included as a control variable in multivariable models of cancer screening (Keating, Landrum, Guadagnoli, Winer, & Ayanian 2006; Taplin et al., 2004; Rakowski, Clark, Truchil, Schneider, & Meersman, 2005; Gorin & Heck, 2005), but the determinants of cancer screening have rarely been studied within populations of unmarried women.

Sociologists suggest several reasons why unmarried women may experience more barriers to care than married women. First, marriage is a selective process; women with greater financial assets, better health, and higher social and human capital are more likely to marry (Oropesa, Lichter & Anderson, 1994; Becker, 1981; Freiden, 1974; Oppenheimer, 1988; Hirschl, Altobelli, & Rank 2003). Second, marriage confers several societal benefits. Marriage builds wealth (Hirschl, Altobelli, & Rank 2003) and creates opportunities for health insurance through a spouse (Zuvekas & Taliaferro, 2003), thus reducing financial barriers to mammography. Furthermore, marriage is legitimated in society (Lewin, 2004), which may translate to greater respect by health care providers. Finally, research suggests that unmarried middle-aged and older unmarried women may avoid medical care due to emotional factors (Keith 1987) including perceived disrespect by health care providers (Clark et al., 2003).

The Cancer Screening Project for Women (CSPW) was a study about the experiences of legally unmarried women age 40-75 undergoing breast, cervical, and colorectal cancer screening in Rhode Island. Most CSPW respondents provided their addresses. This represented a unique opportunity to explore the relationship between mammography utilization and travel distance among unmarried middle-aged and older women. Further, while many other studies have focused on the effect of distance in vast areas with sparse transportation networks, this study presented the opportunity to assess whether distance still matters in a small, densely populated state with a heavily networked road system.

METHODS

Data

CSPW data. This study utilized data from the Cancer Screening Project for Women. A combination of targeted and respondent-driven sampling strategies was used to recruit a stratified sample of unmarried middle-aged and older women, age 40 to 75, receiving the majority of their health care in Rhode Island. Women were recruited through community

events, health fairs, mailings and flyers, personal networks, and print media, with the goal of recruiting an equal number of respondents who were previously married vs. never married, and women who partner with women or women and men (WPW) vs. women who partner with men (WPM). During recruitment, a small number of women also indicated that they preferred to have no partner. These women were similar to WPMs on a number of characteristics, and therefore were included within the WPM category. Further details of the recruitment approach are provided elsewhere (Clark, Neighbors, Wasserman, Armstrong, Drnach, Howie et al., 2006). Data were collected between 2003 and 2005, and included participants' home addresses, their recruitment mode, most recent mammogram, cancer screening barriers, health/disability status, family history of cancer, socio-demographic variables, and partner preference (WPW vs. WPM). Of the 630 study participants, 567 provided a home address that could be geocoded (i.e., linked to a specific latitude and longitude), and 12 provided an address linkable only to a specific zip code centroid. Precautions were taken to protect the confidentiality of respondent address information following all current HIPAA regulations. Women gave two reasons for not providing an address: (1) fear/discomfort; and (2) homelessness.

Mammography facilities. We identified and located facilities in operation up to 24 months prior to each respondent's interview using the 2003 and 2005 lists of Rhode Island mammography facilities approved by the U.S. Food and Drug Administration (U.S. FDA, 2003, 2005). There were 41 FDA-approved mammography facilities in 2003, and 40 in 2005. Between 2003 and 2005, two facilities were removed and one facility was added to the FDA list. Telephone queries revealed that the two facilities that ceased providing mammograms closed in June 2003, and the new facility opened in November 2004. Data for 2004 were interpolated using this information (39 facilities until November 2004, 40 facilities thereafter). One of the mammography facilities in operation in 2003 and 2005 was located on a Navy base. We excluded this facility from our analysis because most or all women in our sample would not have access to it, and because there was a civilian facility nearby (0.5 miles away). No mobile mammography facilities were in operation in Rhode Island during the study period, and each available facility provided free mammograms to women eligible for the Rhode Island Women's Cancer Screening Program, funded by the National Breast and Cervical Cancer Early Detection Program. Thus, distances to the nearest facility were calculated under the assumption that all Rhode Island women would have access to all non-Navy facilities.

