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Juan L. Rodriguez 07/10/2020

Exploring the role of acculturation on mammography utilization among Hispanic women in the United States

By
Juan L. Rodriguez
Doctor of Philosophy
Public Health

Cam Escoffery, PhD, MPH
Advisor

Kimberly Jacob Arriola, PhD, MPH
Committee Member

Natalie Crawford, PhD
Committee Member

Regine Haardoerfer, PhD, MEd, MS
Committee Member

Accepted:

Lisa A. Tedesco, PhD
Dean of the James T. Laney School of Graduate Studies

Date

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By

Juan L. Rodriguez
B.S., University of Central Florida, 2004
M.P.H., University of Florida, 2006
M.S., Georgia State University, 2011

Advisor: Cam Escoffery, PhD, MPH

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Abstract

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Breast cancer is the leading cause of cancer-related death among Hispanic women in the U.S. While Hispanic women have lower mortality rates than non-Hispanic white women, Hispanic women are more likely to get diagnosed at later stages. Disparities in stage at diagnosis may be explained, in part, by lower levels of mammography use among Hispanic women. In order to develop interventions, there is interest in understanding if acculturation impacts mammography use among Hispanic women. This dissertation conducted a systematic literature review and two quantitative studies to explore the association between acculturation and mammography use among Hispanic women in the U.S.

The systematic review indicated that while research has been conducted to assess the role of acculturation on mammography utilization among Hispanic women, this research has almost exclusively focused on proxy measures of acculturation on immigration status and language utilization. While these studies have provided limited evidence, results suggest that among foreign-born women, non-U.S. citizens are less likely to be up-to-date with mammography screening. Quantitative exploration of the role of immigration status on mammography use among a national sample of Hispanic women indicated that while immigration status was not a significant predictor of recent mammography use, foreign-born non-U.S. citizens faced significantly greater odds of being rarely or never screened for breast cancer. Results also indicated that these same women were more likely to face significant barriers in accessing health care and had lower socioeconomic status.

An ecological study exploring mammography capacity in Hispanic communities in the U.S. found that counties with dense Hispanic communities and counties that have been traditional Hispanic settlement destinations have greater odds of having limited mammography capacity. In addition, these high Hispanic population density and limited mammography capacity counties tend to be rural, and have a larger proportion of their population who are non-U.S. citizens, uninsured, and are living below the poverty level than the average U.S. county. Ensuring Hispanic women have adequate access to mammography screening in the U.S. will require policy and health system interventions to ensure access to health care services for non-citizens and those living in rural areas.

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Note on the use of the terms Hispanic and Latina in this dissertation

The term Hispanic will be used to refer to Hispanic and Latina populations in the U.S. throughout this dissertation. Traditionally, the term Hispanic is used to describe individuals of Spanish-speaking origin, while the term Latino/a refers more broadly to individuals from Central and South America (James et al., 2013). The main difference between these two terms is that individuals with Spanish ancestry are included in the term Hispanic, while those from Brazil are excluded. The inverse is true for the term Latino/a (those from Brazil are included, while those from Spain are excluded) (Oquenedo, 1995).

While these terms denote different populations, the terms are often used interchangeably. Notably, the U.S. Census Bureau, as well as most surveys administered by U.S. government agencies, ask about ethnicity by including both terms (Hispanic/Latina) in the root of the question (James et al., 2013). In addition, the Office of Management and Budget (OMB) in its guidance for racial and ethnic categories (OMB, 2015), recommends using Hispanic/Latina as one group. Given that in federal records these populations are conflated and that federal records and data collection activities form the basis of this dissertation, the term Hispanic will be used to refer to a combined Hispanic/Latina U.S. population. However, it should be noted that some consider the term Hispanic to be a reminder of a colonialist past and erases indigenous ancestry of populations across the Caribbean, Central, and South America.

Chapter One – Introduction

I. Background

Since 1910, heart disease has been the leading cause of mortality among those in the United States. In that same year, cancer was ranked 8th behind pneumonia and influenza, tuberculosis, diarrhea, enteritis and ulceration, intracranial lesions, nephritis, and motor-vehicle accidents. However, over time, cancer mortality continued to increase and in 1938, it became the 2nd leading cause of death among Americans and has maintained that rank since (CDC). Cancer incidence rates are expected to continue to increase with an estimated 45% increase in incidence by 2030. This increase is expected to be driven mostly by older individuals and members of minority racial/ethnic populations (Smith et al, 2009).

While cancer still remains the second leading cause of death in the U.S. it has already overtaken heart disease in some key demographic groups. Starting in 2009, the leading cause of death among Hispanics in the United States became cancer (Heron & Anderson, 2016). Cancer accounts for 21% of all deaths among Hispanics (ACS, 2018). This shift in leading of cause of mortality has sparked a specific interest in cancer prevention and control efforts in the Hispanic population of the U.S.

However, in order to understand factors driving cancer mortality in the Hispanic population, as well as the cancer prevention and control efforts that are best suited to address these issues, an understanding of the Hispanic population of the U.S. is needed.

A. The Hispanic population of the United States

There are approximately 60 million individuals who identify as Hispanic in the United States, comprising about 18% of the population (Colby & Ortman, 2014; ACS, 2015, 2018). This makes them the largest minority group in the U.S. Approximately 35% of the Hispanic

population is foreign-born and immigrated, or migrated, to the U.S. (Colby & Ortman, 2014). Behind Mexico, Columbia, and Spain, the U.S. has the 4th largest Spanish speaking population in the world (Cervantes, 2016). A majority are of Mexican origin (64.3%). Other sizable Hispanic populations include those from or with ancestors from Puerto Rico (9.5%), El Salvador (3.7%), Cuba (3.7%), and the Dominican Republic (3.1%) (Colby & Ortman, 2014; ACS 2015, 2018).

Hispanics are also the youngest and fastest growing population (Colby & Ortman, 2014). In 1990 Hispanics were only 9 percent of the U.S. population (Guzman & McConnell, 2002). Between 2000 and 2014 alone, the Hispanic population grew by 57%, which is about 4 times the growth of the total population (Guzman 2001; Ennis 2011). The size of the Hispanic population is also expected to continue growing. By 2060 it is projected that the Hispanic population will be about 30% of the U.S. population (Colby & Ortman, 2014). Recent years of growth in the Hispanic population, as well as the bulk of the growth projected by 2060, is not due to immigration however, but to births in the U.S. (Colby & Ortman, 2014). Recent studies have shown that immigration to the U.S. by foreign-born Hispanics has decreased or remained stagnant. This is mostly due to immigrants from Mexico leaving and entering the country at similar rates, or even leaving at higher rates than entering (Pew, 2015; Colby & Ortman, 2014; ACS, 2015). The decrease in immigration coupled with higher fertility rates and lower mortality (due to a younger age distribution) will produce a demographic shift wherein the U.S. will go from a demographically dominant white society to a minority-majority nation, led, in part, by native Hispanic births (Johnson & Lichter, 2008; Lichter & Johnson, 2009; Lichter et al, 2012).

The settlement of Hispanic populations in the U.S. has also shifted over time. Traditionally, Hispanics have settled in the West (40%) or South (37%) of the U.S., with more than half of all Hispanics living in 3 states (California, Texas, and Florida) (ACS, 2015, 2018).

However, since 2000, a number of states have seen significant increases in Hispanic migration and immigration. These include, but are not limited to, North and South Carolina, Georgia, Utah, Nevada, and Idaho (Ennis, 2011; ACS 2015). The geographic spread of the Hispanic population across the U.S. has been especially evident in small-sized metropolitan cities, suburban communities, and non-metro counties. In the Midwest specifically, the influx of Hispanic migrants has helped revitalize small and dying towns (Lichter & Johnson, 2009; Carr et al, 2012; Crowley et al, 2015). Hispanic communities are quickly developing across the country with the bulk of the population located in the South and West (ACS, 2018).

While Hispanics comprise a significant and growing portion of the population, they face significant income, education, and health disparities (Morales 2002; Haile 2012). Hispanics face gaps in educational achievement and approximately 26.6% live in poverty. It is estimated that 32% are uninsured, even after implementation of the affordable care act, and 29% are on Medicaid (Pew, Jan 2013; Pew, Feb 2013; KFF, 2016). Hispanics are the racial/ethnic group least likely to have health insurance, as well as least likely to have a usual source of care (Pew, Jan 2013; Pew, Feb 2013). These disparities have resulted in 22% of Hispanics reporting that they have a poor/fair health status, having the highest percentage of households living in inadequate, unhealthy housing, having the lowest vaccination rates, higher obesity rates, higher rates of hospitalization, and a disproportionate burden of HIV diagnoses (Pew, Jan 2013; Pew, Feb 2013).

Disparities in socio-economics and health care access, however, do not translate to increased rates of mortality. In reality, Hispanics actually enjoy a mortality advantage over non-Hispanic whites (Palloni & Arias, 2004). This phenomenon, called the Hispanic Mortality

Paradox, provides important context to understanding disease morbidity and mortality among Hispanic populations in the United States.

B. Hispanic Mortality Paradox

Hispanic groups in the U.S. have a mortality advantage over non-Hispanic whites (Palloni & Arias, 2004; Ruiz et al, 2012; Morales et al, 2002). However, understanding this paradox does require a more nuanced approach. To simply label all Hispanics as having mortality advantage presents a very homogeneous perspective on the Hispanic population of the U.S. When mortality in adulthood is examined more closely to assess differences between Hispanic subpopulations by nativity and place of birth, several facets of the paradox are better explained. Studies have indicated that the mortality advantage experienced by Hispanics in the U.S. is real; however, these mortality benefits are only present for foreign-born Hispanics that are originally from Mexico, or from Hispanic countries other than Cuba and Puerto Rico (Palloni & Arias, 2004; Ruiz et al, 2012; Morales et al, 2002). The mortality advantage enjoyed by these groups can be considerable. Mortality rates for some Hispanic groups can be as much as 35% to 47% lower than those experienced by non-Hispanic whites. This translates to an additional 5 to 8 years of life expectancy. Life-expectancy advantages may also differ by age and other socio-demographic factors (Palloni & Arias, 2004; Markides and Esbach, 2005; Turra & Goldman, 2007).

Several explanations have been presented for the Hispanic Mortality Paradox. The first is that the mortality advantage can be explained, at least in part, by data artifacts (Palloni & Arias, 2004; Morales et al 2002). Vital records and other health documentation, like death certificates and medical records, suffer from poor identification of Hispanic ethnicity (Arias et al, 2010; Smith & Bradsahw, 2006; Clegg et al, 2007). In addition, Hispanics are also more likely to

misreport their age and appear older than they may actually be (Palloni & Arias, 2004). This could be especially problematic for those who are foreign born and who lack birth records in U.S. vital statistics systems. These data related issues can bias results to show a mortality advantage toward Hispanics (Smith & Bradshaw, 2006). Another possible explanation for the mortality paradox is related to who is able to immigrate (Palloni & Arias, 2004; Morales et al, 2002). It is possible that those who immigrate or migrate to the United States are more likely to be healthy – also known as the healthy migrant effect (Abriado-Lanza et al, 1999). Another possibility is that Hispanics living in the U.S. may return to their country of origin when ill or close to death – salmon bias (Palloni & Arias, 2004; Turra & Elo, 2008). Both of these effects, the healthy-migrant effect and salmon bias, respectively, may also bias mortality rates to show a Hispanic protective effect (Palloni & Arias, 2004; Turra & Elo, 2008). Finally, it is also posited that a socio-cultural effect may also help explain this paradox (Palloni & Arias, 2004; Morales et al, 2002). It is possible that certain social and cultural characteristics of Hispanic communities differentiate them from non-Hispanic white communities and that these differences, be they related to individual health behaviors, family structures, or robust social networks and social capital, may provide a mortality advantage (Palloni & Arias, 2004; Morales et al, 2002).

These potential sources of bias in mortality among Hispanics in the U.S. have important implications for research methods and design. Understanding the Hispanic Mortality Paradox not only provides important context to understanding burden of disease in Hispanic populations, but should also make researchers question potential sources of bias in data sets, and recognize the importance of immigration and acculturation related factors in health outcomes. These issues are of great importance to understanding the cancer burden in the U.S. Hispanic population.

C. Cancer Burden of the Hispanic Population

As previously mentioned, cancer is the leading cause of death among Hispanics in the U.S. In 2018, it is estimated that 149,100 Hispanic individuals in the U.S. were diagnosed with cancer and 42,700 succumbed to the disease (USCS, 2016; ACS, 2018). Among Hispanic men, the most commonly diagnosed cancers were prostate, colorectal, and lung cancer, while the most common causes of cancer related death were lung, liver, and colorectal cancer (ACS, 2018; USCS, 2016). Among Hispanic women, breast, thyroid and colorectal cancer were among the most frequently diagnosed, while breast, lung, and colorectal cancer were the most common causes of cancer related death (ACS, 2015; USCS, 2016). Patterns of cancer incidence and mortality between Hispanics and non-Hispanics are somewhat different because the Hispanic population is somewhat younger and historically they have different histories of exposure and engagement in risk behaviors (ACS, 2015). The cancer burden among U.S. Hispanics is somewhat comparable to that of Hispanic countries of origin (ACS, 2015, 2018).

Overall, Hispanics are actually less likely to get and die from cancer than non-Hispanic whites (ACS, 2015, 2018; USCS, 2016). While on average the probability that a person who is non-Hispanic white will get cancer is 39% - 42%, for Hispanics it is 34% - 39% (ACS, 2015, 2018). While incidence and mortality rates are slightly higher for non-Hispanics whites, Hispanics are significantly more likely to get diagnosed with later stage cancers. This is especially true for breast and lung cancer and melanoma (ACS, 2015, 2018). Cancer survival rates, however, are rather comparable to the non-Hispanic white population, with melanoma being an exception where Hispanics have lower 5-year survival (ACS, 2015, 2018; Howlander et al, 2016).

However, as with the Hispanic Mortality Paradox, there is more to the cancer burden than appears. Much like the pattern seen with all-cause mortality, cancer mortality can also differ by nativity and country of origin (Seigel et al, 2015; ACS, 2015). Cancer incidence also varies by nativity and country of origin due to differing exposures and participation in healthy or risk behaviors (Siegel et al 2015; ACS, 2015). Cancer incidence and mortality statistics may also be subject to the same biases that affect overall mortality statistics. Data artifacts that may make Hispanic ethnicity less apparent are present in cancer registry records and death certificates potentially leading to under-reported cancer incidence and mortality (Clegg et al, 2007). Cancer registry data have been shown to be excellent on race, while data quality on Hispanic ethnicity and especially immigration status can be moderate to poor (Clegg et al, 2007). Similarly, the healthy migrant effect may also bias survival statistics. Hispanic cancer patients returning to their country of origin for treatment or death may also cause under-reporting of cancer mortality (Turra & Elo, 2008; Pinheiro et al, 2011). Finally, there may be cultural effects impacting the cancer related burden of U.S. Hispanics. Factors associated with settlement, duration of residence in the U.S., and acculturation have been found to be associated with cancer mortality and survival (Eschbach et al, 2004; Eschbach et al, 2005; Mejia de Grubb et al, 2013).

While Hispanics are at lower risk of developing or dying from cancer than non-Hispanic whites, the increased likelihood of being diagnosed at later stages is concerning (ACS, 2015; Modiano et al, 1995). This is especially true and concerning for breast cancer given its large prevalence.

D. Breast Cancer among Hispanic women

Breast cancer is the most commonly diagnosed cancer among Hispanic women and accounts for approximately 29% of all cancers diagnosed among Hispanic women in a given

year. It is also the leading cause of cancer related death among Hispanic women and accounts for 16% of all cancer deaths in a given year (ACS, 2015, 2018; USCS, 2016; Seigel et al, 2015). Trends in cancer incidence have been fairly similar to those in non-Hispanic whites showing a decrease until 2003, with rates stabilizing. In mortality however, while rates for Hispanics and non-Hispanics whites have been decreasing over time, non-Hispanic whites have seen a larger reduction than Hispanics (25% reduction versus 36%) (Seigel et al, 2015; ACS 2015).

Overall, however, breast cancer incidence and mortality, are about 30% lower in Hispanics than non-Hispanic whites (Seigel et al, 2015). This is mainly attributed to differences in protective factors. Hispanic women are more likely to be younger age at first birth, have higher parity, and breastfeed (CDC, 2013; Martin et al, 2015; Sweeney et al, 2008). Also, there is also evidence that risk of developing breast cancer varies significantly within the Hispanic population (Banegas et al, 2013). Those that are foreign born are less likely to develop breast cancer than those who are native born and length of time living in the U.S. may also impact risk (Seigel et al, 2015). Incidence has also been shown to vary by country of origin (Keegan et al, 2010; Seigel et al, 2015). One study showed that breast cancer incidence rates were 35% to 40% lower in those of Mexican ancestry than Cuban or Puerto Rican women (Pinheiro et al, 2009).

One of the major disparities in breast cancer among Hispanic and non-Hispanic white women is in stage at diagnosis (Seigel et al, 2015). Women diagnosed with breast cancers at earlier stages have the greatest chances of prolonged survival (Howlander et al, 2016). Non-Hispanic whites are almost 10% more likely to be diagnosed at an early stage when the cancer is localized to the breast (Seigel et al, 2015; ACS, 2018). Several studies have also found that Hispanic women are significantly more likely to be diagnosed with stage IV breast cancer (Banegas et al, 2012; Li et al, 2003). Differences in stage at diagnosis between Hispanic women

have been attributed to decreased access or lower rates of mammography utilization among Hispanics and being less likely to have received appropriate follow-up after abnormal mammography results (Press et al, 2008; Stuver et al, 2011; ACS, 2018). Creating a shift in stage at diagnosis of breast cancer among Hispanic women could have a significant impact on breast cancer survival and decreases in mortality.

Mammography is the only imaging test recommended for breast cancer screening (Mandelblatt et al, 2009). It has been shown to reduce mortality from breast cancer by making breast tumors more easily detectable at earlier stages where tumors are less severe and treatments are more effective (Mandelblatt et al, 2009). However, mammography does have its limitations. There can be false positives leading to over-diagnosis and over-treatment, and/or false negatives leaving tumors untreated (Mandelblatt et al, 2009; Lidbrink et al, 1996). Its ability to actually decrease mortality has also been called into question (Miller et al, 2000). In addition, a recent study indicated that while the number of small or early stage tumors being diagnosed has increased since the introduction of mammography in the 1980's, but we have not seen a dramatic decrease in the number of large, more advanced stage tumors being detected (Welch et al, 2016). Despite these limitations, most medical professional organizations that issue population level clinical practice guidelines and the federal government through the United States Preventive Services Task Force (USPSTF) agree that there is sufficient evidence on the ability of mammography to detect breast cancer at earlier stages and reduce breast cancer related mortality to recommend its use to regularly screen asymptomatic women for breast cancer. While there is some disagreement between guidelines on age to start screening and screening intervals, usually screening begins between ages 40-50 for women of average risk and recommended to occur annually or bi-annually (Siu et al, 2016; Lee et al, 2010; Oeffinger et al, 2015; USPSTF, 2016).

Data from national surveillance systems indicate that we are well below meeting the Healthy People 2020 objective of 81.1%. In 2015 approximately 71.8% of non-Hispanic white women were meeting breast cancer screening guidelines (White et al, 2017). Comparatively, screening rates for Hispanic women were 72.1% overall, with rates dropping as low as 66.2% among Hispanic subgroups. The lowest mammography screening rates were observed among foreign-born individuals who had been in the U.S. less than 10 years (53.7%) (White et al., 2017). Given these wide-ranging rates of mammography utilization or adherence to screening guidelines, understanding factors driving utilization and adherence are essential to improving breast cancer outcomes.

II. Literature Review

A. Mammography use among Hispanic women in the U.S.

Several studies have been conducted to assess potential reasons or barriers for lower mammography adherence among minority and/or Hispanic women in the U.S. Study findings can be classified into 4 areas: 1) immigration related factors, 2) insurance and access issues, 3) test related factors, and 4) inter-/intra- personal factors.

Immigration related factors and their impact on mammography have been assessed in multiple studies. Results have indicated that those who are undocumented or are experiencing difficulties with their immigration are less likely to receive a mammogram (Shelton et al., 2011). In addition, factors related to being an immigrant, including less time spent living in the U.S., being foreign born, or reporting lower levels of acculturation and assimilation have also been associated mammography non-compliance (Rodriguez et al., 2005; Abraido-Lanza et al., 2005). Language related barriers, namely English not being the predominant language spoken, have also associated with mammography non-compliance (Guerra et al., 2005; Jacobs et al., 2005; Garcia

et al., 2012; Alexandraki & Moordian, 2010). Findings related to mammography and immigration related factors have not been consistent (Abraido-Lanza et al., 2005; Rodriguez et al., 2005; Garcia et al., 2012; Lawsin et al., 2011). This may be explained by differing or inconsistent measures of acculturation and assimilation across studies or due to sampling differences and heterogeneity of Hispanic subgroups, or lack thereof, in study samples. Since approximately 37% of Hispanics living in the U.S. are foreign born (Ennis et al., 2011), immigration related factors may impact the mammography compliance of a significant segment of the population.