Maps. Year 2000 Census tract shapefiles for Rhode Island were downloaded from the Census Bureau website (U.S. Census Bureau, 2005a). Additionally, the StreetMap USA file for the year 2000 was imported into ARC/GIS to allow the calculation of exact travel distances.

Neighborhood data. Year 2000 Census tract-level data for Rhode Island were downloaded from the Census Bureau website to calculate neighborhood compositional characteristics such as age, education levels, poverty levels, car ownership, and minority status (U.S. Census Bureau, 2005).

Dependent variable

The dependent variable was recent mammography, defined as a self-report of having received a mammogram within the past two years. This outcome measure is consistent with current breast cancer screening recommendations (NCI 2005; ACS 2005), and identifies women clearly past due for screening.

Key explanatory variable

The key explanatory variable for this study was the exact driving distance between each respondent's home and the nearest mammography facility. The Network Analyst tool in ARC/GIS generated exact distances in meters from each woman's home to the nearest mammography facility in operation up to 24 months prior to her interview.

Mammography facilities and respondent home addresses were geocoded according to the ARC/GIS automated matching system. We matched 100% of facilities and 80% of respondents using this method. The remaining 20% of respondents were matched interactively where possible. Using these methods, the total match rate for respondents was 92%. Remaining respondents were matched to a zip code centroid where possible. In total, 579 respondents were geocoded, and the exact travel distance from each woman's home or zip code centroid to the nearest mammography facility was calculated. However, of these 579 respondents, 11 did not provide information about the timing of their most recent mammogram. Thus, the final sample consisted of 568 women.

The distance variable was converted into three dummy variables denoting ranges of distance from women's homes to the nearest mammography facility. To create the tertiles, we conducted a sensitivity analysis to choose cutpoints for the categorical distance variables. Distance was initially divided into deciles, and a series of dichotomous variables were created splitting the sample into two distance groups, sliding the cutpoint up the scale in 10 percentage point increments (creating, for example, a 30-70 split, 40-60 split, etc.) Chi-square tests were then calculated to test the association between being in the top distance group and having had a recent mammogram. Results showed that further distance was consistently positively associated with having had a mammogram, regardless of the cutpoint used. Given the stability of the variable, we opted to split distance into tertiles so that each category would have a sufficient number of observations for analysis. Women in distance tertile 1 lived between 14 and 1,629 meters (0-1 mile) from the nearest mammography facility; distance tertile 2 ranged between 1,630 and 3,330 meters (1-2 miles) from the nearest mammography facility; and distance tertile 3 ranged between 3,331 and 16,601 meters (2-10 miles) from the nearest mammography facility.

Control variables

Individual-level and sampling-structure variables.

We considered several individual characteristics for inclusion as control variables, based on their potential for affecting a respondent's willingness or ability to travel for a mammogram. These included variables related to demographic characteristics (age, minority status); socio-economic status (education, employment status, income); partner preference (women who partner with men exclusively or prefer no partner [WPM] vs. women who partner with women or with women and men [WPW]), and self-reported

masculine vs. feminine gender expression); factors affecting risk perception (breast cysts, a family history of breast or other forms of cancer); disability perceived by self or others; and eight variables related to access barriers for mammography or other cancer screenings. These access barrier variables were derived from responses to the following questions:

> Have you put off or avoided having a mammogram because… (a) You were waiting for a doctor or nurse to recommend one? (b) You did not have insurance or your insurance did not pay for the exam? (c) You thought the test was painful? (d) You were afraid of finding something wrong?
>
> Have you put off or avoided having a mammogram, Pap test, sigmoidoscopy or colonoscopy because… (e) You have problems taking time off from work or from your other responsibilities? (f) You have problems with transportation that make it difficult for you to get to screening facilities? (g) You have medical problems that make it hard for you to get the test? (h) It is difficult for you to get someone to take care of the people who depend on you, such as your children or elderly family members, while you go for the test?

To achieve a parsimonious model, these access barrier variables were grouped into two indices. Variable groupings were informed both by theory and by the results of a factor analysis. The first barrier index was an index of avoidance, constructed by adding together variables a, c, and d, described above. Coding for this index ranged from 0 (no avoidance behaviors reported) to 3 (all three avoidance barriers reported). The second index was an index of structural barriers, constructed by adding together variables b, e, f, g, and h, described above. Coding for this index ranged from 0 (no structural barriers reported) to 5 (all five structural barriers reported).

To further achieve parsimony, continuous covariates were converted into categorical variables representing 2 to 3 categories, and chi-square tests were computed to test the association of each of the covariates with recent mammography. ANOVA analyses were performed to test the association of each of the covariates with distance tertiles. Variables were retained for the multivariable model if they were associated with both recent mammography and the distance tertile variables ($p<0.05$). An exception was made for the age variable, which was not associated with distance tertiles in the bivariate analysis, but which was strongly associated with mammography utilization and for which prior research suggested that it could modify the effect of other variables.

Partner gender and recruitment mode were associated with distance tertiles, but not with recent mammography use. However, they were included in the model to control for the sampling structure. Similarly, marital status was not associated with either distance tertiles nor mammography use, but it was included in the model to control for the sampling structure.

The final list of individual-level and sampling-structure related variables retained for the model included: a continuous measure of age; employment status; education (fewer or

greater than 16 years, i.e. bachelor's degree); income (above or below $15,000); the previously described index of avoidance and index of structural barriers; partner gender; marital status; and recruitment mode (community event/health fair, broadcast ad, or other).

Income information was missing for 4% of respondents. Among respondents who did not provide income information, the proportion of women who had a recent mammography was similar to that of women with higher incomes. A value denoting income over $15,000/year thus was imputed for respondents who did not provide income information. Similarly, between 2 and 6% of data were missing for the four questions on structural barriers. Women for whom this information was missing had rates of recent mammography comparable to those of women who reported that they did not experience those barriers. Thus, a "no" answer was imputed for those questions when data were missing.

Neighborhood variables

While distance may be an important barrier to care, it could also be a proxy for neighborhood characteristics. For this reason, we controlled for neighborhood characteristics in multivariable analyses. Census tracts were used as a proxy for neighborhoods, and characteristics of each Census tract were derived from Census 2000 data. For respondents who had been geocoded to a zip code centroid rather than to a specific address and Census tract, average values were imputed, which were derived from data for all Census tracts within that zip code.

Several neighborhood characteristics were considered for inclusion in the multivariable model. The first variable was the proportion of the neighborhood population that was comprised of women age 40 to 74. This variable was included as an indicator of the potential for interactions with peers, during which information relevant to mammograms might be exchanged. Other variables providing an indication of neighborhood socio-economic status were considered for inclusion. These included the percent of the neighborhood's population comprised of: African-Americans; Native Americans; Asians; Hispanics/Latinos; persons with limited English proficiency; linguistically isolated persons; foreign-born persons; foreign-born persons who arrived after 1990; women over the age of 25 with a higher education (college or above); persons below 100% of the poverty level; persons below 200% of the poverty level; and persons who did not own a car.

T-tests were calculated comparing the mean proportions for these characteristics between women who had had a recent mammogram and women who had not. ANOVA analyses were performed to test the association between neighborhood characteristics and distance tertiles. None of the neighborhood variables were associated with mammography use at the bivariate level ($p<0.05$). However, all were associated with distance tertiles. Since these variables collectively could still significantly modify the effect of distance variables in a multivariable model, we opted to include them as a group. In the interest of a parsimonious model, the number of variables was reduced to the minimum number possible to reflect essential neighborhood characteristics. In the final model, variables

kept represented the proportion, in each neighborhood, of: women age 40-74; minority persons (including African-Americans, Native Americans, Asians, and Hispanics/Latinos); foreign-born persons; women over the age of 25 with a higher education; persons below 200% of the federal poverty level; and persons who did not own a car.

Analysis

Descriptive analysis.