A number of studies have highlighted insurance and access to care related issues and their potential impact on mammography uptake. One of the most frequent and consistent conclusions is that lack of health insurance and affordability are major barriers to mammography screening among minority and/or Hispanic women (Alexandraki & Mooradian, 2010; Rodriguez et al., 2005; Shelton et al, 2011; Mack et al., 2009; Schueler et al., 2008). In addition, research studies have shown that one of the strongest predictors of mammography screening is receiving a physician recommendation for screening (Schueler et al., 2008). However, since Hispanic women are less likely to have a usual source of care, they are usually less likely to have recently seen a physician, lack a physician recommendation for screening, have less knowledge concerning mammography, and have a greater distrust of doctors, hospitals, and the health care system (Wells & Roetzheim 2007; Gonzalez & Borrayo, 2011; Mack et al., 2009; Aldrige et al., 2006; Schueler et al., 2008). In addition, Hispanic population face challenges obtaining access to quality health care services (Escarce & Kapur, 2006).

Several studies have indicated that many minority and Hispanic women have significant concerns about the mammography test itself and that these concerns or myths are impeding the

screening process (Engelman et al., 2012; Schueler et al., 2008; Watson-Johnson et al., 2011). It has been shown that Hispanic women worry about pain during mammography and find the test to be embarrassing (Schueler et al., 2008; Englemam et al., 2012; Alexandraki & Mooradian, 2010; Watson-Johnson et al., 2011). Embarrassment related to mammography screening and other medical procedures or tests may be due to cultural norms of modesty (Engelman et al., 2012; Alenandraki & Mooradian, 2010). There are also significant concerns about the efficacy of screening and its ability to detect breast cancers (Watson-Johnson et al., 2011). Given higher levels of medical distrust and lack of a usual source of care, Hispanic women tend to have low levels of knowledge about mammograms and have personal reservations about being screened (Alexandraki & Mooradian, 2010; Ramirez et al., 2013; Schueler et al., 2008).

Several inter- or intra-personal level factors have been found to be associated with mammography. It has been shown that minority and Hispanic women are more likely to face structural barriers to screening, such as having lack of transportation, dealing with inflexible work policies and a lack of medical leave, and facing demanding caretaking responsibilities or relationships (Alexandraki & Mooradian, 2010; Watson-Johnson et al., 2011; Shelton et al., 2011; Otero-Sabogal et al., 2003). In addition, these women are more likely to have competing health issues making prevention and early detection less of a priority for already scarce medical resources (Shelton et al., 2011). While Hispanic women tend to report higher levels of general social support and have larger social networks than women from other racial/ethnic groups, studies have found that some Hispanic women report a lack of social support for mammography screening (Shelton et al., 2011). Cultural factors, such as having family input in medical decision making, may also be influencing screening and interacting with receipt of medical care (Watson-Johnson et al., 2011). Several psychosocial factors have also been identified as being associated

with mammography uptake. These include Hispanic women having significant negative or fatalistic cancer-related beliefs and therefore not being screened for fear of bad news (Espinosa et al., 2011; Niederdeppe & Levy, 2007; Ramirez et al., 2013; Watson-Johnson et al., 2011). Studies have also found that Hispanic women have exaggerated perceptions of their breast cancer risk, which may exacerbate fears and concerns about screening (Engelman 2012; Orom et al., 2012; Graves et al., 2008).

While there has been a considerable amount of research concerning the utilization of, or adherence to, mammography screening among women in the U.S., some of which has included or been stratified by Hispanic ethnicity, there are certain cross-cutting limitations in this research that leave important gaps in the literature. These limitations include: 1) the focus on mammography utilization or adherence as a one-time event; 2) studying Hispanic populations as homogeneous groups; 3) the conceptualization and measurement of acculturation; 4) settlement and migration of the U.S. Hispanic population; and 5) the role and conceptualization of SES and access to care.

The vast majority of studies on mammography utilization assess compliance with screening guidelines. This usually entails understanding the factors that make women more or less likely to have had a mammogram within the past two years (White et al, 2017). However, this outcome faces some limitations. Operationalized outcomes for mammography compliance, or being up-to-date with mammography screening, combine women who are routinely screened, but are simply overdue for re-screening, with women who are rarely or never screened. Those that have been screened for breast cancer in the past and are not currently compliant may be different in many aspects from those who are rarely screened or have never been screened. The literature on mammography rescreening indicates that women who are not rescreened or are

overdue for screening usually have more fears associated with the mammogram itself (e.g. embarrassment or lack of trust in test), have had bad experiences obtaining a mammogram (e.g. pain or perceived discrimination), or face logistical and structural issues to getting screened (e.g. scheduling, facility hours, transportation) (Peipins et al., 2006; Bobo et al., 2004). In addition, women who are re-screened are more likely to have lived longer in the U.S., have previously had several mammograms, have a usual source of care, and have received a recommendation for screening from a physician (Lopez et al., 2009; Otero-Sabogal et al., 2004). Whereas women who are rarely screened or have never been screened are less likely to have a usual source of care and receive a physician recommendation, lack health insurance, and are more likely to face access related issues (Lopez et al., 2009; Meissner et al., 2007). Also, women who are rarely or never screened report greater competing demands and tend to have more fatalistic views and greater fear of having breast cancer be detected (Lopez et al., 2009; Meissner et al., 2007). While there are some areas of overlap between women who are due for rescreening versus women who are rarely or never screened, the differences between these two groups are such that they likely require different types of interventions and health promotion efforts in order to get them in for a mammogram. Combining these women into the same group assumes that their motivations for behavior and the barriers to screening they face are similar. This limits the interpretability of results and their ability to guide future efforts to increase screening rates.

These issues have not been specifically studied or teased apart in Hispanic cohorts. While Hispanics were included in some of the rescreening studies (Peipins et al., 2006; Bobo et al., 2004), results were not stratified by race/ethnicity due to small sample sizes and therefore the extent to which study factors may disproportionately, or specifically, impact Hispanics, and how rescreening can vary by racial and ethnic group are unclear. Studies on women who are rarely or

never screened have identified Hispanic women and women not born in the U.S. as being more likely to be rarely or never screened because they face greater access issues and are less likely to have a usual source of care (Lopez et al., 2009; Meissner et al., 2007). The generalizability of these results, however, is limited due to their small homogeneous samples. In order to better guide health efforts to increase mammography screening rates among Hispanics, it is imperative to understand how screening, lack of screening, or rescreening, differs between prevalent Hispanic subgroups within the U.S. Since being screened for breast cancer is a continuous, cyclical process, study methodology and analytic approaches must support and account for that process.

B. Hispanics as homogeneous population

The vast majority of epidemiologic and behavioral science research conducted with U.S. Hispanics tends to categorize all those from, or with decedents from, Spanish speaking countries into one homogeneous group (Borak et al., 2004; Aponte 2009; James et al., 2013). While this method is convenient for statistical sampling procedures, it impedes the interpretability and generalizability of study results. While the majority of Hispanics in the U.S. are Mexican or of Mexican descent, Puerto Ricans, Cubans, Dominicans, and those from Central and South American countries each still number in the millions (Ennis et al., 2011). Researchers from various disciplines have advocated for a more detailed analysis of Hispanic ethnicity in order to better understand potential differences and highlight health disparities between Hispanic subgroups (Borak et al., 2004; Aponte 2009; James et al., 2013). A perfect example of the need to address the issues of homogeneity among Hispanics in research is previous discussion of the Hispanic mortality paradox.

An additional concern for not taking Hispanic heterogeneity into account is subgroup differences in risk factor exposure and preventive measure uptake (Fenelon 2013; Cokkinides et al., 2012; Lara et al., 2005; Smedley et al., 2002; Ward et al., 2008; Curry et al., 2003). In addition, differences in cancer screening rates, including mammography were found. Mammography uptake was lowest among Mexican American women than those from other Hispanic subgroups (Fenelon 2013; Cokkinides et al., 2012; Lara et al., 2005; Smedley et al., 2002; Ward et al., 2008; Curry et al., 2003).

While it has been illustrated that mammography rates vary by Hispanic subgroup, it is unclear from previous research if the factors facilitating (or acting as barriers to) mammography screening are consistent, or differ, across these subgroups. Given differences in subgroup SES, risk factors exposures, and geography (Lara et al., 2005; Smedley et al., 2002; Ward et al., 2008; Curry et al., 2003), it is possible that different factors are driving mammography screening (or lack thereof) within subgroups. While smaller scale or more localized studies have been conducted within particular Hispanic subgroups, these studies have suffered from small sample sizes and lack the ability to compare results to that of other subgroups. In order to better compare and understand differences between Hispanic subgroups and develop more tailored and effective interventions, additional studies are needed on the factors associated with mammography uptake among Hispanics of differing nationalities and nativity.

C. Conceptualization and measurement of acculturation

Given the large and growing Hispanic population in the U.S., understanding the process through which Hispanics adopt or change their attitudes, values, beliefs, and behaviors (i.e. acculturation) after moving to the U.S., may have implications for health. While several studies have found associations between acculturation and health behaviors, including mammography,

the results have not been consistent (Brown et al., 2006; Hasnain et al., 2013; Thomson & Hoffman-Goetz, 2009; Riosmena et al., 2013). While this may be partly due to differences in study populations and sampling methodology, the measurement of acculturation also varies widely among research studies (Thompson & Hoffman-Goetz, 2009; Wallace et al., 2010; Charkraborty & Charkraborty, 2010). Most studies utilize basic unidimensional measures of acculturation, such as language spoken at home, or length of time living in the U.S. While these measures capture facets of the acculturation process, they fail to consider that acculturation is a complicated, multidimensional process (Abraido-Lanza et al, 2006; Andrews et al., 2013; Charkraborty & Charkraborty, 2010; Thomson & Hoffman-Goetz, 2009).

Acculturation is better measured as a latent variable with multiple indicators to more fully capture the various components of this larger more abstract concept (Abraido-Lanza et al., 2006). It has also been argued that components of acculturation may be specific to certain health behaviors and therefore applying more broad theoretical frameworks of acculturation to specific health behaviors may be inappropriate (Abraido-Lanza et al., 2006; Charkraborty & Charkraborty,2010). Additionally, it is important to consider that acculturation can be multidirectional, meaning that it could either serve as a protective factor or a risk factor for health and disease outcomes (Abraido-Lanza et al., 2006).

Potential areas of interest when assessing acculturation may include social ties among those with same and differing ethnic backgrounds, language(s) spoken and frequency, food/music preferences, individuals and parents place of birth, ethnic identity, neighborhood type and demographic composition, social and cultural norms, biculturalism (blending of two cultures), exposure to adverse or stressful circumstances associated with immigration and settlement, facing racial discrimination and segregation, and loss of social networks. In addition,

assessing change in identity, beliefs, values and norms is paramount to understanding the process of acculturation and its potential impact on health behaviors (Abraido-Lanza et al., 2006; Brown 2006; Hasnain 2013; Thomson & Hoffman-Goetz, 2009; Riosmena et al., 2013). Acculturation also assumes that there is a referent category to which immigrants should strive to acculturate towards (Abraido-Lanza et al., 2006). Given that the U.S. is a large country with widely differing populations, customs, and norms, the communities in which individuals settle may have significant impact on the determinants of acculturation. When assessing the process of acculturation, geography and neighborhood factors are essential to understanding how acculturation is occurring and what is being acculturated to.

Research has argued that currently available scales of acculturation simplify culture and may mask health disparities through structural constraints and barriers (Abraido-Lanza et al., 2006; Andrews et al., 2013; Charkraborty & Charkraborty, 2010; Thomson & Hoffman-Goetz, 2009). Some have gone as far as to say that measures of acculturation should be avoided as they are poor proxies of culture (Abraido-Lanza et al., 2006). However, research that appropriately understands the context of culture and the life of Hispanics in the U.S. may be a valuable tool to help develop interventions and public health programs to address important health care needs (Hasnain et al., 2013; Brown et al., 2006). Research is needed to determine the components of acculturation that are most salient to Hispanic women concerning their use of mammography screening. This research must take structural and geographic contextual factors, ethnic subgroups, and cultural and social norms around cancer and health care into account.

D. Contextual factors and mammography use

An additional factor that has not been widely studied among Hispanic women concerning mammography uptake, yet may be a key determinant of access of care and help clarify issues of

population homogeneity, is the settlement and migration patterns of the Hispanic population of the U.S.

Traditionally, Hispanics that immigrated to the U.S. have settled predominantly in the West and South (Ennis et al., 2011). Specifically, New Mexico, Texas, California, Arizona, Nevada, Colorado, Florida, New York, New Jersey, and Illinois have the largest proportions of Hispanic residents (Ennis et al., 2011). However, over the past 15 years, new immigration and settlement patterns have completely changed the way we view Hispanic dispersion within the United States (Ennis et al., 2011; Gresenz et al., 2012). While these ten states have ranked as those with the greatest proportion of Hispanic residents for almost 20 years, newly immigrated and native-born Hispanics are moving to new destinations across the country at higher rates than to more traditional locations. States like Georgia, Maryland, Arkansas, Delaware, Alabama, the Carolinas and the Dakotas are seeing their Hispanic populations double or even triple in the last 10-15 years (Ennis et al., 2011; Gresenz et al., 2012). Given the estimated continued growth of the Hispanics in the U.S. over the next 30-40 years, it is expected that Hispanics will continue to settle in new communities and areas across the country (Gresenz et al., 2012).

Several studies have suggested that geographic setting may be a source of health disparities and a potential contributor to differing health outcomes between racial/ethnic groups (Rainham et al., 2010; Beyer et al., 2011; Williams & Jackson, 2005). Researchers from multiple disciplines have discussed the significant influence that “place” may have on health. They have hypothesized that environmental contaminants, psychosocial stress, social isolation or infringement of social networks or social capital, and lack of control are among the potential pathways for place to impact health outcomes (Gresenz et al., 2012; Rainham et al., 2010; Beyer et al., 2011; Williams & Jackson, 2005). In addition factors related to population density,

community representativeness and racial segregation, and community perceptions may also be driving the link between place and health (Gresenz et al., 2012; Kramer & Hogue, 2009; Greer et al., 2011; Williams & Jackson, 2005). An individual's community may affect his/her health either directly or indirectly by influencing his activities and health related behaviors, including being screened for cancer (Grensenz et al., 2012; Williams & Jackson, 2005).

Studies have shown that where Hispanics reside may play a part in explaining differences in access to care and health outcomes. Kirby and colleagues (2006) found that a substantial portion of disparities in health care use between whites and Hispanics is accounted for by neighborhood socioeconomic status and availability of care. A separate study also found that Hispanics living in areas with high concentrations of Spanish speakers or Hispanic immigrants had better access to health care services (Gresenz et al., 2009). Studies assessing the impact of place on health, given changes in settlement patterns of Hispanics across the U.S., have indicated that those who settle in new destinations are less likely to have health insurance, live near a safety net provider, and have a usual source of care compared to those living in more traditional Hispanic destinations (Gresenz et al., 2012). In addition, those who reside in new areas have been found to have less favorable health care outcomes (e.g. poorer self-rated health, greater reports of chronic conditions), more unmet health care needs, face greater delays in seeking medical care, and report being less satisfied with the care they have received (Gresenz et al., 2012). This research indicates that place of settlement or migration can have an impact on access to care and plausibly on a woman's ability to have a mammogram.

The impact of place on mammography screening has focused on determining the availability of mammography machines or services in particular locations or cities, routinely characterized as area mammography capacity, and its impact on cancer risk. Studies of

geographic mammography capacity have shown that about 27% of U.S. counties, most of them rural have no capacity for mammography (meaning there are no mammography machines in that county or area) (Peipins et al., 2012). Studies conducted in urban settings have shown that in Chicago and Atlanta, residents of predominantly black neighborhoods have longer travel times to mammography facilities and in Los Angeles and Detroit, greater distance to mammography facilities were related to late-stage breast cancer diagnoses (Peipins et al., 2011; Zenk et al., 2006; Meersman et al., 2009; Gumpetz et al., 2006; Dai, 2010). A study of mammography capacity in Texas indicated that half of their counties had no mammography capacity and Black and Hispanic women were at increased risk for a late stage breast cancer diagnoses due to this lack of capacity (Elting et al., 2009). To date, no studies have been conducted that have assess mammography capacity and differences in access to breast cancer screening in predominantly Hispanic communities, while taking new and traditional areas of Hispanic settlement into account.

In addition to the link between place and health outcomes, the geography of Hispanics within the U.S. is also important because of the unequal geographic distribution of Hispanics subgroups across the country. While those of Mexican descent are mostly in California and Texas, Cubans mostly reside in Florida, and Dominicans and Puerto Ricans are mostly in New York (Ennis et al., 2011). Given that different Hispanic subgroups face differing immigration policies and access to state and federal aid and health care programs, where a Hispanic immigrant or migrant is from, and where they settle can have an impact on their overall socio-economic status, their access to health care services, and their ability to receive a mammogram for breast cancer screening.

III. Theoretical Approach

A conceptual framework informed by several theories and constructs in health behavior and social epidemiology will be used to guide study development, operationalization of constructs, selection of study measures, organize results, and inform research and practice implications. Overall, the dissertation is guided by the Social Ecological Model (SEM) proposed by McLeory (1988). This model posits that there are multiple levels of factors, with several factors working together within and between levels, to influence a health behavior. This model is essential to study design because it provides a multi-level perspective. Sociocultural theory, specifically the process of acculturation, will provide insights into the conceptualization of acculturation and its potential impact on health behavior, namely health care access and utilization of mammography. Finally, a five-factor model by Pechansky and Thomas (1981) will be used to conceptualize access to care.

Social ecological model

Descriptive studies on the utilization of mammography among Hispanic women have indicated that there are a myriad of determinants and correlates associated with screening (Schueler et al., 2008). Given the array of factors associated with mammography, theoretical models applied to this area of research must be broad and allow for consideration of multiple levels of influence. Social-ecological models of health behavior, such as the Social Ecological Model (McLeroy et al, 1988), do just this by considering broader contextual determinants of behavior, such as public policy or environmental factors, while also taking social and individual determinants into account (Sallis et al, 2008).

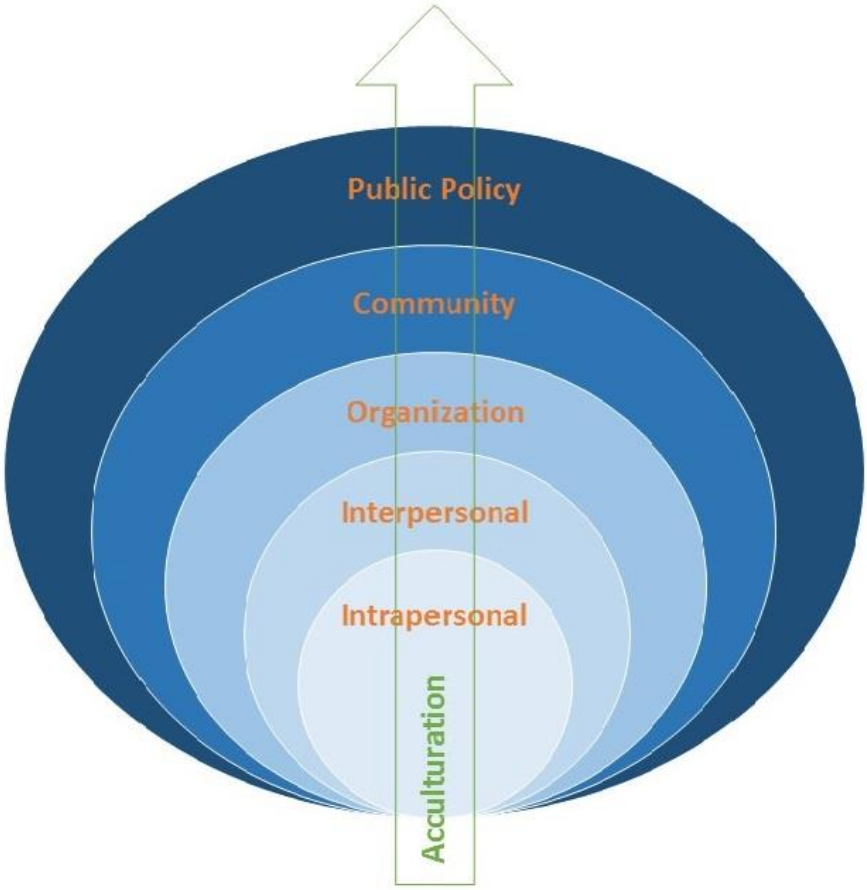

Figure 1.1 *The social ecological model, with acculturation included as a crosscutting construct.*

Social-ecological models of health behavior have four basic tenants: 1) they have multiple levels of influence on health behaviors, 2) these influences on behaviors interact across the differing levels, 3) models should be behavior specific, and 4) multi-level interventions will have the greatest impact on behavior change (McLeroy et al, 1988; Sallis et al, 2008).

As originally proposed by McLeroy and colleagues (1988), the Social Ecological Model (SEM), most often depicted as an onion with layers or as a rainbow, posits that there are five levels of influence that can impact a health behavior (Figure 1.1). The broadest level or outermost layer is public policy. At this level of the SEM the focus is not on the health of an

individual, but rather that of a population. Public policy impacts health behavior through laws, policies or regulations that can change or protect a population's health (McLeroy 1988).