An initial assessment of the spatial distribution of respondents in relation to mammography facilities was conducted using ARC/GIS. On the map, we plotted the mammography facilities, respondents who received a mammogram in the past two years, and respondents who did not receive a mammogram in the past two years.

Stata 9.0 (Stata Corporation, College Station, TX) was used to describe the individual and neighborhood characteristics of the sample by distance tertile.

Logistic regression models.

Three logistic regression models were computed in Stata 9.0. In all three models, distance tertile 1 served as the reference category. The first model included only the distance tertile variables. In the second model, variables relating to individual characteristics and sampling structure were added. Variables denoting neighborhood characteristics were added in the third model.

Likelihood ratio tests were computed for the second and third models to test whether individual/sampling structure and neighborhood variables were statistically significant as a group. Additionally, we assessed whether individual/sampling structure and neighborhood variables could be classified as confounders by calculating whether, as a group, they changed regression coefficients for the distance tertile variables by 10% or more.

RESULTS

Descriptive results

All women in the sample lived fairly close to one or more facilities, with exact travel distances to the nearest facility ranging from 14 to 16,601 meters (approximately <1–10 miles). The map of mammography facilities and survey respondents is shown in figure 1. No clear pattern emerged from the map relating to distance and mammography utilization.

In the bivariate analyses, we found that women living farther from mammography facilities were more likely to receive mammograms than women living closer to facilities. The overall prevalence of recent mammography was 86.3%. Tertile-specific prevalences were 80.3% for women in distance tertile 1, 87.8% for women in distance tertile 2, and 90.6% for women in distance tertile 3 (Table 1).

Women living in the first tertile of distance to mammography facilities did not have the lowest socio-economic status, but they reported the most barriers to cancer screening

(table 1). Almost 27% of women living in distance tertile 1 reported at least one psycho-social barrier from the index of avoidance, compared to 22.9% among women in distance tertile 2 and 18.2% among women in distance tertile 3. Further, 37.2% of women in distance tertile 1 reported at least one structural barrier to cancer screenings, compared to 33.5% among women in tertile 2 and 33.3% among women in tertile 3. Women living in distance tertile 1 were also more likely than women in distance tertile 3 to have been recruited in person through community events and health fairs (33.0% compared to 21.9%).

Women living in distance tertile 2 had the lowest socio-economic status: 39.9% of respondents in tertile 2 were not employed, compared to 27.7% in tertile 1 and 22.9% in tertile 3. One quarter of women in tertile 2 did not have a college degree, compared to 21.3% in tertile 1 and 14.1% in tertile 3. Incomes were also lowest in tertile 2 with 28.7% of respondents earning less than $15,000 per year, compared to 21.8% in tertile 1 and 9.4% in tertile 3. In addition to having low socio-economic status themselves, women living in tertile 2 lived in neighborhoods characterized by higher average proportions of persons living below 200% of the poverty level (27.9% vs. 25.4% for tertile 3 and 19.0% for tertile 1), persons who do not have access to a motorized vehicle (12.7% vs. 10.6% for tertile 3 and 7.2% in tertile 1), racial/ethnic minorities (16.4%, vs. 13.2% for tertile 3 and 7.7% for tertile 1), and foreign-born persons (12.8% vs. 8.9% for tertile 3 and 8.2% for tertile 1). Women living in distance tertile 2 were significantly more likely than women in distance tertile 3 to have been recruited in person through community events and health fairs (42.6% compared to 21.9%).

Women living in tertile 3 had the highest socio-economic status, lived in moderately diverse neighborhoods, and were most likely to be WPW (45.3%, compared to 29.8% in tertile 1 and 26.1% in tertile 2). They were more likely than women in distance tertiles 1 and 2 to have been recruited through broadcast ads (45.8% compared to 42.5% for tertile 1 and 31.4% for tertile 2).

Results from multivariable analyses

Results from multivariable analyses are shown in table 2. Odds ratios, and their corresponding 95% confidence intervals, are reported instead of beta-coefficients for greater ease of interpretation. In the first model, which included only distance variables, residing in distance tertile 2 was positively associated with having had a recent mammogram, at a level closely approaching statistical significance (OR=1.76, CI=1.00–3.09), and residing in distance tertile 3 was significantly positively associated with having had a recent mammogram (OR=2.37, CI=1.29–4.33).

In model 2, variables related to individual characteristics and sampling structure were added. Based on results of the likelihood ratio test, we rejected the null hypothesis that all individual and sampling structure variables had a zero coefficient. Three individual variables were associated with recent mammography: age (OR for each additional year of age=1.07, CI=1.03–1.11), the index of avoidance (OR=0.52, CI=0.38–0.74), and the index of structural barriers (OR=0.58, CI=0.42–0.79). Adding individual and sampling structure variables reduced estimated distance variable coefficients by 23% for both

tertile 2 (from 0.56 to 0.43) and tertile 3 (from 0.86 to 0.66). The corresponding new odds ratios for distance tertiles were no longer statistically significant using $p < .05$ (tertile 2 OR=1.53, CI=0.81–2.89; tertile 3 OR=1.94, CI=0.99–3.81).

In model 3, variables related to neighborhood characteristics were added. None of these variables were associated with recent mammography using a $p < .05$ criterion. Further, based on the likelihood ratio test, we could not reject the null hypothesis that all neighborhood variables had a zero coefficient. However, adding neighborhood variables reduced estimated distance variable coefficients by 13% for tertile 2 (from 0.43 to 0.37) and by 8% for tertile 3 (from 0.66 to 0.61). The corresponding new odds ratios for distance tertiles were 1.45 (CI=0.76–2.81) for tertile 2 and 1.84 (CI=0.92–3.67) for tertile 3. Table 2, model 3 displays the adjusted odds ratios for distance tertile, individual-level and sampling structure variables, controlling for the influence of neighborhood variables. However, odds ratios for neighborhood variables themselves are not reported because they were non-significant with wide confidence intervals.

We suspected that the lack of significance of distance tertiles and neighborhood variables in the final analysis might be caused by the low level of variation in the outcome variable. To test whether this might be the case, we re-ran the analysis using a stricter criterion for recent mammography screening, namely a mammogram in the past one year. This is the shortest recommended interval under existing guidelines; 73.6% of our sample met this standard. While neighborhood variables remained non-significant when we used this outcome variable, odds ratios for distance tertiles became larger and statistically significant (OR for distance tertile 2: 1.86, CI=1.12– 3.09; OR for distance tertile 3: 1.84, CI= 1.12–3.03; results not reported in table 2). Under this model, women who lived farther from mammography facilities were still more likely to have received a recent mammogram than women who lived within a mile or less from facilities.

DISCUSSION

The purpose of this study was to assess the relationship between distance to mammography facilities and recent mammography utilization for a population of unmarried women aged 40 to 75 years, living in Rhode Island. Counter-intuitively, our analysis shows that women who lived closest to facilities were least likely to have received a recent mammography. In multivariable models, variables denoting individual socio-economic status, partner preference, and neighborhood characteristics were not statistically significant. Older age was significantly positively associated with the outcome variable, and index variables denoting the number of psycho-social and structural barriers to cancer screening were negatively associated with the outcome variable. When control variables were added to the model, the association between distance and recent mammography became statistically non-significant, but there remained a trend of more recent mammogram use the farther away women lived from mammography facilities.

In fact, when a more stringent criterion was used to define the outcome variable (mammography in the past year), greater distance remained positively and significantly associated with recent mammography in multivariable models. This result suggests that

there are indeed barriers to mammography associated with living close to facilities. The fact that coefficients were statistically insignificant in multivariable models that used the less stringent criterion (mammography in the past two years), suggests that given additional time, women could overcome barriers associated with their living in close proximity to mammography facilities. However, longitudinal data would be needed to confirm whether additional time does indeed allow women to overcome these barriers.