In the context of mammography screening in Hispanic populations in the U.S., there are several key public policy efforts that need to be considered. The first of these policies is related to immigration. While Hispanics are routinely seen as a homogeneous group, immigration laws and policies differ depending on one's country of origin, family reunification, refugee or asylum status, and employment or educational history (American Immigration Council, 2016). For example, those from Puerto Rico are American citizens and therefore not subject to immigration laws, and those of Cuban descent have pathways to permanent residency that are not available to any other group of Hispanics – a program that ended with the Obama presidency in 2017 (Hirschfeld Davis & Robles, 2017). Others from Mexico, Central and South America may be subject to yearly per-country immigration ceilings or obtaining refugee or asylum status to enter the country legally (American Immigration Council, 2016), or cross the U.S. border without legal authorization. Immigration status can impact a person's ability to get access to public service and health insurance programs and ability to obtain lawful employment; for example, the Personal Responsibility and Work Opportunity Reconciliation Act prohibited unauthorized immigrants from obtaining public benefits (PRWORA, 1996). Individual states may also have additional laws and policies on access to public insurance and assistance programs based on immigration or citizenship status. Policies can be restrictive in nature with the intent of reducing immigration, or conversely, they can work to increase access to public services (National Conference of State Legislatures, 2015). Additionally, the Affordable Care Act is another key policy. Medicaid expansion and greater availability of health insurance access to care may have the potential to impact mammography utilization (Sommers et al, 2015; Baiker et al, 2013).

Finally, programs such as the CDC funded Breast and Cervical Cancer Early Detection Program make it possible for lower income individuals to access cancer screening services, many of which are members of minority populations (Adams, et al, 2007; Tangka et al, 2010).

The next level of the SEM is community. McLeroy discusses three different aspects of community. The first is a fairly standard view of community where it is composed of social networks, neighborhoods, schools, and organizations that impact health behavior through social capital (1988). He also presents community as the relationships between organizations in a given area and their ability to work together and leverage the resources available to them. The final concerns power differentials in communities in regard to how resources are allocated among organizations and if all segments of a community have an equal voice (McLeroy et al, 1988; Sallis et al, 2008).

Several facets of community could be critical to Hispanic women getting screened for breast cancer. These include geographic and spatial factors that impact access to care. Contextual factors in Hispanic neighborhoods that may have an impact on mammography screening include social capital, structural barriers and facilitators to screening facilities, and demographic composition of neighborhoods (Hendryx et al, 2002; Gresenz et al, 2012; Gresenz et al, 2009; Baron et al, 2008). In additional, social class and socio-economic status and position will be key to contextualize the neighborhoods and areas where Hispanic immigrants settle (Kreiger et al, 1997; Adler et al, 1994). Several of these factors are multi-dimensional and require additional conceptual frameworks to inform selection of measures and operationalization of constructs. The additional conceptual frameworks proposed to address community level factors are presented below.

The third level of the SEM concerns organizations or institutions and focuses on how these structures can be used to support behavioral change or how changes within the organizations themselves can bring about change (McLeroy et al, 1988; Sallis et al, 2008). Organizations include health care systems, employers or worksites, professional organizations, non-profit organizations, and/or schools. For the present study, access to health care systems and clinics, as well as mammography facilities, are presented as being key determinants to the uptake of mammography among Hispanic women. A more thorough conceptualized model of access to care is presented below.

Interpersonal relationships comprise the next level of the SEM. This level addresses the potential influence that our social relationships, such as friends, family, neighbors, co-workers, etc., can have on our health, as well as the importance of social resources as mediating factors (McLeroy et al, 1988; Sallis et al, 2008). As previously mentioned, social support and social networks are generally robust among Hispanic women, but acculturation and immigration related factors might moderate that relationship (Shelton et al., 2011). In addition, cultural and social norms may impact Hispanic women differently than non-Hispanic white women (Watson-Johnson et al., 2011). The final and most micro level of influence of the SEM is the intrapersonal or individual level. This level is characterized by individual characteristics and psychological or physiological processes (McLeroy et al, 1988; Sallis et al, 2008). Key interpersonal level factors for the current study are mostly related to acculturation and immigration, but also include risk perception, fatalism, and previous experiences with mammography (Espinosa et al., 2011; Niederdeppe & Levy, 2007; Ramirez et al., 2013; Watson-Johnson et al., 2011).

One of the major strengths of ecological models like the SEM is that it challenges researchers to consider multiple levels of determinants for health behaviors. This not only leads to more comprehensive research, but also cross-cutting multi-level interventions that are more likely to have greater impacts on population level health and potentially lead to more sustainable health behavior changes (McLeroy et al, 1988; Sallis et al, 2008). In addition, due to the multi-level nature of ecological models, constructs from other health behavior theories, such as the Health Belief Model at the individual level, theories of social support and social networks at the interpersonal level, and capacity building and community coalitions at the community level, can be easily integrated to build comprehensive frameworks to guide research and interventions (McLeroy et al, 1988; Sallis et al, 2008). For the proposed study, additional conceptual frameworks for acculturation, residential segregation, access to care, and socio-economic status are being utilized to conceptualize key factors at multiple levels of the SEM.

While a significant amount of research has been conducted among Hispanic women in the U.S. on their utilization of mammography, very little of that work has attempted to take a social-ecological perspective and assess multilevel determinants to mammography utilization. Studies that have assessed more than one level are mostly looking at individual and interpersonal level factors associated with uptake of mammography (Schueler et al., 2008). Some of these studies have lacked the utilization of multi-level analytic techniques making it difficult to understand the role contextual factors play in screening (Coughlin et al, 2008). Several studies have also looked at determinants to screening at the organizational and community levels, namely factors associated with health care systems and mammography capacity (Meersman et al., 2009; Peipins et al., 2011; Peipins et al., 2012). However, these studies are mostly ecological in nature, and do not use individual level data or designs. In addition, a number of studies have

looked at cross-cutting factors, namely culture and acculturation, but rarely beyond the inter- and intra-personal level (Shelton et al., 2011; Rodriguez et al., 2005; Abraido-Lanza et al., 2005; Garcia et al., 2012).

There are also limitations associated with models like the SEM. Given the broad nature of these frameworks and the myriad of inputs that can be associated with one particular health behavior, it can often be difficult to identify the most salient relationships are (Sallis et al, 2008), which can make hypothesis generation difficult. Unlike other health behavior theories that list specific constructs, social-ecological models don't specify constructs to consider other than the broader levels of influence (McLeroy et al, 1988; Sallis et al, 2008). While ecological models allow for interactions between levels, the nature of these interactions is unclear. Crosscutting constructs, such as culture, social class, or racism/discrimination, can also be difficult to conceptualize in these models since they don't clearly fit into any of the levels. In addition, the broad nature of the model can make research more demanding (Sallis et al, 2008). Not only can development of measures and collecting data at multiple levels can be challenging, but more sophisticated statistical techniques are required to analyze these data.

For the proposed study, the use of additional conceptual frameworks should addresses several of these limitation by more specifically defining variables at each level, highlighting key relationships of interest, and conceptualizing cross-cutting constructs.

Additional conceptual frameworks

Research aims related to understanding the role of acculturation, access to care, and socioeconomic status in mammography utilization and the relationships between these variables necessitate having a conceptual framework with a multi-level perspective to guide the

operationalization of these concepts into measures. Below are additional conceptual frameworks that will guide the discussion of constructs at multiple levels of the SEM.

Acculturation

As previously mentioned, McLeroy and colleagues specifically discussed socio-cultural factors, including acculturation, as cross cutting factors that impact each level of the SEM (McLeroy et al, 1988; Sallis et al, 2008). Policies related to immigration, social capital at the community level, access to medical care in health systems, social support and social networks, and cultural factors that may impact risk perception, are all acculturation related factors across the five levels of the SEM that may impact health care utilization. However, given the need to have a more accurate operationalization and measures of acculturation, an additional conceptual framework for acculturation was developed for this dissertation.

While much has been written on acculturation, formal models or conceptual frameworks linking acculturation and health care utilization are lacking (Abriado-Lanza et al, 2006). To guide the conceptualization and measurement of acculturation, an original conceptual model for acculturation was developed for this dissertation. The intention of this conceptual model was to identify domains of acculturation based on published literature that would assist in selection of measures and organization of results. The domains and definitions were based on a review of texts and peer-reviewed articles on acculturation, as well as a literature review of measures of acculturation (Zane & Mack, 2005; Sam, 2006; Sam, 2006b; Abriado-Lanza et al., 2006; Abriado-Lanza et al., 2016; Schwartz et al., 2010; Acevedo-Garcia, 2012; Fox et al., 2017). Eight distinct domains of acculturation were identified, including: immigration and nativity, language use, participation and maintenance of customs and traditions, migration and settlement,

ethnic identity and heritage, acculturation stress and discrimination, interactions and social networks, and cultural beliefs and norms.

Definitions and examples for each domain of acculturation are presented in Table 1.1. In brief, the immigrant and nativity dimension includes factors related to pace of birth, citizenship status, length of residence in the U.S., and age at immigration. The language utilization dimension is focused on the languages spoken, fluency and comfort with language, and frequency of language utilization. Factors associated with participation in new activities and traditions, continued participation in traditional cultural activities, and behavior or custom extinction or acquisition would be assessed in the participation and maintenance dimension. The migration and settlement dimension focuses on where immigrants settle, the immigrant communities located there, and the demographic composition of their neighborhoods. The identity and heritage domain address current ethnic identify and classification, cultural allegiance, and ethnic/national pride. Acculturation stress and discrimination refers to stress and anxiety associated with immigration and assimilation into new surroundings. In addition, this domain also includes experiences racial and ethnic racism and discrimination that immigrants may have faced. Interactions and social networks focus on interactions with members of similar and different ethnic groups, the development of friendships, social ties, and social networks, and time spent with members of similar and different ethnic/racial groups. The final dimension, cultural beliefs and norms, refers to cultural beliefs or norms, such as familism, or fatalism, that are unique to the initial culture and may change as a result of exposure to the new culture.

These domains were then classified as being either at the person-level, cultural practice or belief based, or place-based. Three person-level domains were identified: 1) immigration and nativity, 2) identity and heritage, and 3) acculturation stress and discrimination. These domains

focus on characteristics or attributes of the individual or psychosocial processes. Four domains were classified as being based on cultural practices or beliefs: 1) language utilization, 2) cultural beliefs and norms, 3) interactions and social networks, and 4) participation and maintenance of cultural traditions. One domain, migration and settlement, was classified as being place-based.

Our framework, presented in Figure 1.2, posits that person-level and practice/belief-based domains occur in the context of place-based acculturation factors. Previous writing on acculturation has stressed the importance of considering place, or local context, in order to understand the reference culture immigrants are acculturating to (Abraido-Lanza, et al, 2006; Schwartz, et al 2010). Double-headed arrows between person and practice/belief domains demonstrate that these domains may have a reciprocal influence on each other, as well as on the place (Abraido-Lanza, et al, 2006; Schwartz, et al 2010; Lopez-Class, et al. 2011; Acevedo-Garcia, 2012). The confluence of these domains may in turn impact access to health services, such as mammography, and then lead to health outcomes, namely breast cancer and components of that diagnosis.

Figure 1.2. *Conceptual framework for acculturation*

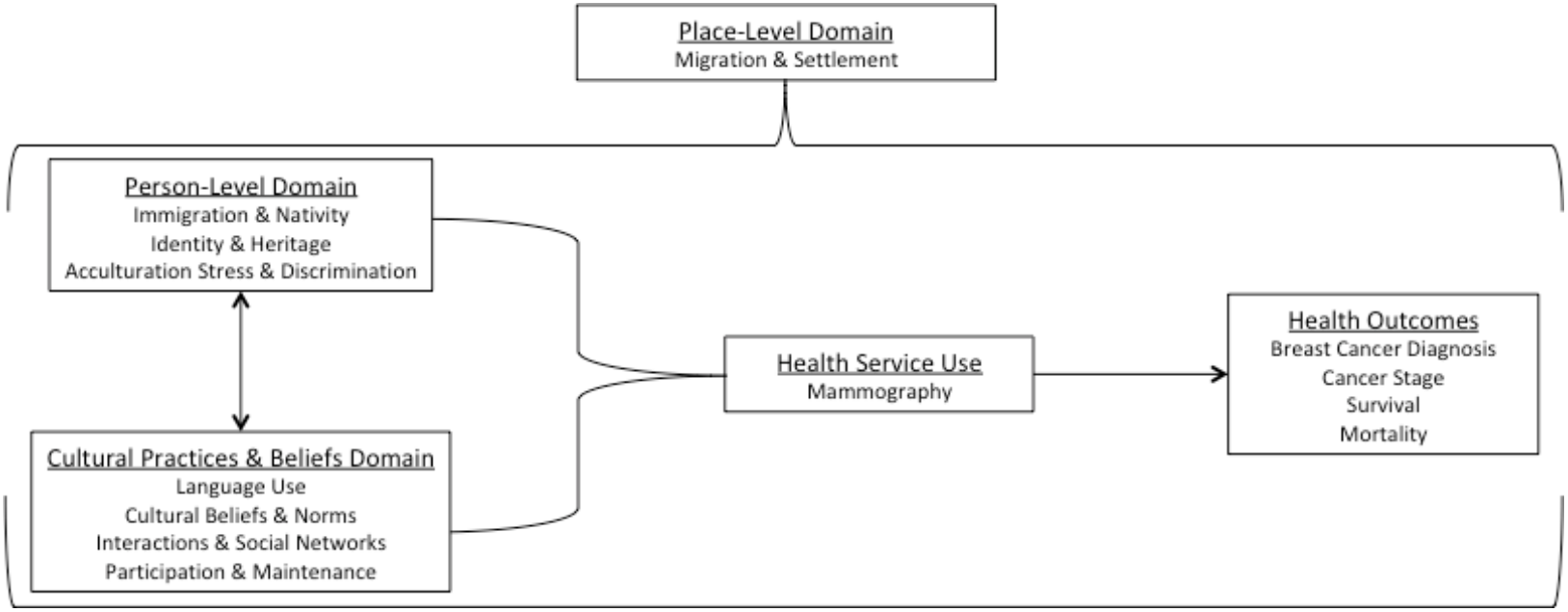

Table 1.1 Conceptual definitions for acculturation framework domains

Domain	Conceptual definition
Person-Level Domain	
Immigration and Nativity	Refers to a person's place of birth, their immigration process, number of years since immigration, and their current residency or legal status in their new country of residence
Identity and Heritage	The identity and heritage domain refers to how a Hispanic individual identifies, in terms of culture and ethnicity, and their pride in their culture and country of origin. Ethnic identity refers to the extent to which individuals have explored what their ethnic group means to them and attachment to that identity (Phinney, 1990; Phinney & Ong, 2007; Schwatrz et al., 2010).
Acculturation Stress and Discrimination	Stress associated with immigration, like adapting to new places and surroundings. Also includes experiences associated with racism and discrimination (Berry, 2006).
Practice/Belief Domain	
Language use and preferences	Encompasses language(s) spoken, including fluency, frequency of use, and comfort with language(s) spoken. This domain would also include situational use of language (for example, language spoken at home and with friends and family, versus language spoken at work), as well as the language in which one consumes entertainment, news, or literature. Comfort communicating in particular situations (e.g. communicating in non-native language at doctor's office) would also be encompassed in this domain
Cultural Beliefs and Norms	Rules or expectations of behaviors or thoughts based on shared beliefs within a specific cultural group; Cultural beliefs/norms are rules or expectations of behaviors or thoughts based on shared beliefs within a specific cultural group (Marin & Gamba, 2005). This domain focuses on changes in social/cultural norms and values (e.g. familism, communication style, hierarchy and authority, uncertainty, and fatalism) (Masgoret & Ward, 2006; Cuellar et al., 1995).
Participation and Maintenance	The participation and maintenance domain refers to participation in, or maintenance of, cultural traditions and practices, and adoption or participation in new traditions or events. Discontinuation or continued participation in daily habits, such as changes in food preferences, may also be considered part of this domain. Changes in cultural practices and daily habits may be an indicator of cultural adaptation.
Interactions and Social Networks	Refers to the types of people, including family and friends, one interacts with during leisure time. This domain focuses on interactions with members of similar and different ethnic groups, the development of friendships, social ties, and social networks. The types of social interactions one has after immigrating may provide the reference for the receiving culture and the template for acculturation (Abriado Lanza et al., 2006; Schwatz et al., 2010). This domain is influenced by

	social network theory that suggests “social structure of a network is largely responsible for determining individual behaviors and attitudes by shaping the flow of resources which determines access to opportunities and constraints on behaviors” (Berkman & Glass, 2000).
Place-Based Domain	
Migration and Settlement	This domain refers to the places and communities where immigrants settle. Place-based factors associated with the areas where individuals who immigrated settle (i.e. demographic composition of the neighborhood, living in an ethnic enclave).

Access to Care

A five-factor model proposed by Pechansky and Thomas (1981) will be used to operationalize access to care. In many studies access to care is routinely operationalize as a one item question assessing last medical visit or if a person is insured, however, access to care is conceptually a multi-dimensional construct (Andersen et al, 1983). Pechansky and Thomas proposed that operationalization and measurement of access to care has to consider availability of care, accessibility to care, affordability of care, accommodations of care, and acceptability of care (Figure 9).

Availability of care is a question of health care volume and supply. This construct refers to the adequacy of the number of physicians, health centers or clinics, hospitals, or health professionals. Accessibility refers to one's ability to reach the supply. This would include transportation, travel time, distance, and transportation costs. Affordability refers to cost of health services, specifically out-of-pocket costs, and health insurance. Accommodations of care refer to facets of the health care system that facilitate or impede a patient's ability to receive care. This could include the ease of making an appointment, clinic hours of operation, wait times, or walk-in appointments. Acceptability of care denotes the conditions in which care was received and how patient preferences and perceptions match those of providers and health systems. This factor is sometimes measured by assessing satisfaction with the provider's offices and surrounding neighborhood (Pechansky & Thomas, 1981).

Utilization of this model of access to care provides an opportunity to understand receipt of a mammogram in a more holistic environment. It may also provide an opportunity to better understand which facets of access to care are most in need of intervention to impact mammography utilization.

IV. Significance and Aims of Research

This dissertation project sought to examine the role of acculturation in mammography utilization among Hispanic women in the U.S. by exploring individual and areas level domains of acculturation to better understand influence on breast cancer screening uptake. This was done by 1) summarizing conceptual definitions of acculturation and describing their associations with mammography utilization, 2) exploring the role of immigration status on the uptake of mammography, and 3) assessing population-level mammography capacity among Hispanic communities in the U.S.

This project is guided by previous research showing inconsistent results on the relationship between mammography use and acculturation. While some studies have indicated that lower levels of acculturation are associated with less mammography use (Shelton et al, 2011; Alexandraki & Mooradian, 2010; Jacobs et al., 2005), other studies have found that acculturation is associated with greater mammography use, and other studies have found null results (Abriado-Lanza et al, 2005; Rodriguez et al., 2005; Garcia et al, 2012). There are several plausible reasons for these differences. One reason may be the variability of measures that could be encompassed under acculturation (Algeria, 2009; Fox et al., 2017). Measures of acculturation can range from well-validated multi-dimensional scales, to brief individual items included as socio-demographic characteristics of Hispanic individuals. In addition, these measures may be measuring completely distinct domains of acculturation that, conceptually, may be difficult to compare (Fox et al., 2017; Zane & Mak, 2005). Lack of a thorough understanding on the behavioral mechanisms through which acculturation may affect health service use further complicates the process of elucidating the relationship between acculturation and mammography use (Abraido-Lanza et al., 2006). This dissertation sought to add context to this issue by

developing a conceptual framework that defines domains of acculturation and then uses that framework to organize and synthesize the results of mammography research by acculturation domain. This approach allows us to assess results across studies with similar measures and conceptual definitions for acculturation and elucidate if differences in measurement may be driving inconsistent results.

One domain of acculturation that has shown inconsistent results is immigration status. Immigration status here is being used a broader term intended to capture citizenship or legal status, time spent living in the U.S., having been born domestically or abroad, and country of origin (Hunt et al, 2004 Thomson & Hoffman-Goetz, 2009). These are some of the most commonly used measures of acculturation due to both their simplicity and brevity (Abraido-Lanza et al., 2006; Hunt et al, 2004; Wallace, et al, 2010). The prevailing theory on this domain of acculturation is based on that as one becomes a U.S. citizen and spends a longer amount of time in the U.S. instead of an individual's country of origin, they acculturate to the host culture (Hunt et al, 2004; Fox et al., 2017). While this theoretical perspective has some significant flaws, namely that the host culture (i.e., U.S. culture) can vary significantly depending on where one settles after immigration (Abraido-Lanza et al., 2006), this domain may be of interest to public health professionals and researchers because of the implications U.S. immigration policy may have on access to care (Zambrana & Carter-Pokras, 2010). Previous studies have found inconsistent results on the role of immigration status on mammography use among U.S. women (Echeverria & Carrasquillo, 2006; Rosales & Gonzalez, 2013). The dissertation sought to further explore the role of immigration status on mammography use, as well as access to care and socioeconomic status, with a large and diverse national sample of Hispanic women.

Previous studies have found that Hispanic populations may less access health care centers and services. Gresenz and colleagues found that in some of the emerging Hispanic communities in the U.S., Hispanics faced challenges accessing health care services compared to those living in more long-established Hispanic neighborhoods (2012). Studies have also found the contextual factors may be important contributors to mammography utilization. Neighborhood poverty level and racial/ethnic neighborhood composition have been among the contextual factors linked to mammography use (Mobley et al, 2009; Coughlin et al, 2008). An additional contextual factor of interest may be availability of mammography facilities in one's neighborhood or community. Conceptual models of access to care, namely those by Pechansky and Thomas (1981) and Andersen and colleagues (2013), both include supply of health care services as important determinants of access. Previous studies have found that there are areas of the U.S. where there is no physical access to mammography facilities or units (Peipins et al, 2012; Eberth et al, 2013). Not having accessible mammography services has been previously linked with increased wait time for screening, decreased mammography use, and late-stage breast cancer (Elting et al, 2009; Elkin et al, 2010; Elkin et al, 2012). Due to more Hispanic immigrants settling in rural areas (Lichter & Johnson, 2009), Hispanic populations may be facing limited physical access to mammography use. Previous studies have found that rural areas are more likely to lack mammography capacity (Elting et al, 2009; Peipins et al, 2012). This dissertation builds on previous studies of mammography capacity by estimating mammography capacity in Hispanic communities in the U.S. and describing these low access, high Hispanic population density areas. In addition, to describing community contextual factors associated with access to care and socio-economic status, contextual factors related to acculturation, namely citizenship status and language use, will also be described.

This dissertation's focus on elucidating the relationship between acculturation and mammography use is intended to inform future research and public health interventions at multiple levels. Multiple theoretical frameworks, which informed study research methods and design, selection of measures, and assisted in organizing and framing results, guided this dissertation. Frameworks include the socio-ecological model (McLeroy et al, 1988) and Pechansky and Thomas's five-factor access to care framework (1981), as well as a framework on acculturation developed for this dissertation.

The specific aims of this dissertation are:

Aim 1: Explore the role of acculturation on mammography screening among Hispanic women in the U.S. through a systematic review.

Research questions for this aim are:

1. How has acculturation been operationalized and measured in research on mammography use among Hispanic women?
    a. To what extent are the measures of acculturation being utilized in research on mammography use multi-dimensional?
2. What is the effect of acculturation on mammography use and how does it vary by domain?

Aim 2: Examine immigration status as a determinant of mammography use among Hispanic women in the U.S.

Research questions are:

1. What proportion of Hispanic women are being screened for breast cancer through mammography? Does test use vary by country of origin and/or immigration status?

2. Does access to care and socio-economic status among Hispanic women vary by country of origin and/or immigration status?
3. Does immigration status contribute to mammography use beyond access to care and socio-economic status?

Aim 3: Assess mammography capacity in Hispanic communities in the United States and describe the communities facing challenges in availability of screening.

Research Questions are:

1. Do Hispanic women living in primarily Hispanic areas have similar access to mammography facilities as those who do not live in mostly Hispanic areas?
2. What are the characteristics of Hispanic areas with limited mammography capacity?
3. What proportion of Hispanic women live in areas with limited or no mammography capacity?

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Chapter Two

Exploring acculturation as a multi-dimensional measure in research on mammography utilization among Hispanic/Latina women in the U.S.

I. Introduction

Cancer is the leading cause of death and breast cancer is the leading cause of cancer-related death among Hispanic women in the U.S. (ACS, 2015, 2018; USCS, 2016; Siegel et al., 2015). While Hispanic women have lower incidence and mortality rates for breast cancer than non-Hispanic white women, they are less likely to have their cancer diagnosed at a localized stage (Siegel et al., 2015). Mammography is the only imaging test recommended for breast cancer screening. It has been shown to reduce mortality from breast cancer by making breast tumors more easily detectable at earlier stages where tumors are less severe and treatments are more effective (Mandelblatt et al, 2009).

The proportion of Hispanic women receiving mammograms consistent with cancer screening recommendations has remained fairly stable over time have (Reyes &Miranda, 2015; Coleman King et al., 2012; Sabatino et al., 2015; White et al., 2017), and remained below the rate in the Healthy People 2020 objective (81.1%). In addition, interventions to increase mammography use among Hispanic women have shown limited effectiveness (Corcoran et al., 2010). Developing a better understanding of barriers and facilitators to mammography use among Hispanic women is needed in order to better inform future interventions. In addition, understanding factors driving utilization and adherence to screening recommendations are essential to improving breast cancer outcomes.

Acculturation, broadly defined, is a process through which values, behaviors, lifestyles, and language can change due to sustained exposure to other cultures (Berry, 2006; Berry & Sam,

2006). The potential role acculturation may play in the health and health service use of Hispanic women has been of significant interest and widely studied. However, results among studies have been inconsistent. While some studies have found that lower levels of acculturation are associated with less use of mammography for breast cancer screening (Rosales et al., 2013; Rodriguez et al., 2005), other studies have found that the effects of acculturation are often explained by socio-economic or access factors (Abraido-Lanza et al, 2005). These inconsistencies may be the result of significant variation in measures of acculturation, relying on proxy measures, and lack of cross-cultural validity of measures (Algeria, 2009). Exploring the measures of acculturation that have been used in studies of mammography use may help us consider results in a new context and provide insights into the mechanisms through which culture may impact health service utilization.

A systematic review of the literature was conducted to explore the role of acculturation on mammography screening among Hispanic women in the U.S. This review will assess the measures of acculturation used in studies of mammography use and evaluate if associations between mammography and acculturation vary by type of domain of acculturation being measured. Specifically, we seek to answer the following research questions:

1. How has acculturation been operationalized and measured in research on mammography use among Hispanic women?
    a. To what extent are the measures of acculturation being utilized in research on mammography use multi-dimensional?
2. What is the effect of acculturation on mammography use and how does it vary by domain?

II. Methods

The methods of this systematic review were designed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009).

Conceptual Framework

To guide our understanding of acculturation as a multi-dimensional construct and allow us to operationalize and assess the potential mechanisms through which acculturation may impact mammography use, we developed a framework defining domains of acculturation based on a review of textbooks and peer-reviewed articles on acculturation, as well as a literature review of measures of acculturation (Zane & Mack, 2005; Sam, 2006; Abriado-Lanza et al., 2006; Abriado-Lanza et al., 2016; Schwartz et al., 2010; Acevedo-Garcia, 2012; Fox et al., 2017). Based on our review and synthesis, we identified eight distinct domains for the construct of acculturation (Table 2.1). These domains were then classified as being either at the person-level, cultural practice or belief based, or place-based. Three person-level domains were identified: 1) immigration and nativity, 2) identity and heritage, and 3) acculturation stress and discrimination. These domains focus on characteristics or attributes of the individual or psychosocial processes. Four domains were classified as being based on cultural practices or beliefs: 1) language utilization, 2) cultural beliefs and norms, 3) interactions and social networks, and 4) participation and maintenance of cultural traditions. One domain, migration and settlement, was classified as being place-based.

Our framework, presented in Figure 2.1, posits that person-level and practice/belief-based domains occur in the context of place-based acculturation factors. Previous writing on acculturation has stressed the importance of considering place, or local context, in order to

understand the reference culture immigrants are acculturating to (Abraido-Lanza, et al, 2006; Schwartz, et al 2010). Double-headed arrows between person and practice/belief domains demonstrate that these domains may have a reciprocal influence on each other, as well as on the place (Abraido-Lanza, et al, 2006; Schwartz, et al 2010; Lopez-Class, et al. 2011; Acevedo-Garcia, 2012). The confluence of these domains may in turn impact access to health services, such as mammography, and then lead to health outcomes, namely breast cancer and components of that diagnosis.

Search strategy and eligibility criteria

A systematic literature review was conducted using the following databases: Medline/PubMed, PsychInfo, CINHAL, SCOPUS, and EMBASE. Inclusion criteria included quantitative studies or analyses: 1) from English language peer-reviewed journals, 2) involving human subjects conducted in the United States, and 3) published between January 2005 and December 2017. Keywords used in search included: Hispanic or Latino or Latina; mammogram OR mammography OR breast cancer screening; early detection OR cancer screening. In addition, the references of retrieved papers deemed eligible as well as review articles identified in the search, were reviewed.

Abstract Review

Titles and abstracts for all identified citations were reviewed and classified as relevant, unsure, or not relevant by 2 independent reviewers (JR, MV). Eligibility criteria were having mammography use as an outcome, having Hispanic/Latina specific results, and including an acculturation related measure included as an independent variable of interest. An Excel spreadsheet listing each article was used for reviewers to record their classification and a brief reason for their classification. All entries marked relevant or unsure continued to full-text review.

Any disagreements between the reviewers were discussed and consensus was reached. Next, the reviewers employed the same process for review of full text articles.

Data Abstraction

After the full-text review, all articles marked relevant were abstracted into an Excel spreadsheet. Fields for abstraction included study authors and title, study characteristics (location, population, Hispanic population of interest, setting or location), study design (quantitative/qualitative, observational/intervention), measures of acculturation (type, # of items, constructs measured, items, and psychometric properties), key covariates included in analyses, magnitude of effect (measures of association), conceptual frameworks or theory utilized, and results associated with acculturation. A primary abstractor abstracted these data elements and then secondary abstractor reviewed every 5th entry for completeness and accuracy (MK).

Risk of Bias Assessment

Quality assessment of individual studies was conducted using the National Heart, Lung, and Blood Institute's Quality Assessment Tool for observational and cross-sectional studies (NHLBI). This quality assessment tool consists of fourteen criteria to evaluate the internal validity of a study (e.g. having clearly defined research questions and populations, a response rate presented, clearly described measures) (Table 2.5). Each article was reviewed to indicate if it met each of the fourteen criteria, or if it was not relevant to the methodology of the study (e.g. blinding or follow-up). The number and proportion of studies meeting each criterion were summed.

Data Synthesis

First, we (JR, MV) abstracted characteristics of studies including their setting, the study design, the study population, age group, recruitment processes, sample size, and basic study

methodology (Table 2.2). All measures and scales of acculturation described in each study were mapped to the acculturation framework domains (Table 2.3 & Supplementary Table 2.1; Figures 2.3 & 2.4). Study results describing the associations between acculturation and mammography use were summarized by acculturation domain category and among multi-dimensional measures of acculturation.

III. Results

Search Results

The process for study selection is presented as a flow diagram in Figure 2.2. Our initial search identified 512 unique abstracts. Three hundred ninety were excluded based on review of study abstracts and titles. After reviewing the references of the fourteen review articles identified, nine additional publications were added to the review. One hundred and thirty-one articles were included in the full text review, of which eighty did not meet the inclusion criteria. Of the fifty-one remaining articles, 35 were quantitative and met the eligibility criteria (16 qualitative studies were excluded). Three studies by Cadet et al (2015, 2017a, 2017b) all utilized the same dataset and had the same outcome and acculturation measure, but utilized different covariates in their modeling in each paper. For this review, they were counted as distinct studies.

Study Characteristics

Characteristics of studies included in the review are presented in Table 2.2. Eleven studies (31.4%) were conducted with national samples, nine (25.7%) were conducted with state or multi-state samples, thirteen (37.1%) were conducted in cities or counties, and three (8.6%) were conducted in communities along the U.S./Mexico border. Recruitment methods varied widely and included national or state-based representative samples, clinic samples, intervention participants, and community based convenient samples. While some studies had varied Hispanic

populations, others focused on only foreign-born Hispanic women, women from specific countries or origin, or those who did not speak English, attended religious services regularly, or were low income and uninsured. Of the thirty-five quantitative studies included in the review, the vast majority were cross-sectional surveys (33/35 or 94.3%). However, six of the surveys were the baseline survey for an intervention study (6/33 or 18.2%). One study (2.9%) presented results from a review of medical records, and one study (2.9%) presented results from an intervention. On average, studies had a sample size of 1025, with a minimum of 66 and a maximum of 5546. Eleven studies (31.4%) recruited a national sample of diverse Hispanic women.

Mammography use was operationalized in a few different ways across the studies included in the review. Five studies (14.3%) included more than one mammography use outcome. Twenty-two studies (62.9%) focused mammography use on having had a mammogram in the past two years, while ten (28.6%) used having received a mammogram in the last year. Study participant age was directly tied to mammography use because of age-associated clinical practice recommendations. Given that multiple recommendations with inconsistent screening starting age are available, there was some variability in participant age. Twenty studies (57.1%) included women aged 40 and older in their analyses, while two studies (5.7%) included women 50 and older, and one study included women aged 35 and older (2.9%).

Measures of Acculturation

Acculturation measures from the 35 studies mapped onto seven of the eight acculturation domains (Table 2.3; Figure 2.3). Measures most frequently mapped onto the immigration and nativity and language use items. No studies identified included measures of tradition participation and maintenance. Most studies (23, 65%) included measures across more than one

domain (Figure 2.4). Twelve studies (34%) only included measures in one domain, 18 (51%) included measures in two domains, 4 (11%) across three domains, and one study included measures across four (3%) domains. Of the 23 studies that included measures across more than one domain, 13 (57%) studies included immigration and nativity and language use measures, two (9%) included measures of immigration and nativity and acculturation stress, and two (9%) included measures associated with immigration and nativity, language use, and cultural beliefs and norms. Six additional combinations were used by individual studies.

Twelve (34%) of the identified studies used eight scales to assess domains of acculturation. Three of the scales identified were multi-dimensional, while the remaining five focus on specific domains of acculturation. Additional details on each of the scales identified are presented in Supplement 1. Individual questions related to acculturation were primarily used to measure facets of the Immigration and Nativity domain. Frequently asked questions were: country of origin or ethnic subgroup, citizenship status, being foreign born or U.S. born, and length of time spent living in the U.S. While scales were frequently used to measure aspects of language use, studies also utilized individual items, like asking language preference in one item, using administrative records to determine language use, or using language of interview as a proxy for broader language use. In the single study that measured migration and settlement, the authors employed addresses and other geographic data to determine if study participants lived in a town bordering, or in proximity to, the U.S.-Mexico border.

Additional results on acculturation scales identified in this review are presented in the Supplementary Materials section (Supplementary Results; Supplementary Table 2.1).

Acculturation and Mammography Use

Overall, sixty-one comparisons or tests of associations were made across the thirty-five studies included in the review. Of those, eleven (18%) indicated that acculturation was associated with increased mammography use, twelve (19.7%) indicated that acculturation was associated with decreased mammography use, and thirty-eight (62.3%) showed that there was no significant association between mammography use and acculturation (Table 2.4).

Person-Level Domains

Immigration and Nativity

Thirty studies (85.7%) included measures associated with Nativity and Immigration Status, however three studies did not present results associated with these measures. Of the 27 remaining studies (77.1%), twenty-three included one measure, or a composite measure, two included two measures, and one included three measures of nativity and immigration status. Measures were grouped into five categories: citizenship status, being U.S. or foreign born, the number of years spent living in the U.S., a composite measure of being U.S. or foreign born and number of years spent in the U.S., and country of origin (Supplementary Figure 2.1). No scales were used to measure this domain. All measures consisted of individual questions or a short set of questions.

Three studies included measures of citizenship status. Two found no significant differences in mammography use between citizens and non-citizens (Table 2.4) (Lim, 2010; Echeverria & Carrasquillo, 2006), while one study found that non-citizens had significantly lower odds of having had a recent mammogram (OR=0.634, 95%CI: 0.62, 0.65) and significantly lower odds of ever having had a mammogram compared to naturalized citizens (OR=0.286, 95% CI: 0.28, 0.29) (Rosales & Gonzales, 2013).

Seven studies included measures of acculturation to assess if mammography use varied among Hispanic women who were born in foreign countries compared to those born in the United States. One study compared mammography screening use among foreign and U.S. born Hispanic to non-Hispanic white women and found that foreign-born Hispanic women had lower odds of mammography use (OR=0.60, 95% CI: 0.45-0.81) compared to NH white women, while U.S. born Hispanic women had similar odds of mammography use (OR=0.91, 95% CI: 0.69-1.2) to NH white women (Rodriguez et al., 2005). Three analyses by Cadet (2015, 2017a, 2017b) using data from the Health and Retirement study all found that U.S. born women had lower odds of having recently had a mammogram compared to foreign-born Hispanic women. Three additional studies that compared U.S. born Hispanic women to Mexican born Hispanic women all found that differences in screening use by this characteristic were non-significant (Table 2.4) (Castañeda et al., 2014; Nuño et al., 2011; Palmer et al., 2005).

Seven studies assessed the potential impact of years spent living in the United States would have on mammography use. Of these seven studies, three operationalized years living in the U.S. as a continuous measure, while five created categorical variables. Two studies found that Hispanic women that had been living in the U.S. less time were not having mammograms as recently as Hispanic women who had been in the U.S. for longer periods (Dang et al., 2013; Rosales and Gonzales, 2013). Rosales and Gonzales (2013) found that foreign-born Hispanic women that had been in the U.S. less than ten years had significantly lower odds of ever having had a mammogram (OR= 0.483, 95% CI:0.47-0.49) and lower odds of having had a recent mammogram (OR=0.86, 95% CI:0.84, 0.88) compared to foreign-born Hispanic women that had been in the U.S. 10 or more years. The remaining five studies found no significant differences in

mammography use by time spent living in the U.S. (Table 2.4). Differences in operationalization of measure did not seem to drive associations.

Five studies created a composite categorical variable to capture both time spent living in the U.S. and being U.S. born. Only two studies found informative results (Table 2.4). While a study using data from three years of the National Health Interview Survey found that Hispanic women who were in the U.S. less than ten years were screened at a lower proportion (53.0%) than Hispanic women who had been in the U.S. ten years or more (68%), or U.S. born Hispanic women (71.2%), no statistical testing was conducted to discern differences (Shoemaker & White, 2016). A study by Mack and colleagues (2009) found that there was no significant difference in odds of having been screened between women in the U.S. less than fifteen years compared to those who were U.S. born (OR=1.08, 95% CI: 0.67-1.72). However, they did find that foreign-born Hispanic women in the U.S. more than fifteen years had greater odds of being screened (OR=1.45, 95% CI: 1.05-1.99). The remaining three studies found no significant results (Table 2.4).

Ten studies assessed differences in mammography use by country of origin. Four of these studies found no significant differences in mammography use by country of origin (Table 2.4). Four studies indicated that Mexican women were the least likely to receive mammograms (Cokkinides et al., 2012; Lawsin et al., 2011; Miranda, et al., 2011, Rosales & Gonzales, 2013), while two studies found that Dominican women reported the most frequent use of mammography (Brown et al., 2006; Sheinfeld Gorin et al., 2005).

Identity and Heritage

One study included a measure of Hispanic identify and heritage (pride in Hispanic heritage) that is part of the General Acculturation index. However, the relationship between this

item and mammography use was not presented. Acculturation results were only presented in aggregate.

Acculturation Stress & Discrimination

Three studies (8.6%) assessed measures associated with acculturation stress and mammography use. All three studies focused on perceived or experienced racial/ethnic discrimination. None of the three studies found a significant relationship between racial/ethnic discrimination and mammography use (Benjamins, Valdovinos, Sheppard) (Table 2.4). For example, a study by Valdovinos (et al., 2016) found there was no significant difference in having been adherent to mammography guidelines versus being screened but not adherent, and never screened, by perceived ethnic discrimination among Hispanic women from four large urban centers in the US.

Practice/Belief Domain

Language Utilization

Of the 23 studies (65.7%) utilizing acculturation measures in the language utilization domain, 11 (47.8%) used single item measures, 11 (47.8%) used multi-item measures or scales, and 1 (4.4%) used administrative records. Of the 11 studies using single item measures, 6 (54.5%, or 26.1% of all language studies) looked at the relationship between language of interview and mammography use, while five (45.5%, or 21.7% of all language studies) used single item measures of language preference, proficiency, or use (Supplementary Figure 2.2).

Of the six studies assessing the association between language of interview and mammography use, only one study found significant results (Table 2.4). Mack and colleagues analyzed data from the California Women's Health Study found that Hispanic women who took the study survey in Spanish had approximately 2.5 greater odds of having had a mammogram in

the past two years when compared to women who took the survey in English (AOR=2.44, 95% CI: 1.65-3.62) (2009).

Of the remaining five studies using single item measures, only one had a significant effect. A study analyzing data from the 2007 California Health Interview Survey found that among non-U.S. born Hispanic women, those who had limited English proficiency had significantly greater odds of ever having had a mammogram (AOR=1.34, 95%CI: 1.28-1.41) and five times greater odds of having had a recent mammogram (AOR=5.58, 95% CI: 5.41, 5.75) then Hispanic women who spoke English only (Rosales et al., 2013).

One study utilized medical records to establish language concordant dyads between Hispanic patients and medical providers and found there was no significant difference in odds of mammography use between patients that were language concordant (both patient and provider spoke Spanish) and language discordant (patient spoke Spanish, provider spoke English) (OR=1.02, 95% CI:0.72-1.32) (Eamranond et al., 2011).

Eleven studies used scales or multiple items to assess acculturation associated with language. Two of those studies only used language acculturation as a control variable and did not present any relevant results. Four articles used a multi-dimensional measure of acculturation that contained items that mapped to the language domain, but only presented results for the full measure and not by subscale. Of the remaining five studies, three used a modification of Marin's Short Acculturation Scale for Hispanics (SASH). All three of those studies found that there was no significant association between language use and mammography screening (Table 2.4) (Sheinfeld Gorin et al., 2005; Echevarria et al., 2006; Martinez-Donate et al., 2013). The remaining two community-based studies found contradictory results. While a study by Castaneda and colleagues (2014) found higher levels of acculturation (or better English language skills)

were associated with decreased odds of mammography use (AOR= 0.329, 95% CI: 0.156, 0.693, p=0.003), a study in the DC area found that those with higher levels of acculturation based on language had greater odds of having received a mammogram (AOR=1.18, 95% CI:1.02, 1.36, p<0,05) (Graves et al., 2008).