Multivariable results do not fully explain why women living closest to facilities experienced the greatest barriers to mammography. However, results do suggest that in Rhode Island, greater distance to facilities does not present a substantial barrier to mammography. The relatively short distances involved may be responsible for this result. Research on distance and utilization of care is often conducted in sparsely populated areas where distances are vast, such as Australia or Canada (Bamford, Dunne, Taylor, Symon, Hugo, & Wilkinson 1999; McLafferty, 2003; Scott, Temovsky, Lawrence, Gudaitis & Lowell, 1998). By contrast, all women in this study lived within 16 km (approximately 10 miles) of facilities providing free or low-cost mammograms. Even so, 10 miles can pose a significant obstacle, depending on an area's geographic features and public transportation system. However, in Rhode Island, the heavily networked street pattern and comprehensive public transportation system may have greatly reduced barriers related to distance.

Although it seems counter-intuitive that women living farther from facilities would be more likely to have received a recent mammogram, other recent studies have found similar results. Unpublished results from an ongoing study conducted in Los Angeles by one of the present authors (Meersman, Breen, Meissner, Pickle, & Simon) revealed an increasing trend of recent mammography use the farther women lived from the nearest mammography facility. Women residing within less than 0.5 miles from a mammography facility were significantly less likely to have received a recent mammogram than women residing at a greater distance. Similarly, Rahman (2005) found that women residing within a geographic radius containing more mammography facilities were significantly less likely to have had a previous mammogram compared to women residing in a radius containing fewer facilities. Results by Zenk, Tarlov & Sun (2006) suggest a partial explanation for the direction of this association. In their study of Chicago, Illinois, distance and travel times to mammography facilities decreased as neighborhood poverty increased. If mammography facilities are more likely to be located in socioeconomically disadvantaged neighborhoods, then women who live closest do not necessarily have the resources to be screened.

Yet, within our sample, women living closest to facilities did not have the lowest socio-economic status, and none of the individual- and neighborhood-level socio-economic status variables was significantly associated with the outcome variable in multivariable models. However, women living closest to facilities reported the greatest number of psycho-social and structural barriers to mammography, and the indices constructed from these variables had a statistically significant negative association with mammography use in multivariable models.

Using the theoretical framework about activity space, we might speculate that low screening levels among women living in the immediate vicinity of mammography facilities may be related to the range of women's activity space. In Rhode Island, there is only one major metropolitan area, the city of Providence. Many white-collar jobs are located in Providence, where several large mammography facilities are located. Since women residing in the third distance tertile have the highest socio-economic status, they may be more likely to have white-collar jobs in Providence, near facilities. Conversely, the near-poor women residing closer to facilities may have blue-collar jobs outside Providence or in parts of the city without screening facilities. Thus, during business hours, their daily activity space might not include areas close to their homes.

One of our study limitations prevented us from empirically testing whether activity space accounts for the association of greater distance with greater mammography use. We used women's most current home addresses as the departure point for calculating distance to the nearest facility, but mammograms could have been accessed from another departure point, such as a work address or past residence. If work addresses had been available, this might have allowed us to further explore the theory of "activity space" as a proposed explanation for the counter-intuitive findings.

A second limitation of this study relates to study design. The external validity of this study may be limited due to the specificity of the population studied and the lack of a probability sample. Further, the internal validity of the study is limited by its cross-sectional design. Women were asked concurrently for information regarding recent mammography and current home address, income, and other socio-demographic characteristics. We cannot be certain of the temporal sequence between these factors and recent mammography. If residential addresses of the past 24 months had been included in the dataset, possibly a better measure of distance could have been calculated, namely the shortest distance between any residential address of the past 24 months and the nearest facility.

A third limitation is that we used self-report data to assess whether respondents had received a recent mammogram. Research suggests that with self-reported data, there is a "telescoping effect", meaning that women underestimate the time since their last mammogram (Degnan, Harris, Ranney, Quade, Earp, & Gonzalez, 1992). This may have introduced error in the data, which would tend to reduce the estimated magnitude and statistical significance of coefficients. Further, if the "telescoping effect" were more pronounced in one of the distance tertile groups, this could produce biased coefficients.

Despite the limitations of this study, several insights may be gained from the results. First, in small, densely populated areas with a heavily networked road pattern, greater distance in and of itself does not appear to constitute a barrier to mammography. Second, within our study sample, women who lived closest to mammography facilities experienced the greatest structural and psycho-social barriers in accessing mammograms. Controlling for socio-economic status did not eliminate the association of these barrier variables.