Cultural Beliefs and Social Norms

Three studies (8.6%) included measures of cultural beliefs and social norms and presented results of their association with mammography use. While a study by Abriado-Lanza did not show a significant effect of fatalistic beliefs on mammography use (2015), two other studies did show significant effects (Table 2.4). A small study of Hispanic women in Wisconsin found that being concerned that receiving a mammogram could find something abnormal was associated with decreased odds of being screened (AOR=0.17, 95% CI: 0.03, 0.90, p=0.038) (Martinez-Donate et al., 2013). An additional small-scale study by Teran and colleagues found that as reported general fatalistic beliefs increases, odds of having a mammogram in the past year decreased (AOR=-.51, 95% CI=0.32, 0.81, p=0.004). They also found that higher levels of familism were associated with greater odds of mammography in the last year (AOR=2.39, 95% CI:1.16, 4.90, p=0.02) (Teran et al., 2007).

Interactions and Social Networks

Of the three studies included in the review that included measures of acculturation related to the interactions and social networks domain, none presented results of the associations between the specific domain and mammography use. These items asked respondents to report their frequency of interactions with non-Hispanic individuals and the size of their social networks.

Tradition Participation and Maintenance

No studies that explored the association between this domain of acculturation and mammography use were identified.

Place Domain

Migration and Settlement

One study (2.9%) by Fernandez and Morales (2007) explored the potential effects place-based characteristics may have on mammography use. Their study focused on Hispanic women living in Texas and sought to compare mammography use among those living along the U.S.-Mexico border and those living throughout the rest of Texas. Their results indicated that Hispanic women residing in a Texas border county had similar odds of having had a mammogram in the last two years to Hispanic women not living in border county in Texas (AOR=1.005, 95%CI: 0.634, 1.592).

Multi-Dimensional Measures of Acculturation

Four studies used full multi-dimensional scales of acculturation (11.4%). However only one found significant results (Table 2.4). A study by Abraido-Lanza and colleagues used the ARSMA and found that greater levels of acculturation using the ARSMA were associated with lower screening use (Beta=-0.17). The remaining studies utilized the full SASH scale by Marin (Pagan et al., 2012) and the Generalized Acculturation Index (Nuño et al., 2011; Lopez & Castro, 2006) and found no significant relationships between acculturation level and mammography use.

Quality Rating

All thirty-five studies included in the review had clearly articulated research questions and described, even if briefly, how participants were recruited (Table 2.5). Eighteen studies (51.4%) reported response rates over 50%, while 5 studies (14.3%) reported response rates below 50%. However, twelve studies (34.3%) did not report a response rate, or enough information to

calculate a response rate, or referred readers to other articles that may have provided that information. All 35 studies recruited participants for the underlying population of interest and inclusion and described exclusion criteria applied to subject recruitment. Justification for study sample size through power calculations or other means were only discussed in one paper (2.9%). Only two studies (5.7%) measured acculturation prior to measurement of mammography. Thirty-two (91.4%) studies provided clear explanations of measures for their acculturation measures, while thirty-four (97.1%) provided clear descriptions of measures for mammography use. No studies used repeated measures or utilized any form of blinding. One study (2.9%) discussed follow-up rates for their study. Thirty-three of thirty-five (91.4%) studies presented results from statistical analyses that were adjusted for potential confounders.

IV. Discussion

Results indicate that while there has been considerable research conducted on mammography use among Hispanic women in the U.S., few of those studies included measures of acculturation. Our review identified only 35 studies that included measures of acculturation and excluded 102 studies for lacking an acculturation measure. Most of these studies were cross-sectional surveys. Of the studies we identified, most were focused on how immigration and nativity (85.7%), and language use (65.7%) may affect mammography utilization. Few studies included measures associated with acculturation stress (8.6%), cultural beliefs and social norms (8.6%), or migration and settlement (2.7%). While four studies included measures associated with ethnic identity and heritage and interactions and social networks, their results were presented in aggregate with other acculturation related measures. Multi-dimensional scales of acculturation were also seldom used (11.5%). Most statistical tests or comparisons among these studies reported finding no significant differences in mammography use based on acculturation

level (62.3%). Among those that did find significant effects, eleven (18%) found that acculturation levels were associated with increased mammography use, while twelve (19.7%) found that acculturation levels were associated with decreased mammography use.

Studies assessing immigration status found that overall, mammography use did not vary substantially among citizens and non-citizens after adjusting for key structural variables (namely socioeconomic status and access to care). However, results suggest that this may not be the case when considering only foreign-born women. A study by Rosales and Gonzales (2013) found that among foreign-born women, non-citizens were less likely to have been recently screened or ever screened than U.S. citizens. Similarly to citizenship status, time spent living in the U.S. also seemed to only be a relevant predictor of mammography use among foreign-born women (Rosales et al., 2013). When considering being U.S. or foreign born, only one study found that foreign-born women were screened significantly less than white women, and U.S. born Hispanic women were being screened similarly to white women (Rodriguez et al., 2005). Studies assessing country of origin frequently found that Mexican women were reporting the lowest screening levels of all Hispanic women. These select results support previous research that indicates that immigrants struggle with obtaining access to care and using the health care system (Tarraf et al., 2012). The determinants of these access issues may be a result of U.S. immigration policy.

The Immigration Act of 1990, the most recent broad scale immigration law to be passed by Congress, revised previous policy by creating more opportunities for family-based immigration, implementing a diversity program to give immigration opportunities to those from countries where fewer individuals have immigrated to the U.S., creating “Temporary Protection Status” (TPS) visas, and allowing for changes that would facilitate the naturalization process.

However, the implications of this policy have differing applications based on country of origin. For example, while this act made it more difficult for immigrants from Mexico to obtain permanent residency status in the U.S. or to be eligible for U.S. citizenship, it allowed for more immigration from South and Central American countries due to humanitarian and political turmoil through the TPS visa program. This law has also made it easier for long-term immigrants to apply for citizenship since they can take the test in their native language (Immigration Act of 1990). Furthermore, the Cuban Adjustment Act of 1966 created very favorable conditions for Cuban immigration to the U.S. and a direct pipeline to permanent residency and eventual citizenship, although these policies changed considerably in 2017. In addition, Puerto Rico has been a U.S. commonwealth since 1898 and all Puerto Ricans have been U.S. citizens since 1917 (Jones-Shafrath Act of 1917). These policies have created disparate paths for Hispanic immigrants to become naturalized citizens. Citizenship, or permanent residency, is a key component of access to health care in the U.S. Access to the health care exchange created by the Affordable Care Act is restricted to U.S. citizens and lawfully present immigrants (DHHS, KFF). Even for lawfully present immigrants, obtaining health insurance coverage through Medicaid may require a five-year waiting period (DHHS; KFF). Recent changes to regulations make it harder for immigrants who participated in public insurance programs to obtain citizenship or lawful status, and thus may decrease access and discourage use of the health care system for fear of being labeled a “public charge” (DHHS).

In the context of research, these policies may also create concerns for potential multi-collinearity among the measures of immigration and nativity we identified. Given that being in the U.S. for a longer period is required to become a U.S. citizen, and differential ability to immigrate and obtain legal status is based on country of origin and family reunification policies,

these different survey items are potentially measuring overlapping facets of U.S. immigration policy. Researchers may consider creating composite variables to address overlap, or stratification to better understand the implications of immigration and foreign policy on the use of health care services like mammography. These policies may also require us to consider if these measures should be viewed as attributes of the individual or as policy-level variables. This process may be especially important for those who are applying frameworks on acculturation. Researchers should consider if immigration and foreign policy are the drivers of an individual's health behaviors instead of being attributes of an individual (Castañeda et al., 2015).

The second most popular measure of acculturation was language use. Few studies found that language use or preferences were associated with mammography use. Language is frequently used as a proxy measure of acculturation because Hispanic immigrants are the bulk of the population with limited English proficiency (USCB, 2011). Not speaking the same language as one's medical provider can interfere with patient-provider communication (Wilson, 2013) and is associated with dissatisfaction with health care and more discriminatory experiences (Pitkin DeRose et al., 2009). Based on recent estimates there are over 40 million people in the U.S. who speak Spanish at home (USCB, 2018). However, these Spanish speaking populations are concentrated in certain parts of the U.S., indicating that language access issues may be a barrier experienced only by some immigrants (USCB, 2018). Researchers interested in language as a barrier to health care access should consider the setting of their study carefully as areas with large Hispanic populations that speak Spanish may not face as many language-related access issues.

Limited work has been done outside of these two areas. The effects of acculturation domains associated with migration and settlement, acculturation-related stress, and cultural

beliefs and norms showed mostly non-significant findings. Of those that did show significant results, two focused on fatalism, and found that higher levels of fatalism are associated with less mammography use. Fatalism is routinely defined as pessimistic feelings that deter health care utilization, however there are debates about how well research has conceptualized and measured this cultural factor (Abraido-Lanza et al., 2007). Familism, a factor that is associated with increased mammography use, is focused on the importance of family relationships and the ability to depend on family (Teran et al., 2007). Future studies may want to further explore these cultural beliefs and norms to better understand the mechanisms through which they impact health care use and if they are promising targets for interventions to increase cancer screening.

Few studies included multidimensional scales of acculturation. This finding may be because most of the studies identified utilized data from large national or state surveys with limited space for long or detailed measures. Single items or multiple individual items were the most frequently used types of measures of acculturation. Use of validated multi-dimensional scales could help reduce measurement error and improve internal validity. However, all of the validated acculturation measures that were identified through the course of this review were mostly focused on language and ethnic make-up of social networks. Reviews of acculturation scales have also found that they tend to only address a subset of domains (Wallace et al, 2010). Measures of acculturation that address more domains may warrant development as they may be capturing different facets of acculturation. Additional measurement work is needed to better operationalize measures of acculturation and subscales or factors best suited for measurement. We found limited evidence that variability in acculturation measures was responsible for inconsistency in relationships between acculturation and mammography use. This is likely because of the few studies that utilize validated scales and the majority of studies until single

items or a handful of items. While many of these studies used fairly consistent measures, results showed inconsistency. This may merit further investigation to determine if other study characteristics, such as study setting, or recruited population, may be a factor in these conflicting results. For example, studies conducted in communities with long standing Hispanic populations may have very different experiences acculturation, and acculturation may have very different effects on their ability to get screened, compared to a Hispanic person in a primarily white neighborhood.

There are several strengths to this study. We used a multi-dimensional conceptual framework of acculturation to more specifically define and conceptualize measures in order to better examine their association with mammography use. However, there are several limitations to this study. Despite thorough attempts to identify relevant articles, some may have inadvertently been missed. In addition, the eligibility criteria may have resulted in the exclusion of studies that may have contributed to the results. For example, studies that included both Hispanic and Asian immigrants were excluded if they did not present separate results for these two racial/ethnic groups. The studies varied in the Hispanic populations included and ranged from studies with national probability samples, to small community clinic recruited samples. This variation limits the ability to generalize results to any particular group of Hispanic women. The dearth of studies outside of immigration and nativity and language use made the application of our proposed framework difficult. In addition, while we found limited research being conducted in some domains of acculturation, those domains may be more thoroughly studied with other health care services and outcome that could provide insight for future studies on cancer screening, as well as other cancer prevention and control efforts. The tool used for quality assessment may not have fairly assessed quality for the single intervention study included in the

review. Also, the quality assessment tool was not designed to provide overall assessment of quality of observational studies.

Conclusions

The ability to operationalize acculturation in frameworks has been an elusive target; also, currently available acculturation measures have been widely criticized (Alegria, 2009; Abraido-Lanza et al, 2012). While the use of acculturation as a variable in public health research has been described as a process of classifying people based on ethnic stereotypes (Hunt et al., 2004), it remains a widely used measure in research studies on the health of immigrant and minority populations. Abraido-Lanza and colleagues (2016) argue that while the study of acculturation has made significant strides forward, in order to really understand the role acculturation and culture play in public health research we needed to better understand the complexities of culture and utilize measures that consider contextual and policy related issues. Future research should attempt to consider and operationalize the interrelatedness of acculturation measures associated with immigration and nativity, and develop and use multidimensional measures of acculturation that move beyond language and social network-based domains. Better understanding the role of acculturation in mammography use may provide new opportunities to better tailor public health intervention efforts to decrease late stage breast cancer diagnoses among Hispanic women and address barriers of access among immigrant populations.

V. Tables and Figures

Figure 2.1. Acculturation Conceptual Framework

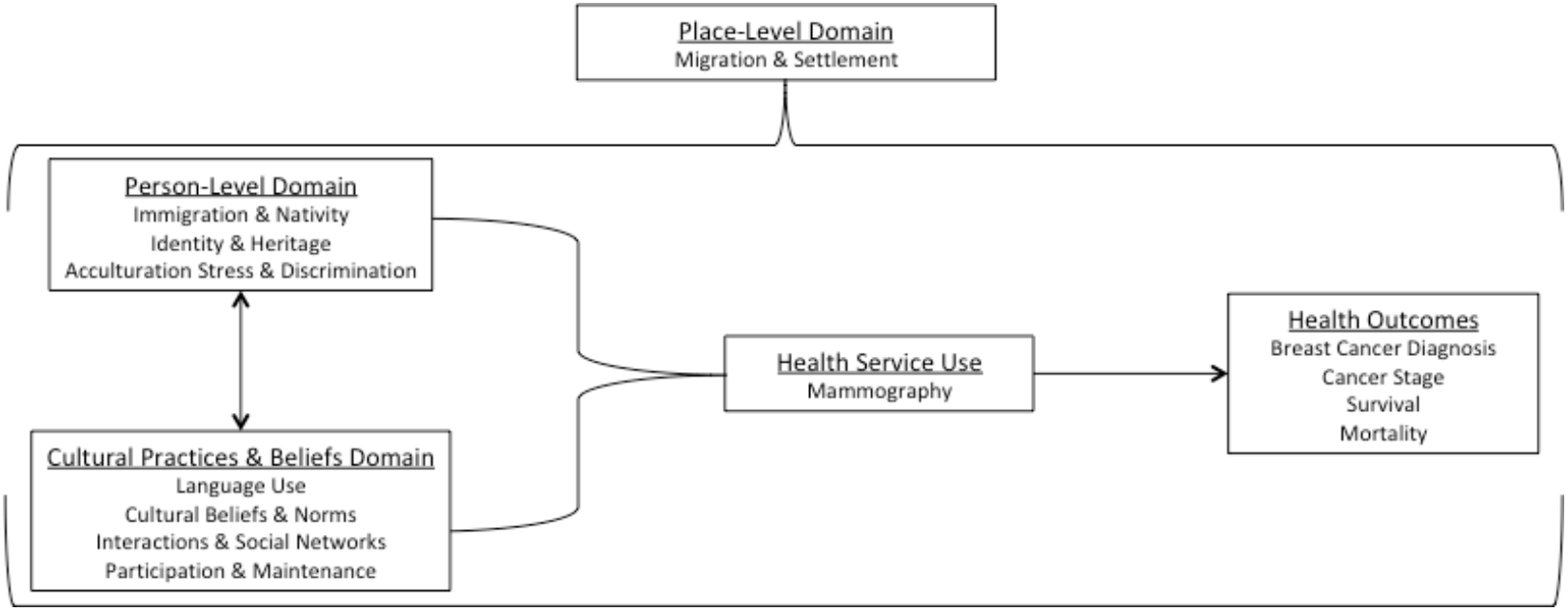

Figure 2.2 Literature Review Eligibility Flowchart

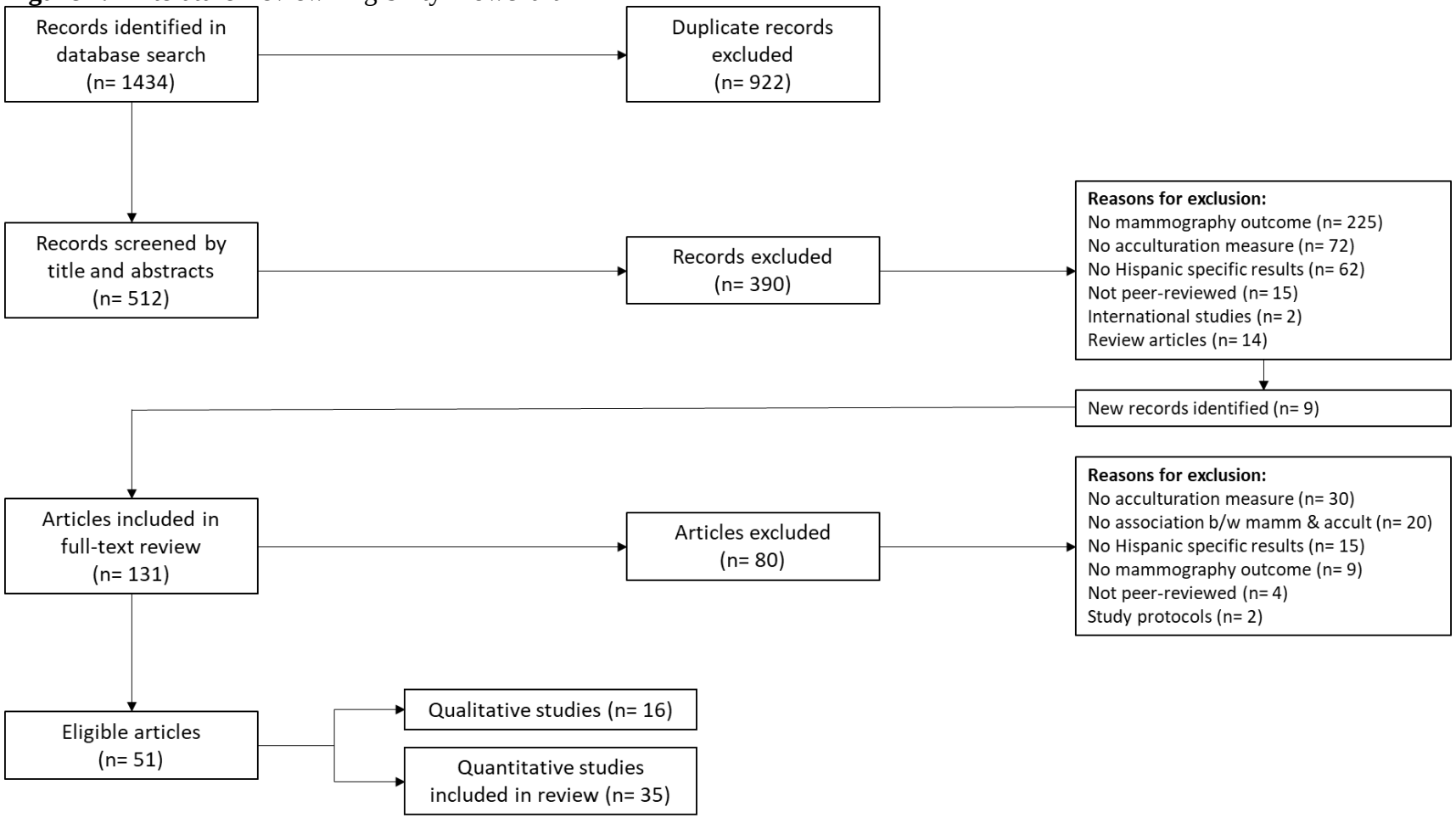

Figure 2.3. Number of Articles Measuring each Domain of Acculturation (n=35)

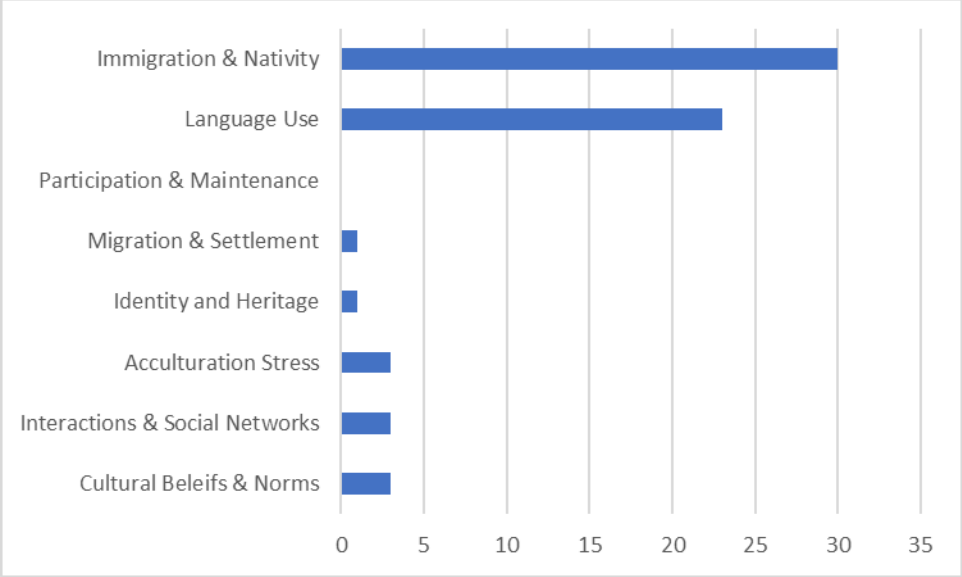

Table 2.1. Domains and Definitions of Acculturation

Domain	Conceptual definition
Person-Level Domain	
Immigration and Nativity	Refers to a person's place of birth, their immigration process, number of years since immigration, and their current residency or legal status in their new country of residence
Identity and Heritage	The identity and heritage domain refers to how a Hispanic individual identifies, in terms of culture and ethnicity, and their pride in their culture and country of origin. Ethnic identity refers to the extent to which individuals have explored what their ethnic group means to them and attachment to that identity (Phinney, 1990; Phinney and Ong, 2007; Schwatrz, 2010).
Acculturation Stress and Discrimination	Stress associated with immigration, like adapting to new places and surroundings. Also includes experiences associated with racism and discrimination (Berry, 2006).
Practice/Belief Domain	
Language use and preferences	Encompasses language(s) spoken, including fluency, frequency of use, and comfort with language(s) spoken. This domain would also include situational use of language (for example, language spoken at home and with friends and family, versus language spoken at work), as well as the language in which one consumes entertainment, news, or literature. Comfort communicating in particular situations (e.g. communicating in non-native language at doctor's office) would also be encompassed in this domain
Cultural Beliefs and Norms	Rules or expectations of behaviors or thoughts based on shared beliefs within a specific cultural group; Cultural beliefs/norms are rules or expectations of behaviors or thoughts based on shared beliefs within a specific cultural group (Marin & Gamba, 2005). This domain focuses on changes in social/cultural norms and values (e.g. familism, communication style, hierarchy and authority, uncertainty, and fatalism) (Masgoret & Ward, 2006; Cuellar, 1995).
Participation and Maintenance	The participation and maintenance domain refers to participation in, or maintenance of, cultural traditions and practices, and adoption or participation in new traditions or events. Discontinuation or continued participation in daily habits, such as changes in food preferences, may also be considered part of this domain. Changes in cultural practices and daily habits may be an indicator of cultural adaptation.
Interactions and Social Networks	Refers to the types of people, including family and friends, one interacts with during leisure time. This domain focuses on interactions with members of similar and different ethnic groups, the development of friendships, social ties, and social networks. The types of social interactions one has after immigrating may provide the reference for the receiving culture and the template for acculturation (Abriado Lanza, 2006; Schwatz, 2010). This domain is influenced by social network

	theory that suggests “social structure of a network is largely responsible for determining individual behaviors and attitudes by shaping the flow of resources which determines access to opportunities and constraints on behaviors” (Berkman & Glass, 2000).
Place-Based Domain	
Migration and Settlement	This domain refers to the places and communities where immigrants settle. Place-based factors associated with the areas where individuals who immigrated settle (i.e. demographic composition of the neighborhood, living in an ethnic enclave).

Table 2.2 Study Characteristics

Reference	Setting	Study Design	Study Population	Recruitment	Sample Size	Methods	Mammography Outcome
Abraído-Lanza (2005)	National	Cross-sectional Survey	Hispanic women in the U.S.	In-home survey; door to door recruitment in targeted census tracts across U.S.	1370	Analysis of 1991 NHIS	Mammogram in the last 2 years
Abraido-Lanza (2015)	New York City	Cross-sectional Survey	Dominican women in NYC	University based research center referrals; participant referral; community clinic;	318	In-person interview conducted in respondents choice of location	One variable combining recent screening and ever screened; Used as a continuous variable
Benjamins, M. R. (2012)	Chicago	Cross-sectional Survey	Chicago area minority women	3-stage probability sampling; in-person interview from each community	1699	In-person interview	Mammogram in the last 2 years
Breen (2010)	California	Cross-sectional Survey	Mexican or Mexican American women in California	CHIS	4400	RDD survey	Mammogram in the last 2 years
Brown (2006)	Brooklyn, NY	Cross-sectional Survey	Dominican women in Brooklyn	Stratified cluster sampling; In person interview	160	Survey	Number of mammograms in the last ten years
Cadet, T. J. (2015)	National	Cross-sectional Survey	Hispanic women in the Health and Retirement Study	Household survey	246	Secondary analysis of 2008 wave	Mammogram in the last 2 years

Cadet (2017a)	National	Cross-sectional Survey	Hispanic women in the Health and Retirement Study	Household survey	246	Secondary analysis of 2008 wave	Mammogram in the last 2 years
Cadet (2017b)	National	Cross-sectional Survey	Hispanic women in the Health and Retirement Study	Household survey	246	Secondary analysis of 2008 wave	Mammogram in the last 2 years
Castañeda (2014)	San Diego, CA	Cross-sectional Survey	Hispanic women in San Diego	Snowball sampling and word of mouth	208	Face-to-face interview at community-based sites	Mammogram in the last 2 years
Cokkinides (2012)	National	Cross-sectional Survey	Hispanic women in the U.S.	Hispanic women in NHIS	NR	2010 NHIS	Mammogram in the last 2 years
Dang (2013)	Los Angeles, CA	Cross-sectional Survey	Hispanic women recruited at a health fair	In person recruitment at health fair	689	Convenient sample at health fair	Mammogram in the last 2 years
Eamranond (2011)	Boston, MA	Medical Record Review	Hispanic women and their providers	From academic hospital clinic or community ambulatory center	306	reviewed medical records of Hispanic patients and compared to language of provider	Mammogram in the last 2 years
Echeverria (2006)	National	Cross-sectional Survey	Hispanic women in the U.S.	In-person survey	553	Analysis of 2000 NHIS	Mammogram in the last 2 years
Fernandez (2007)	Texas	Cross-sectional Survey	Hispanic women in Texas	2000, 2002, & 2004 Texas BRFSS	1226	Analysis of Texas BRFSS	Mammogram in the last 2 years
Graves (2008)	Washington DC	Cross-sectional Survey	Women who go to free clinic that specializes in Hispanic pop (35 and older)	Recruited from 3 community clinics in DC area	450	In-person interview in clinic at time of appointment	Mammogram in the last 2 years

Kadivar (2016)	National sample	Cross-sectional Survey	Hispanic women recruited through the National Assessment of Adult Literacy	In-person interview	652	Analysis of 2003 NAAL data	Mammogram in the past year
Lawsin (2011)	New York and Arkansas	Cross-sectional Survey	Hispanic women - recruitment focused on those who live in low SES areas, more recent immigrants, and those live in medically underserved areas	Baseline survey of educational intervention study;	92	In-person survey; had bilingual staff to assist with survey questions	Ever screened; mammogram in the past year
Lees (2005)	National	Cross-sectional Survey	Hispanic women in the U.S. recruited through NHIS	In-home survey; door to door recruitment in targeted census tracts	18,102	Analysis of 2000 NHIS data	Ever had mammogram
Lim, J. (2010)	California	Cross-sectional Survey	Hispanic and Asian Women in the California Health Interview Survey	RDD	3513	Analysis of 2007 CHIS data	Mammogram in the last 2 years
Lopez (2006)	Phoenix, AZ	Pre/post quasi-exp intervention	Hispanic women from a church-based intervention	Recruited from church membership roster list	234	Post-intervention assessment of mammography use	Mammogram in the last 5 years; mammogram in last year
Mack (2009)	California	Cross-sectional Survey	Hispanic Women in the California Health Women's Survey	RDD; California Women's Health Survey	1298	Analysis of data from 2002, 2003, 2004, and 2005	Among mammogram user, had one in the last 2 years

Martínez-Donate (2013)	Dane County, WI	Cross-sectional Survey	Community sample of Latinas in Wisconsin	Baseline survey of intervention; recruited for by lay health advisor at small group education sessions	66	Survey of cervical and breast cancer screening practices at enrollment in intervention study (pre-education session)	Ever received a mammogram; mammogram in the last 12 months
Miranda (2011)	National	Cross-sectional Survey	Hispanic women in the MEPS	Drawn from households who participated in previous NHIS	5546	Analysis of 2007 Medical Expenditure Panel Survey	3 categories: 1) past year, 2) more than one year, 3) never
Nuño (2011)	Yuma County, AZ	Cross-sectional Survey	Women in Yuma county living in 50%+ Hispanic tract	7 census tracts with highest Hispanic pop in Yuma county; randomly selected dwellings and recruited in-person	452	Data are from a baseline survey of an intervention on cancer screening; interviewer administered survey	Mammogram in the last year
Pagán (2012)	Rio Grande Valley, TX	Cross-sectional Survey	Mexican American women from the Border Epidemiologic Study on Aging	Women randomly selected from BESA panel sample	736	Analysis of BESA data - randomly selected sample of Mexican American women	Ever had mammogram, mammogram in last year, and mammogram in the last 2 years
Palmer (2005)	Rio Grande Valley, TX	Cross-sectional Survey	Convenient sample; age 50 and older	Door-to-door	200	In-person interview at home (year 2000)	Mammogram 2 years ago or less vs. more than 2 years prior or never screened

Rodríguez (2005)	California	Cross-sectional Survey	Hispanic women in California	Random digit dial across state; California Women's Health Survey (1998)	850	Survey administered in English/Spanish	Ever and most recent; mammogram in last 2 years
Rosales (2013)	California	Cross-sectional Survey	Hispanic women in California	Random digit dial survey	1675	Analysis of 2007 CHIS data	Ever had mammogram; mammogram in the last 2 years
Scheel (2017)	Western Washington State	Cross-sectional Survey	Hispanic women in Western Washington State	Hispanic women identified in medical records from FQHC's in western Washington	641	Analysis of baseline data from an RCT hoping to increase breast cancer screening in Hispanic women	Mammogram in the last 2 years
Sheinfeld Gorin (2005)	National	Cross-sectional Survey	Hispanic women in the U.S. recruited through the NHIS	In-home survey	1092	Analysis of 2000 NHIS	Mammogram in the last year
Shelton (2016)	Western NY and NYC	Cross-sectional Survey	Hispanic women in Western NY and NYC	Survey administered pre-educational intervention	394	Analysis of baseline intervention survey	Mammogram in the last year
Sheppard (2008)	Washington DC	Cross-sectional Survey	Latina women in the DC area	From Latino focused primary care clinic and Latino radio station program ads	166	Recruited in clinic or from radio add; radio folks did phone interview; clinic folks did in-person	Mammogram within the past 2 years vs. more than two years or never
Shoemaker (2016)	National	Cross-sectional Survey	Hispanic women in the U.S. recruited through NHIS	Household survey	2,043	Analysis of 2008, 1010, and 2013 NHIS	Mammogram in the last 2 years

Teran (2007)	Los Angeles, CA	Cross-sectional Survey	Hispanic women in LA who 3 to 4 years previously called B&C program referral line	Called B&C program participants	72	Telephone survey	Mammogram it the last year and mammogram in the last 2 years
Valdovinos (2016)	Bronx, NY; Chicago IL; Miami FL	Cross-sectional Survey	Hispanic adults from 4 cities who are part of the Hispanic Community Health Study	Two-stage probability sample of households; part of ancillary study	1997	Data from "Socio-cultural ancillary study"	3 categories: screened, adherent; screened non-adherent; not screened

Table 2.3. Study Acculturation Measures mapped to Acculturation Framework Domains

	Acculturation Framework Domains							
	Immigration & Nativity	**Language Use**	**Participation & Maintenance**	**Migration & Settlement**	**Identity & Heritage**	**Acculturation Stress**	**Interactions & Social Networks**	**Cultural Beliefs & Norms**
Abraído-Lanza (2005)	X							
Abraido-Lanza (2015)	X	X						X
Benjamins (2012)	X					X		
Breen (2010)	X	X						
Brown (2006)	X							
Cadet (2015)	X	X						
Cadet (2017a)	X	X						
Cadet (2017b)	X							
Castañeda (2014)	X	X						
Cokkinides (2012)	X							
Dang (2013)	X	X						
Eamranond (2011)		X						
Echeverria (2006)	X	X						
Fernandez (2007)		X		X				
Graves (2008)	X	X						
Kadivar (2016)		X						
Lawsin (2011)	X							
Lees (2005)	X	X						
Lim (2010)	X	X						
Lopez (2006)	X	X					X	
Mack (2009)	X	X						
Martínez-Donate (2013)	X	X						X
Miranda (2011)	X							
Nuño (2011)	X	X			X		X	
Pagán (2012)		X					X	
Palmer (2005)	X							
Rodríguez (2005)	X							

Rosales (2013)	X	X			
Scheel (2017)	X	X			
Sheinfeld Gorin (2005)	X	X			
Shelton (2016)	X				
Sheppard (2008)	X	X	X		
Shoemaker (2016)	X				
Teran (2007)		X			X
Valdovinos (2016)	X		X		

Table 2.4. Associations between Acculturation Measures and Mammography Use

	Direction of Association	Results
Immigration and Nativity		
Citizenship Status		
Echeverria, et al. (2006)	0	No significant difference in mammography use among citizens and non-citizens
Lim (2010)	0	No significant difference in mammography use among citizens and non-citizens
Rosales, et al. (2013)	-	Non-citizens had significantly decreased odds of mammography use compared to naturalized citizens
Nativity		
Cadet (2015)	+	U.S. born Hispanic women had lower odds of mammography use compared to foreign born Hispanic women
Cadet, et al. (2017)	+	U.S. born Hispanic women had lower odds of mammography use compared to foreign born Hispanic women
Cadet, et al. (2017)	+	U.S. born Hispanic women had lower odds of mammography use compared to foreign born Hispanic women
Castañeda,et al. (2014)	0	No significant difference in mammography use based on being U.S. or foreign born
Nuño,et al. (2011)	0	No significant difference in mammography use based on being U.S. or foreign born
Palmer, et al. (2005)	0	No significant difference in mammography use based on being U.S. or foreign born
Rodríguez, et al. (2005)	-	Foreign born Hispanic women had decreased odds of mammography use compared to NH white women
Number of Years in the U.S.		
Abraido-Lanza, et al. (2015)	0	No significant difference in mammography use by time spent living in the U.S.
Dang, et al. (2013)	-	Women who had not recently had a mammogram had been in the U.S., on average, less time than those who had
Martínez-Donate, et al. (2013)	0	No significant difference in mammography use by time spent living in the U.S.
Nuño,et al. (2011)	0	No significant difference in mammography use by time spent living in the U.S.
Rosales, et al. (2013)	-	Women in the U.S. less than 10 years had decreased odds of mammography use compared to women in the U.S. more than 10 years
Scheel, et al. (2017)	0	No significant difference in mammography use by time spent living in the U.S.
Shelton, et al. (2016)	0	No significant difference in mammography use by time spent living in the U.S.
Number of Years in U.S. or U.S. Born		

Abraído-Lanza, et al. (2005)	0	No significant difference in mammography use by time spent living in the U.S.
Breen, et al. (2010)	0	No significant difference in mammography use by time spent living in the U.S.
Mack, et al. (2009)	+	Women in the U.S. more than 15 years have greater odds of mammography use compared to U.S. born Hispanic women
Palmer, et al. (2005)	0	No significant difference in mammography use by time spent living in the U.S.
Shoemaker, et al. (2016)	-	Smaller proportion of Hispanic women in the U.S. less than 10 years had mammogram (no statistical testing)
Country of origin		
Benjamins (2012)	0	Similar proportions of Puerto Rican and Mexican women being screened
Brown, et al. (2006)	+	Dominican women reported greater mammography use than other immigrant women
Cokkinides, et al. (2012)	-	Mammography use lowest among Mexican women (no statistical testing conducted)
Graves, et al. (2008)	0	No significant differences in mammography use by country of origin
Lawsin, et al. (2011)	+	Significant differences mammography use by country of origin
Miranda, et al. (2011)	-	Mexican women more likely not to report mammography use compared to NH white women
Rosales, et al. (2013)	-	Mexican women had lower odds of mammography use compared to women from South American
Sheinfeld Gorin, et al. (2005)	+	Dominican women had significantly greater odds of mammography use compared to Mexican women
Sheppard, et al. (2008)	0	No significant differences in mammography use by country of origin
Shoemaker, et al. (2016)	0	No significant differences in mammography use by country of origin
Language Use		
Language of interview		
Breen, et al. (2010)	0	No significant difference in mammography use based on language of interview
Cadet (2015)	0	No significant difference in mammography use based on language of interview
Cadet, et al. (2017)	0	No significant difference in mammography use based on language of interview
Fernandez, et al (2007)	0	No significant difference in mammography use based on language of interview
Lees, et al. (2005)	0	No significant difference in mammography use based on language of interview
Mack, et al. (2009)	+	Women who completed survey in English had greater odds of mammography use
Language proficiency or preference		
Kadivar,et al (2016)	0	Similar proportions of women reported mammography use regardless of language preferences
Lim (2010)	0	No significant differences in odds of mammography use by language preferences
Rosales, et al. (2013)	+	Women with limited language proficiency had greater odds of mammography use compared to those who spoke English only
Scheel, et al. (2017)	0	Similar proportions of women reported mammography use regardless of language preferences

Sheppard, et al. (2008)	0	Similar proportions of women reported mammography use regardless of language preferences
Administrative Records		
Eamranond, et al (2011)	0	No significant differences in odds of mammography use based on patient-provider language concordance
Multi-dimensional measures of language use		
Castañeda,et al. (2014)	-	Those with greater English proficiency had lower odds of mammography use
Echeverria, et al. (2006)	0	No significant association between language and mammography use
Graves, et al. (2008)	+	Greater English proficiency associated with greater odds of mammography use
Martínez-Donate, et al. (2013)	0	No significant association between language and mammography use
Sheinfeld Gorin, et al. (2005)	0	No significant association between language and mammography use
Migration and Settlement		
Fernandez and Morales (2007)	0	Odds of mammography use for those living in a border county were similar to those living in non-border counties
Acculturation Stress		
Benjamins (2012)	0	Three separate measures of discrimination were not significantly associated with mammography use
Sheppard, et al. (2008)	0	No significant differences in mammography use based on experiencing discrimination
Valdovinos, et al. (2016)	0	No differences in mammography use based on experiencing ethnic discrimination
Cultural Beliefs & Norms		
Abraido-Lanza, et al. (2015)	0	Non-significant finding that as fatalistic beliefs increase, mammography use decreases
Martínez-Donate, et al. (2013)	-	Higher levels of concern about screening results were associated with decreased odds of mammography use
Teran, et al. (2007)	-	Higher levels of fatalism were associated with decreased odds of mammography use
Teran, et al. (2007)	+	Higher levels of familism were associated with increased odds of mammography use
Multi-Dimensional Measures		
Abraido-Lanza, et al. (2015)	-	Greater levels of acculturation were associated with decreased mammography use
Lopez, et al. (2006)	0	No significant differences in mammography use by acculturation level
Nuño,et al. (2011)	0	No significant differences in mammography use by acculturation level
Pagán,et al. (2012)	0	No significant differences in mammography use by acculturation level

(-) Acculturation measure was associated with decreased mammography use
(+) Acculturation measure was associated with increased mammography use
(0) Acculturation was not associated with mammography use

Table 2.5. Quality Rating Criteria

Criteria	**Studies meeting criteria** N (%)	**Studies not meeting criteria** N (%)	**NA or Other** N (%)
Research question or objective clearly stated	35 (100%)	0	0
Study population clearly specified and defined	35 (100%)	0	0
Participation of eligible pop at least 50%	18 (51.4%)	5 (14.3%)	12 (34.3%)
Subjects selected or recruited from similar pop; inclusion/exclusion criteria pre-specified	35 (100%)	0	0
Sample size justification (power description or variance and effect estimates provided)	1 (2.9%)	34 (97.1%)	0
Independent variable (IV) measured prior to outcome	2 (5.7%)	32 (91.4%)	1 (2.9%)
Timeframe sufficient to expect association with outcome	2 (5.7%)	32 (91.4%)	1 (2.9%)
Examine different levels of IV as related to outcome	0	0	35 (100%)
Independent variables and measures clearly defined	32 (91.4%)	3 (8.6%)	0
Measures assessed more than once	0	0	35 (100%)
Outcome measures clearly defined	34 (97.1%)	1 (2.9%)	0
Outcome assessors blinded	0	0	35 (100%)
Loss-to-follow-up after baseline 20% or less	1 (2.9%)	0	34 (97.1%)
Key potential confounders measured and adjusted for statistically	33 (94.3%)	2 (5.7%)	0

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VII. Supplementary Materials

Results

Acculturation Scales

The most commonly used scale, utilized in 7 publications, whether in part or whole, was the Short Acculturation Scale, also known as the Marin Scale (Marin et al, 1987) (Supplementary Table S1). The Marin scale is a 12-item scale that is composed of three subscales (language use, language of media consumption, and ethnicity of social relationships). It has five responses from Only Spanish to Only English or All Spanish or All Non-Hispanics. However, not all studies included the three subscales on their study survey. Most studies only included the language use subscale, which includes five items that focus on language used for reading/speaking, language used as a child, language spoken at home, language in which you think, and language you speak with your friends. The General Acculturation Index, used in two studies, is a five-item scale that includes items on ethnic pride, language spoken, language in which one reads, where the person spent their childhood, and the ethnic make-up of their current circle of friends (Balcazar, et al, 2005). The Brief- Acculturation Rating Scale for Mexicans Americans (ARSMA), used by 1 study, assessed language use, and interactions and social networks. The brief-ARSMA contains 12 items, 10 of which are focused on language, while 2-items are about the ethnicities of the people they interact with (Cuellar et al, 1995).

Three scales were identified as measures of acculturation stress, specifically measures of discrimination. A study by Benjamins (2012) utilized two different measures of discrimination. The first was the Experiences of Discrimination (EOD) scale (Kreiger et al., 2005), where respondents are asked about potential situations and settings where they have previously faced discrimination with response options based on a frequency response of never too often. The

second was the Everyday Discrimination Scale (EDS) which assesses chronic and repeated discrimination (Williams et al., 1997). The final discrimination scale identified was the Brief Perceived Ethnic Discrimination Questionnaire used in a study by Valdovinos (2016). This 17-item scale has four subscales that assess exclusion and rejection, stigmatization, discrimination at school/wok, and threats or anger experienced due to ethnicity or race (Brondolo et al., 2005).