One of the strengths of this study was its use of a powerful, relatively new GIS tool for calculating exact travel distances. However, our results show that, even with this powerful tool, investigating the effects of distance remains a complex undertaking. In this study, as in other recent studies, GIS has allowed researchers to observe that women living closest to mammography facilities experienced the greatest barriers to care. Results suggest that research is needed to investigate the reasons for this phenomenon, and outreach is needed to address the psycho-social and structural barriers experienced by women living in the close vicinity of mammography facilities. GIS can be a useful tool to further assess the characteristics of these women so that tailored interventions may be deployed.

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Figure 1. Map of mammography facilities and survey respondents in Rhode Island.

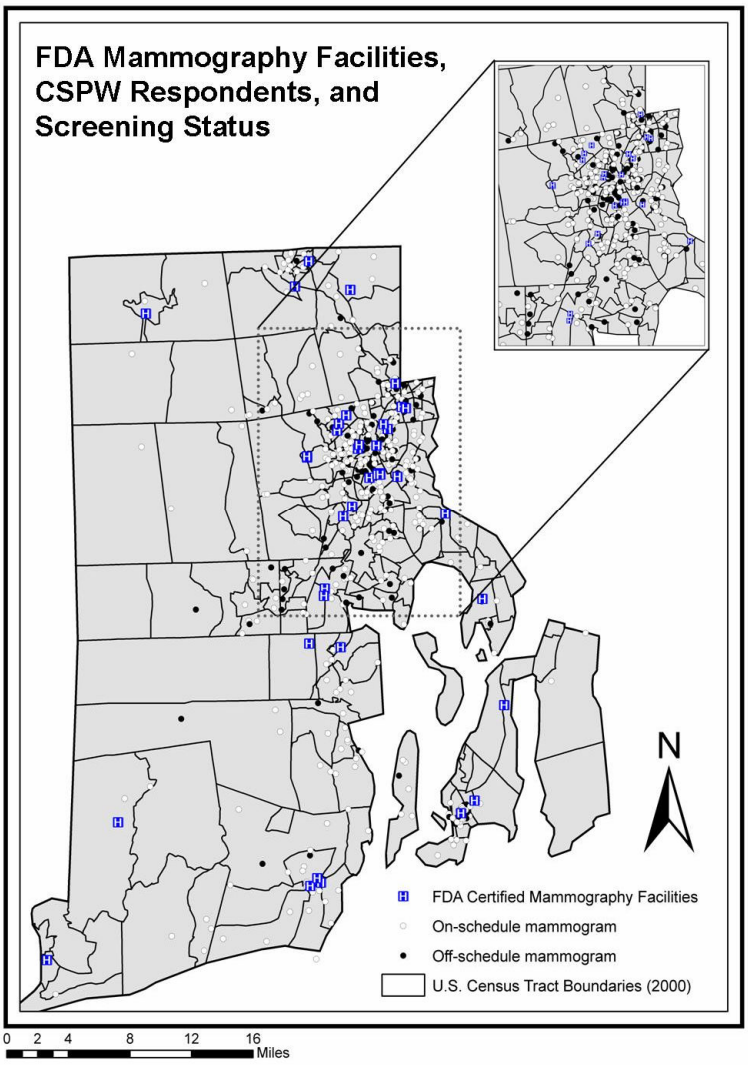

Table 1. Sample characteristics, by tertile of distance to nearest mammography facility