Two scales were identified as measures of cultural beliefs and norms. The Powe Fatalism Inventory (Powe, 1995) was used to assess fatalism associated with breast cancer. While the scale was originally developed to assess fatalism associated with colorectal cancer, the authors modified and adapted the scale to suit their needs. Scales developed by Cuellar (1995) on fatalism and familism were also used to measure cultural beliefs and norms. However, only certain items from their scale were administered in these studies. From the original 12 items on the familism scale only 2 were administered, while 4 were administered from the original 8 on the fatalism scale.

Figure 2.S1. Mammography studies including acculturation measures on immigration and nativity

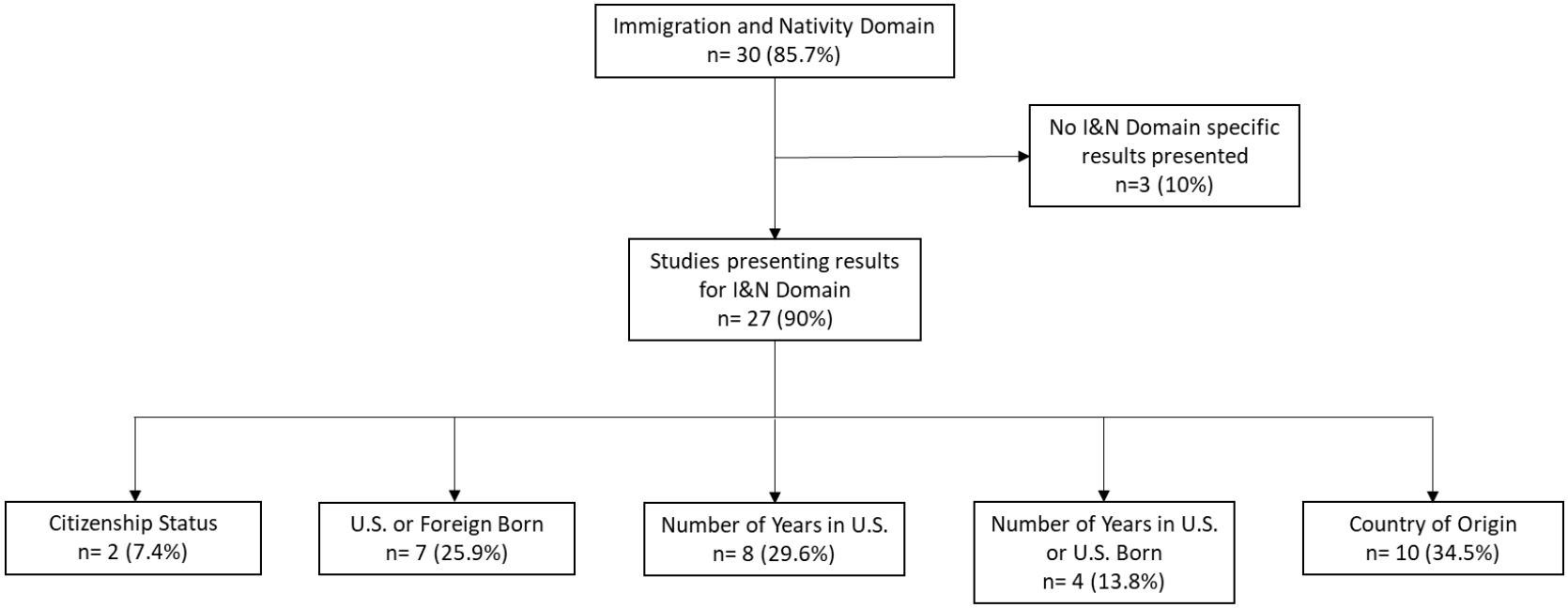

Figure 2.S2. Mammography studies including acculturation measures on language utilization

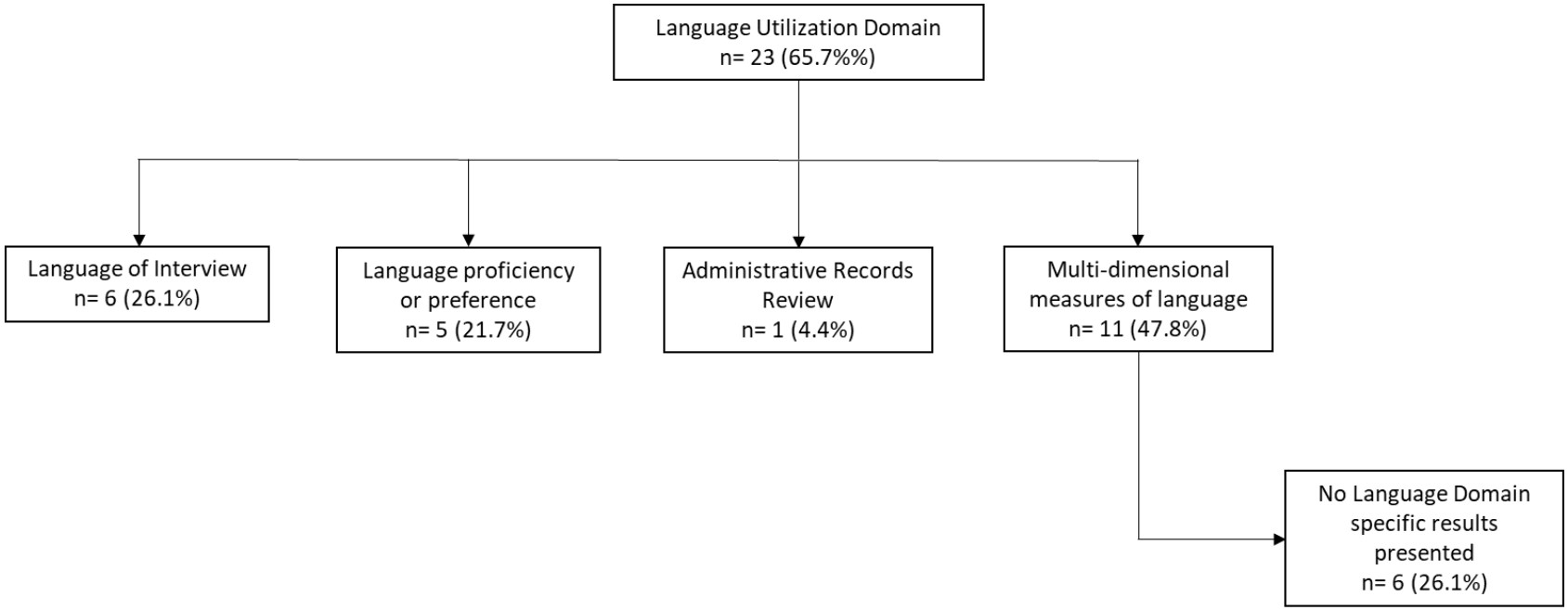

Table 2.S1. Acculturation Scales mapped to Acculturation Framework Domains

Scales	Acculturation Framework Domains							
	Immigration & Nativity	**Language Use**	**Participation & Maintenance**	**Migration & Settlement**	**Identity & Heritage**	**Acculturation Stress**	**Interactions & Social Networks**	**Cultural Beliefs & Norms**
Acculturation Rating Scale for Mexican Americans		X					X	
Experience of Discrimination Scale						X		
Everyday Discrimination Scale						X		
General Acculturation Index		X			X		X	
Short Acculturation Scale		X					X	
Powe Fatalism Inventory								X
Cueller Scale								X
Brief Perceived Ethnic Discrimination Questionnaire						X		

Chapter Three

The role of immigration status on mammography use among Hispanic women in the U.S.

I. Introduction

Breast cancer is the most commonly diagnosed cancer among Hispanic women and accounts for approximately 29% of all cancers diagnosed among Hispanic women. It is also the leading cause of cancer related death among Hispanic women and accounts for 16% of all cancer deaths every year (ACS, 2015; USCS, 2016; Siegel et al, 2015). Trends in cancer incidence for Hispanic women declined until 2003 then stabilized, which are similar to trends for non-Hispanic white women. Mortality trends between Hispanic and white women, however, are not comparable. Non-Hispanic white women have seen larger declines in mortality than Hispanic women over time (25% reduction versus 36%) (Seigel et al, 2015; ACS 2018).

An additional disparity in breast cancer among Hispanic and non-Hispanic white women is in stage at diagnosis (Seigel et al, 2015). The proportion of non-Hispanic white women diagnosed with breast cancer at an early stage was approximately 8% higher than Hispanic women (Seigel et al, 2015). Several studies have also found that Hispanic women are significantly more likely to be diagnosed with stage IV breast cancer than non-Hispanic white women (Banegas et al, 2012; Li et al, 2003). Differences in stage at diagnosis between Hispanic women have been attributed to decreased access or lower rates of mammography utilization among Hispanics, being less likely to receive appropriate follow-up after abnormal mammography results, and have decreased likelihood of receiving quality treatment, or a combination thereof (Press et al, 2008; Stuver et al, 2011; Seigel et al, 2015). Advanced stage breast cancers have the highest risk of mortality and population level mammography screening

programs may have the ability to decrease risk of being diagnosed with an advanced stage breast cancer (Duffy, et al., 2004; Autier et al., 2009).

Mammography is the only imaging test recommended for breast cancer screening and has been shown to reduce mortality from breast cancer by making breast tumors more easily detectable at earlier stages where tumors are less severe and treatments are more effective (Mandelblatt et al, 2009). While there are some limitations and controversies associated with the efficacy and effectiveness of mammography as the primary tool for breast cancer screening (Welch, et al., 2016), most medical professional organizations that issue population level clinical practice guidelines and practice recommendations, as well as the U.S. government through the United States Preventive Services Task Force (USPSTF), agree that there is sufficient evidence on the ability of mammography to detect breast cancer at earlier stages and reduce breast cancer related mortality (ACS, 2018; USPSTF, 2016). These bodies recommend routine mammography screening among asymptomatic women who are at average risk for breast cancer. While there is some variability between guidelines on age to start screening and screening intervals, usually screening begins between ages 40-50 for women of average risk and recommended to occur annually or bi-annually (Siu et al, 2016; Lee et al, 2010; Oeffinger et al, 2015) until age 74-75, or when there are at least 10 years of remaining life-expectancy.

National estimates of screening utilization indicate that the U.S. is well below meeting the Healthy People 2020 objective of 81.1% of eligible women being screened for breast cancer. (USDHHS, 2014). An estimated 71.5% to 71.8%, of non-Hispanic white women were meeting breast cancer screening guidelines (Sabatino et al, 2015; White, et al, 2017). While screening rates for Hispanic women were 72.1% overall, rates varied by immigration status and country of origin. Foreign-born individuals who had been in the U.S. less than 10 years reported the lowest

use of mammography screening at 53.7%, compared to 70% among those in the U.S. more than ten years (Sabatino et al, 2015; White, et al, 2017). Given these wide-ranging rates of mammography utilization or adherence to screening guidelines, understanding factors driving utilization and adherence are essential to improving breast cancer outcomes. In addition, since screening rates vary by Hispanic subgroup, or country of origin, treating Hispanic women as a homogeneous population may mask health disparities. It is estimated that Hispanic women in the U.S. of Mexican origin have the lowest rate of mammography adherence (66.2%), followed by women from Central/South American countries (74.6%). Screening rates were highest among Puerto Rican women (78.1%) (Sabatino et al, 2015; White, et al, 2017).

While considerable research has been conducted to assess factors associated with mammography use among Hispanic women living in the U.S., the role of acculturation or culture on breast cancer screening is not well understood. Broadly defined, acculturation is the process by which immigrants adapt to, or adopt the customs, language, beliefs, and behaviors of their new home (Berry, 2006). While some studies have suggested that lower levels of acculturation are associated with lower rates of mammography use (Shelton, et al, 2011; Alexandraki, et al, 2010, Jacobs, et al., 2005), other studies have found that acculturation-related factors have no effect on mammography use or are associated with greater use of screening (Abriado-Lanza, 2005; Rodriguez, et al., 2005; Garcia, et al, 2012).

Previous work has identified that acculturation is a multi-dimensional construct (Berry & Sam, 2006; Abriado-Lanza et al., 2006). These dimensions could include factors associated with immigration and nativity, ethnic identity and heritage, language use, interactions and social networks, participation in cultural traditions, experiencing stress and discrimination, and place-based effects associated with location of immigration and settlement. One domain of

acculturation that plays a role in health service use and merits further investigation is immigration status. Immigration status is one of the most commonly measured acculturation variables (Wallace, et al, 2010). While routinely operationalized as an individual level measure of citizenship status, a more comprehensive view of this domain could include questions on nativity or country of birth, length of time living in the U.S., and the type of immigration program (e.g. refugee, temporary protected status, permanent resident, etc.), or lack thereof (e.g. undocumented, overstayed travel visa), which brought them to the U.S. (Schwartz, et al, 2010). Immigration status, in particular, is a compelling measure of acculturation because it could determine ability to access social service programs. Federally funded programs that provide access to health care, like Medicaid, are not necessarily guaranteed to non-US citizens (Pew, 2014). In addition, a person's immigration status may also affect one's ability to work and receive an education in the U.S. (USCIS, 2017).

The goal of this exploratory study is to examine country of origin and immigration status as a determinant of structural factors, namely access to care and socio-economic status, and their association with mammography use among Hispanic women living in the U.S. This paper seeks to answer the following research questions:

1) What proportion of Hispanic women are being screened for breast cancer through mammography? Does test use vary by country of origin or immigration status?

2) Does access to care and socio-economic status among Hispanic women vary by country of origin and immigration status?

3) Does immigration status contribute to mammography use beyond access to care and socio-economic status?

II. Methods

Data Source

This study utilizes data from the National Health Interview Survey (NHIS). The NHIS is a yearly cross-sectional survey of the civilian, non-institutionalized populations of the U.S. in the field since 1957. It is conducted by the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention and administered by the Census Bureau. It is the primary source of information on the health of the population and used to monitor trends in illness, disability, and health service utilization. It is also the primary source of measurement for the Healthy People initiative (NCHS, 2019).

The NHIS utilizes a multistage area probability design to produce estimates that are representative of the U.S. population. First, geographic areas are sampled, and then stratified by state, and finally residences are sampled. Oversampling of Black, Hispanic, and Asian persons is conducted twice. First, areas with a higher concentration of people from the target population (based on the most recent decennial census) are oversampled. Then, households with eligible Black, Hispanic, and Asian individuals are retained, while only a subsample of other households are retained (Parsons, et al., 2014).

The survey consists of four core sections: 1) household composition, 2) family core, 3) adult core, and 4) child core. The Household composition section collects basic demographic information on all persons in a household. The family core, which is administered separately per family in a household, collects additional socio-demographic information, along with basic indicators of health status, health insurance coverage, and access to and utilization of health care services. From each family, one child, aged 17 or less, and one adult, aged 18 or more, are randomly selected. Both the adult and child core collect basic information on health status, health

care services, and health behaviors. In addition to the four core sections, sponsored content is also administered in conjunction with the NHIS (NCHS, 2019). The Division of Cancer Prevention and Control at CDC, along with the National Cancer Institute, co-sponsor a 20-minute survey module on priority areas in cancer control, namely cancer screening, including use of mammography, every five years. Mini-modules, usually 3-5 minutes in length, are administered once in the intervening years (NCI, 2019). No compensation or incentives are provided for participation. Surveys are conducted in either English or Spanish (NCHS, 2019).

This analysis utilizes data from the 2008, 2010, 2013, and 2015 NHIS. These years were selected due to the fielding of the Cancer Control Module in 2010 and 2015, and mini-modules in 2008 and 2013. Four data years were utilized in order to ensure adequate sample size for Hispanic subgroup analysis based on country of origin. A previous analysis by Shoemaker (2016) utilized three years of data (2008, 2010, 2013) to assess mammography use among Hispanic women by country of origin and required significant suppression of cells due to unstable estimates. In addition, this analysis will benefit from sample size augmentation that occurred between 2011-2015. During these years the NHIS sample size was augmented in 32 states and the District of Columbia. For the data years in question, sample size was increased in 2015 by 19% and in 2013 by 18%. by approximately (Parsons, et al., 2014). Response rates for the data years in this analysis are 62.6% in 2008 (NCHS, 2009), 60.80% in 2010 (NCHS, 2011), 61.20% in 2013 (NCHS, 2014), and 55.20% in 2015 (NCHS, 2016). Final and conditional response rates per core section are presented in Table 3.1 (NCHS 2009, 2011, 2014, 2016).

Study Population

The combined sample includes approximately 145,947 households containing 149,207 families. Those families included about 372,530 individuals, 117,167 who were included in the

adult core (NCHS 2009, 2011, 2014, 2016). Sample size per data year are presented in Figure 3.1. The combined sample included 35,433 women between the ages of 40 and 75 (2008: 6,553, 23.77%; 2010: 8,088, 24.37%; 2013: 10,399, 25.55%; 2015: 10,393, 26.31%), 5,283 of which self-identified as Hispanic (2008: 934, 21.56%; 2010: 1,290, 22.76%; 2013: 1,538, 26.57%; 2015: 1521, 29.11%).

Measures

Outcome Measures – Mammography use

Two measures were created to assess use of mammography. The first outcome is designed to be consistent with breast cancer screening recommendations. Women aged 40 to 75 were classified as meeting recommendations if they had had at least one mammogram in the last two years. While there is some controversy about when to start breast cancer screening, for this analysis screening start age was considered to be 40 because of insurance coverage policies and provider preferences on screening start age. The USPSTF issued a revised statement in 2009, and again in 2016, recommending women start breast cancer screening at age 50 and receive a mammogram at least every other year until age 75 (USPSTF, 2016). Its prior 2002 statement recommended that women start breast cancer screening at 40 (USPSTF, 2013). The passage of the Affordable Care Act in 2010 required health insurers to cover health care services consistent with Grade A and B USPSTF recommendations (USPSTF, 2017). However, when it came to breast cancer screening, insurers were instructed to follow the 2002 recommendation statement instead of the 2009 (USPSTF, 2019). Also, age for screening initiation varies among other guideline issuing organizations. For example, ACS recommends starting between ages 40 to 45, with regular screening starting at 45 (ACS, 2018). Surveys of provider beliefs have also shown

that primary care providers tend to believe that screening should start at age 40 (Meissner, et al., 2011; Corbelli, et al., 2014).

The second outcome is designed to reflect lack of use of mammography by identifying women who have never received a mammogram or have not recently received a mammogram (i.e., never or rarely screened). While the previous outcome will provide context about those women who are currently being screened, this outcome will provide context around the Hispanic women most in need of public health interventions to increase breast cancer screening. This is similar to definitions used in previous research (Meissner, et al., 2007).

All women aged 40 and older in the NHIS Sample Adult were asked if they had ever had a mammogram. Response options were “yes”, “no”, “don’t know”, or “refused”. Responses coded as “don’t know”, “refused”, or “not ascertained” (which indicates a skipped question or an incomplete interview) were recoded to missing. Approximately 5.39% of Hispanic women aged 40-75 refused or didn’t answer this question, or refused to answer. If they answered yes, they were asked when their most recent mammogram occurred. Respondents could report a date, or were provided with 5 response options to assess recency of mammography (a year ago or less, more than 1 year but less than 2 years, more than 2 years but less than 3 years, more than 3 years but less than 5 years, more than 5 years). The NHIS provides a variable that provides recodes dated responses into the five-level categorical variable. Respondents that refused, answered “don’t know”, or for whom responses were not ascertained were recoded into missing. Approximately 0.53% of responses were recoded into missing. Using these two survey items, 2 dichotomous variables were created. The first classified women aged 40 to 75 who reported ever having had a mammogram and had received their most recent mammogram in the last year, or more than one year ago, but less than 2 years ago, as being screened consistently with

recommendations. The second classified women aged 40 to 75 who reported never having received a mammogram or who reported having been screened in the past, but it had been 5 or more years since their last mammogram as being "rarely or never screened."

Exposure measures

Immigration status

Three survey items were identified across all four survey years that provided context on the immigration status of the respondent. The first item asks if respondents were born in the U.S. Response options include "yes", "no", "refused", and "don't know". Those who responded don't know, refused to answer, or a response was not ascertained were recoded to missing. Less than 1% of responses were recoded to missing. The second item asks if respondents are "a citizen of the United States." Response options include, "yes, born in one of the 50 United States or DC", "Yes born in Puerto Rico, Guam, American Virgin Islands, or other U.S. territory", "Yes U.S. citizen by naturalization" and "no not a U.S. citizen". The NHIS provides a recoded variable in the publicly available data set that already recoded the response options into U.S. citizen or non-citizen. Those who responded that they did not know their citizenship status, refused to answer, or whose response was not ascertained were recoded to missing. Approximately 2% of responses were recoded to missing. The final item on immigration status asked respondents who were not born in the U.S., "how long have you lived in the United States." Respondents were asked to respond, and the interviewer would note their response verbatim. The NHIS provides a five-level variable in the public use dataset that categorizes responses into "less than 1 year", "more than 1 year but less than 5 years", "more than 5 years but less than 10 years", "more than 10 years but less than 15 years", and "15 years or more." Those who responded that they didn't know, refused to answer, or for whom a response was not ascertained were recoded to missing (approximately

3.5%). Because the majority of the sample reported having lived in the U.S. 15 years or more (about 77%) and several of the categories for more recent immigrants would have led to unstable estimates, the variable was dichotomized to those living in the U.S. less than 15 years, and those living in the U.S. 15 years or more.