	Women in distance tertile 1	Women in distance tertile 2	Women in distance tertile 3	All women
Distance in meters from home to nearest mammography facility (min—max)	14—1,629	1,630— 3,330	3,331— 16,601	14—16,601
Received a mammogram in the past 2 years (%)	80.3	87.8	90.6	13.7
Individual characteristics				
Age (mean)	52.7	54.3	52.6	53.2
Unemployed (%)	27.7	39.9	22.9	30.1
Education<16 years (%)	21.3	25.5	14.1	20.2
Income <$15,000 (%)	21.8	28.7	9.4	19.9
Reported at least 1 barrier from the Index of avoidance [a] (%)	26.6	22.9	18.2	22.5
Reported at least 1 barrier from the Index of structural barriers [b] (%)	37.2	33.5	33.3	65.3
WPW (%)	29.8	26.1	45.3	33.8
Marital status [c]				
Never married (%)	55.85	44.68	53.13	51.2
Previously married (%)	44.15	55.32	46.87	48.7
Recruitment mode				
Community event or health fair	33.0	42.6	21.9	32.4
Broadcast ad (print media, listserv, brochure)	42.5	31.4	45.8	40.0
Other (researcher/participant networks, other\)	24.5	26.0	32.3	27.6
Neighborhood characteristics: % of residents in same tract as respondent who are…				
Women age 40-75	20.8	19.3	19.7	19.9
Members of racial/ethnic minorities	7.7	16.4	13.2	12.5
Foreign-born	8.2	12.8	8.9	9.9
Below 200% of poverty level	19.0	27.9	25.4	24.1
Not car owners	7.2	12.7	10.6	10.2

N=568

[a] Index of avoidance is a count of the following reasons cited for ever avoiding or postponing a mammogram: waiting for a doctor or nurse to recommend one; afraid of pain; afraid of bad results.

[b] Index of structural barriers is a count of the following reasons for ever avoiding/postponing a mammogram or other cancer screening test: medical problems or lack of insurance, time, transportation, or of help caring for dependents.

[c] All study participants were legally unmarried, as per eligibility criteria

Table 2. Multivariable analysis, distance to nearest mammography facility against mammography in the past 2 years

	Model 1 Unadjusted OR	Model 2 OR adjusted for individual characteristics	Model 3 [c] OR adjusted for individual and neighborhood characteristics
Distance tertiles			
Distance tertile 1: 14—1,629m.	(reference category)	(reference category)	(reference category)
Distance tertile 2: 1,630— 3,330m.	1.76 (1.00—3.09)	1.53 (0.81—2.89)	1.45 (0.76—2.81)
Distance tertile 3: 3,331— 16,601 m.	2.37 (1.29—4.33)**	1.94 (0.99—3.81)	1.84 (0.92—3.67)
Individual characteristics			
Age	—	1.07 (1.03—1.11)**	1.07 (1.03—1.11)**
Unemployed	—	0.76 (0.36—1.61)	0.73 (0.34—1.55)
Education<16 years	—	0.59 (0.31—1.16)	0.59 (0.30—1.15)
Income <$15,000	—	0.75 (0.35—1.59)	0.75 (0.35—1.61)
Index of avoidance [a]	—	0.52 (0.38—0.74)**	0.53 (0.37—0.74)**
Index of structural barriers [b]	—	0.58 (0.42—0.79)**	0.58 (0.42—0.80)**
Sampling structure			
WPW	—	0.66 (0.35—1.21)	0.65 (0.35—1.22)
Never married		0.84 (0.46—1.52)	0.83 (0.46—1.51)
Recruitment mode			
Community event or health fair		0.66 (0.31—1.46)	0.67 (0.30—1.46)
Broadcast ad (print media, listserv, brochure)		0.55 (0.27—1.11)	0.55 (0.27—1.12)
Other (researcher/participant networks, other)	(reference category)	(reference category)	(reference category)
Likelihood ratio chi-square test (degrees of freedom in parentheses)		74.22(10), p<0.01	2.67(5), p=0.75

N=568

* p<0.5 ** p<0.01

[a] Index of avoidance is a count of the following reasons cited for ever avoiding/postponing a mammogram: waiting for a Dr. or nurse to recommend one; afraid of pain; afraid of bad results.

[b] Index of structural barriers is a count of the following reasons for ever avoiding/postponing a mammogram or other cancer screening test: medical problems or lack of insurance, time, transportation, or of help caring for dependents.

[c] Model 3 controlled for the influence of neighborhood level variables, including percentages of women age 40-75, members of racial/ethnic minorities, foreign-born, below 200% of poverty level, and not car owners. Odds ratios were non-significant with wide confidence intervals and thus not reported in this table.