Due to the overlap between these variables and the potential for collinearity, they were combined into one categorical variable with 5 levels: foreign-born non-citizens in the U.S. less than 15 years, foreign-born non-citizens in the U.S. 15 years or more, foreign-born naturalized citizens in the U.S. less than 15 years, foreign born naturalized citizens in the U.S. 15 years or more, and U.S.-born citizens.

Access to Care

A five-factor model proposed by Pechansky and Thomas (1981) was used to operationalize access to care and aid in the selection of measures. Access to care is conceptually a multi-dimensional construct (Andersen, et al, 1983). Pechansky and Thomas proposed that operationalization and measurement of access to care has to consider availability of care, accessibility to care, affordability of care, accommodations of care, and acceptability of care. Availability of care is a question of volume and supply. This construct refers to the adequacy of the number of physicians, health centers or clinics, hospitals, or health professionals. Accessibility refers to one's ability to reach the supply through transportation, travel time, distance, or transportation costs, while affordability refers to cost of health services, specifically out-of-pocket costs, and health insurance. Accommodations of care refer to facets of the health care system that facilitate or impede a patient's ability to receive care. These accomodations could include the ease of making an appointment, clinic hours of operation, wait times, walk-in appointments, or the presence of translators to talk to providers and clinic staff. Acceptability of

care denotes the conditions in which care was received and how patient preferences and perceptions match those of providers and health systems. This factor is sometimes measured by assessing satisfaction with the provider's offices and surrounding neighborhood (Pechansky & Thomas, 1981). In order to achieve a comprehensive measure of access to care, the framework was used to guide selection of relevant items.

Access to care items were identified from the "Adult Access to Health Care and Utilization" section of the Adult core of the NHIS. Survey items associated with access to care that were consistently available across all four survey years were mapped but only items that addressed the availability and accommodation domains were identified. No items addressing care affordability, accessibility, and acceptability were available consistently across all four data years.

Three items were identified that addressed availability of health care. These items represent the availability of health care services to those seeking or in need of them. The first item asked if "there is a place that you usually go to when you are sick or need advice about your health." Response options included "yes, there is more than one place", "there is no place", "refused", and "don't know". Those who reported having a usual source of care or multiple sources of care were recoded into one category. Those who refused to answer, reported that they didn't know, or where a response was not ascertained were recoded to missing. Less than 1% of responses were recoded to missing. The next measure is whether the respondent has health insurance coverage. This is a derived variable available in the public use dataset and provides a dichotomous variable indicating if the respondent is covered by some form of health insurance or not covered. Those who responded that they didn't know if there were covered by health insurance were recoded as missing. This variable had no refusals and all responses were

ascertained. Approximately 1% of responses were recoded to missing. The final measure was time since the respondent had last seen a medical provider. Respondents were asked "about how long has it been since you last saw or talked to a doctor or other health care professional about your own health." Response options included "never," "6 months or less," "more than 6 months but less than 1 year," "more than one year but less than 2 years," "more than 2 years but less than 5 years," and "more than 5 years ago." Response categories "never" and "more than 5 years" were collapsed to indicate infrequent medical care. Those who refused, answered don't know, or whose responses were not ascertained were set to missing. Approximately 1.6% of responses were set to missing. The three items were then summed to create an overall care availability score. This summed score is primarily driven by the time since the respondent last saw a doctor variable given that it has more response categories than the other two items included. The scale was reverse coded, meaning that higher scores would indicate less availability of care, in order to have the same directionality as the accommodation summed score.

Five items were identified that addressed the accommodation domain. These items represent how available health care services accommodate patient needs and schedules. Respondents were asked if they had "delayed getting medical care for any of the following reasons in the past 12 months"; reasons for delaying care included "you couldn't get through on the telephone," "you couldn't get an appointment soon enough", "once you get there, you have to wat too long to see the doctor," "the clinic/doctor's office wasn't open when you could get there," "you didn't have transportation." Response options to each of the five items were coded as "yes," "no," "refused," or "don't know." Responses coded as "refused" or "don't know", or those that were marked as not ascertained due to item non-response were set to missing. Each item had approximately 1% of responses were set to missing. Items were then summed to create

an accommodation of health care score, with higher scores indicating greater challenges with care accommodation.

The accommodation of care and availability of care scores were then summed to create a composite access to care score, with higher scores indicating greater challenges and limitations in accessing health care.

Socioeconomic Status

Measures of socioeconomic status included education, employment status, and a ratio of income to poverty level. Education was ascertained through the question "what is the highest level of school or the highest degree received". The respondent was given 22 categories to choose from that delineates all grades from kindergarten to 12th grade and also includes "GED or equivalent", "high school graduate", "some college – no degree", "associate degree - vocational program", "associate degree- academic program", "bachelor's degree", "master's degree", "professional degree", and "doctoral degree." Education level was recoded into a four-level variable by creating the following categories: 1) 12 grade or less, 2) High school graduate or GED, 3) Associate degree or some college, and 4) Bachelors or Graduate degree. Those who refused or whose responses were not ascertained were recoded to missing (about 3%). Employment status was obtained through the question "which of the following were you doing last week." Response options included "working for pay at a job or business", "with a job or business but not at work", "looking for work", "working, but not for pay", "not working at a job and not looking". Those who reported working for pay, or with a job but not at work last week, were recoded as being employed for wages, while all the other categories were recoded as currently not earning wages or unemployed. Those who refused or whose responses were not ascertained were coded as missing (about 2%).

Given that the NHIS collects data on the family unit, the publicly available dataset contains a variable that calculates the ratio of family income to the poverty threshold by taking into account household income, family size, and number of family members under age 18. It utilizes published poverty thresholds from the Census for these calculations (Parsons, et al., 2014). The variable provided in the publicly available dataset contains 18 categories, but was recoded into 4 categories: 1) those who are 99% or less above the poverty threshold, 2) those who are 100% to 199% above the poverty threshold, 3) those who are 200% to 399% above the poverty threshold, and 4) those who are 400% or more above the poverty threshold. These categories were four of the 18 already available response options. Due to item-level non-response on some of the items needed to compute the variable, the ratio could only be approximated for a subset of respondents and these estimates were provided in the aforementioned categories. Recoding the more specific values of the ratio into these predetermined categories created an opportunity to preserve sample size. Those for whom the ratio could not be calculated or approximated, were coded as indefinable or unknown, and were then recoded to missing. The ratio was indefinable or unknown for approximately 16% of Hispanic women aged 40-75.

Socio-demographics

Socio demographics characteristics of interest included age, marital status, census region, and country of origin. Age was calculated based on respondent data of birth and provided as a continuous variable in the public release dataset. Age was then categorized into ten-year bands for the age range of interest (40-49, 50-59, 60-69, 70-75).

Respondents were asked if they were “now married, widowed, divorced, separated, never married, or living with a partner.” Response options included “married – spouse in household”,

“married – spouse not in household”, “married – spouse in household unknown”, “windowed”, “divorced”, “separated”, “never married”, “living with partner”, or “unknown”. Those who reported being married, regardless of their spouse being in the household, or living with a partner, were recoded into one category, while those who reported being widowed, divorced, or separated were combined into one category, and those who were never married were kept in a separate category. All those who answered unknown were recoded to missing (less than 1%). Census region is a 4-level variable and was derived based on the state where the interview occurred. It was provided as a variable in the public release data set and contained the four categories routinely used by the Census: Northeast, Midwest, South, and West.

Those who reported being Hispanic/Latino were asked to identify their country of origin. A twelve level categorical variable is provided in the public use data file. Categories included: multiple Hispanic, Puerto Rican, Mexican, Mexican-American, Cuban/Cuban American, Dominican, Central or South American, other Latin American unspecified, other Spanish, non-specific type, type refused, type not ascertained, and not Hispanic/Spanish. Mexican and Mexican American were recoded into one category and multiple Hispanic, other Latin American, and Other Spanish were recoded into one variable. Non-specific type, type refused, and type not ascertained contained no responses, leaving a six-level categorical variable. This variable had no missing data.

III. Statistical Analysis

The dataset was constructed by first downloading the Household, Family, Person, Sample Adult, and Cancer module datasets from the NHIS website per data year (cancer data only a separate file in 2010 and 2015). These files were then merged by using the household, family, and person identification variables provided to create four separate datasets (one for each data

year). The four datasets were then concatenated. Since the sampling weight may vary by data year based on the sampling fractions used for oversampling of racial/ethnic minorities, a new weight was calculated by dividing each data year's weight by the number of data years being concatenated (NCHS, 2016b). All analyses were conducted using SAS software version 9.4. SAS Survey Procedures were utilized to account for the complex sample design of the NHIS (SAS, 2009).

Given that the NHIS utilizes a multi-stage area-probability design, using standard analytic techniques that assume a simple random sample would be inappropriate and could lead to incorrect estimates of variances and standard errors (Lee, et al., 1989). Unless otherwise noted, all analyses were conducted so as to account for stratification, clustering, and the oversampling of specific population groups. In addition, all analyses that are specific to a population subgroup, such as Hispanic women aged 40-75, were conducted using domain analysis and not subset to the population in question so as not to omit design elements that may be used in variance estimation (Lewis, 2013).

First, trend analyses were conducted to assess if there are differences in mammography use over the four data years. Because this dataset used four years of pooled cross-sectional data, trend tests were conducted to determine if mammography use was associated with data year and if so, to adjust for that effect. Point estimates were calculated per data year for the percent of women aged 40-75 who have received a mammogram and the percent of women who had been rarely or never screened. Point estimates were calculated for all women, regardless of race or ethnicity, and for Hispanic women. The Cochran-Armitage Trend Test (Agresti, 2002) was used to detect any upward or downward trends in mammography use. Because this test was not available in statistical procedures appropriate for analysis of data from complex sample surveys

(e.g. SAS survey procedures), if the trend test showed a significant effect (at the p=0.05 level) in analyses for a simple random sample, a logistic regression (accounting for the complex sample) using data year as a predictor of mammography use was conducted to verify the trend. If the logistic regression showed a significant effect, then multivariable analyses would adjust for data year. Since one of the trend tests and the subsequent regression model showed a significant effect, all multivariable analyses were adjusted for data year (see results section).

In order to provide context to mammography use among Hispanic women, point estimates for both mammography use outcomes were calculated by race/ethnicity. A chi-square test was used to assess if there were differences in mammography use by race/ethnicity. If significant, a logistic regression model was used to calculate odds of mammography use by women of other race/ethnicity groups compared to Hispanic women.

Univariate analyses were conducted on all variables of interest using the pooled dataset as well as for each individual data year. Frequencies and means were used to describe variable distributions and identify missing data. For summed scores, skew and kurtosis were also assessed. Bivariate analyses were conducted to assess relationships between study variables using chi-square tests, correlations and t-tests. Unadjusted linear and logistic regressions were also used to conduct bivariate analyses.

To assess access to care by country of origin and immigration status, mean differences in health care availability, care accommodation, and overall access to care were analyzed using linear regression. Cross-tabulations using chi-square tests were used to assess difference in ratios of income to poverty level by country of origin and immigration status.

Logistic regression models were used to assess predictors of having been screened in the past two years and being rarely or never screened among Hispanic women in order to test the

third research question. First, all variables of interest were run in unadjusted logistic regression models for both outcomes. For multivariable analyses, block entry methods were used with variables being entered in 3 steps: Step 1: immigration status and socio-demographics (combined immigration status variable, country of origin, age, marital status, and census region); Step 2: access to care (overall access to care summed score); Step 3: SES variables (federal poverty ratio, education, and employment status). Due to a high correlation between the health care availability and accommodation score, only the overall access to care variable was used in multivariable models. Correlations between education, poverty level ration and employment status were not considered high enough to cause concerns about collinearity (below 0.60) (Berry WD, et al., 1985; Vatcheva KP et al., 2016). All models were also adjusted for survey year.

Logistic regression models matched using propensity scores, were used to further explore the effects of citizenship status on mammography use. These methods are often used to reduce bias and approximate a randomized trial (Parsons, 2001; Austin, 2011). They were used to help provide certainty that the observed effects associated with mammography and citizenship status are not being confounded by other variables. These models matched participants on their predicted probability of being (or not being) a U.S. Citizen given the variables entered into the model. First, a logistic regression model was used to calculate the predicted probability of being a U.S. citizen (or non-citizen) given the following variables: length of time in the US, Hispanic subgroup or country of origin, access to care, education, poverty level, employment status, age, marital status, region, and survey year. Then respondents were matched on predicted probability of being citizen/non-citizen using Greedy Matching Techniques (Parsons, 2001). Then matched logistic regressions for each mammography use outcome were conducted to ascertain the odds of test use among non-citizens.

IV. Results

What proportion of Hispanic women are being screened for breast cancer through mammography? Does test use vary by country of origin or immigration status?

Trends in mammography use

In 2008, an estimated 78.01% (95%CI: 76.68%, 79.35%) of women aged 40 or older in the U.S. reported having received a mammogram in the last 2 years. Estimates remained fairly stable in 2010, 2013, and 2015 with 76.91% (95% CI: 75.66%, 78.15%), 77.31% (95% CI: 76.21%, 78.42%), and 75.91% (95% CI: 74.72%, 77.09%), respectively, reporting being up-to-date on receiving a mammogram (Figure 3.2). Results of the Cochran-Armitage Trend Test reported a statistically significant trend (z=2.6603; p=0.0078). A logistic regression indicated that women in 2015 had significantly lower odds of reporting having received a mammogram in the past 2 years compared to women in 2008 (OR=0.888, 95%CI:0.081, 0.984, p= 0.024). There were no significant differences in odds of having received a mammogram in the past 2 years between 2008 and 2010 (OR=0.94, 95%CI: 0.844, 1.044, p=0.24), and 2013 (OR=0.96, 95%CI: 0.867-1.064, p=0.44).

Trends for being rarely or never screened were stable over the data period. In 2008, 18.24% (95% CI: 17.16%, 19.50%) of women aged 40 or older, reported being rarely or never screened. In 2010, 2013, and 2015, 18.92% (95% CI: 17.83%, 20.02%), 19.20% (95% CI: 17.83%, 20.02%), and 19.28% (95% CI: 18.28, 20.27%), respectively, reported being rarely or never screened (Figure 3.2). Results of the Cochran-Armitage Trend Test indicated that there was no significant trend in estimates over the data period (z=-2.07, p=0.40).

Trends in mammography use for Hispanic women

Among Hispanic women aged 40 to 75, an estimated 76.55% (95% CI:72.50%, 80.79%) reported having received a mammogram over the last two years in 2008. In 2010, 2013 and 2015, 76.68% (95% CI: 73.50%, 79.87%), 75.45% (95% CI: 72.33%, 78.58%), and 76.97% (95% CI: 73.92%, 80.02%), respectively, reporting having been screened (Figure 3.3). Results of the Cochran-Armitage Trend test indicate that there was no significant trend in mammography use over the four data years (z=0.1317, p=0.89). Overall 76.42%, or an estimated 4.4 million Hispanic women aged 40-75, reported being up to date with mammography screening.

An estimated 24.55% (95% CI: 21.02%, 28.07%) of Hispanic women aged 40 or older reported being never or rarely screened via mammography in 2008. Estimates remained stable over 2010 (22.30%, 95% CI: 19.57%, 25.03%), 2013 (24.38%, 95% CI: 21.85%, 26.92%), and 2015 (23.61%, 95% CI: 20.77%, 26.45%) (Figure 3.3). Results of the Cochran-Armitage trend test indicate that there is no significant trend (z=-1.008, p=0.3134) in estimates over the data years. Overall, 23.73%, or an estimated 1.7 million Hispanic women aged 40-75, reported being rarely or never screened for breast cancer.

While most trend tests were not significant, there was a slight, but significant, downward trend identified in mammography use in the past 2 years among women aged 40-75. As a result, multivariable analyses were adjusted for data year.

Mammography use by race/ethnicity

Mammography use over the last 2 years was most common among Non-Hispanic Black women (79.56%, 95% CI: 78.15%, 80.98%), followed by NH Asian women 78.38% (95% CI: 75.73%, 81.03%), NH white women (76.68%, 95% CI: 75.91%, 77.47%), Hispanic women (76.42%, 95% CI: 74.80%, 78.04%), and women from all other racial/ethnic groups (72.44%, 95% CI: 66.59%, 78.28%) (Figure 3.4). A chi-square test indicated a significant difference in

being up-to-date with mammography use by race/ethnicity (X^2= 16.87, df= 4, p=0.003). Results of a logistic regression indicate that NH Black women had significantly greater odds (OR=1.20, 95% CI: 1.06, 1.32, p=0.004) of having received a mammogram in the last two years compared to Hispanic women. There were no significant differences in the odds of having received a mammogram in the past two years among NH white (OR=1.02, 95% CI: 0.919, 1.120, p=0.77), NH Asian (OR= 1.12, 95% CI: 0.933, 1.342, p=0.22), and NH "other" women (OR=0.81, 95% CI: 0.592, 1.110, p=0.19), compared to Hispanic women.

Being rarely or never screened was most common among Hispanic women (23.73%, 95% CI: 22.39%, 25.08%), followed by women of "other" race/ethnicity (22.97%, 95% CI: 16.81%, 29.12%), NH Asian women (20.95%, 95% CI: 18.90%, 22.99%), NH Black women (19.15%, 95% CI: 17.67%, 20.63%), and NH white women (17.95%, 95% CI: 17.28, 18.62) (Figure 3.4). A chi-square test indicated a significant difference in the proportion of women who are rarely/never screened by race/ethnicity (X^2=66.39, df= 4, p=<0.001). Results of a logistic regression indicated that NH white women, NH Black, and NH Asian women had significantly lower odds of being rarely/never screened compared to Hispanic women (OR: 0.703, 95% CI: 0.645, 0.766, p=<0.001; OR=0.76, 95% CI: 0.673, 0.860, p=<0.001; (OR=0.85, 95% CI: 0.736, 0.984, p=0.0297, respectively). There was no significant difference in odds of being rarely/never screened between women in the "other" race/ethnicity category and Hispanic women (OR=0.958, 95% CI: 0.671, 1.369, p=0.813).

Does access to care and socio-economic status among Hispanic women vary by country of origin and immigration status?

Characteristics of Hispanic women in the U.S.

Table 3.2 presents frequencies and weighted percentages for key study variables by survey year and in combined sample used for all analyses. Most women were ages 40-49 (43.98%), and 50-59 (30.98%), and married (65.29%). They are primarily located in the West (40.84%) and South (37.12%). Most women were foreign born (65.6%), U.S. citizens (69.47%), and have resided in the U.S. more than 15 years (78.66%). Most are Mexican American, or of Mexican descent (57.35%).

Access to care among Hispanic women in the U.S.

Overall, Hispanic women reported high availability of health care. Most Hispanic women reported having a usual source of care (85.38%), and reported having health insurance coverage (74.56%) (Table 3.2). Most women also reported having seen a doctor in the last 6 months (69.56%) (Table 3.3). The summed availability score ranged from 1 to 7, with a mean of 2.02 (std err=0.03). A higher availability score is indicative of grater challenges accessing health care due to care availability.

Similarly, few Hispanic women reported facing issues with care accommodation. The most commonly reported challenge faced with care accommodation was facing a long wait time at the office (9.15%), followed by not being able to get an appointment soon enough (8.25%). Few women reported not being able to reach their doctors office on the phone (3.62%), not having transportation to go to the doctor (3.16%), and the doctor not being open when they could attend (2.75%). Most women (84.34%) reported not facing any care accommodation challenges, while 8.43% reported facing one challenge, 4.46% reported facing two, and 1.85% reported facing three. Less than one percent reported facing four (0.69%) or five (0.23%) accommodation challenges. The summed accommodation score, scores ranged from 0 to 5, with a mean score of

0.27 (std err= 0.014). A higher accommodation score is indicative of facing a greater number of challenges accessing health care due to difficulty accommodating care.

The composite access score, a sum of the availability and the accommodation scores, scores ranged from 1 to 12, with a mean score of 2.28 (std err= 0.03). A higher access score is indicative of facing greater challenges accessing care due to issues with care availability and/or accommodation.

Analyses assessing differences in access to care by country of origin found that Mexican women reported the highest mean levels of difficulty with availability, accommodation, and overall access to care (Table 3.4). Results indicate that Mexican ($p<0.0001$), Cuban ($p<0.0001$), and Central/South American women ($p<0.0001$) reported significantly higher mean levels of difficulty with availability of care compared to Puerto Rican women. Compared to Puerto Rican women, Mexican ($p<0.0001$), Central/South American ($p=0.039$), and "other" Hispanic ($p=0.0004$) women reported statistically significant higher levels of challenges with care accommodation. When looking at overall access to care, Mexican ($p<0.0001$), Cuban ($p<0.0001$), and Central/South American women ($p<0.0001$), and "other" Hispanic women ($p=0.018$) reported significantly higher mean levels of difficulty accessing care than Puerto Rican women.

Analyses assessing differences in access to care by immigration status found that foreign-born non-citizens who have been in the U.S. less than 15 years reported the highest mean scores of availability of care, accommodation of care, and overall access to care – indicating significant barriers in accessing care (Table 3.5). Women who are foreign-born citizens who have resided in the U.S. more than 15 years, and U.S. born Hispanic women reported the greatest levels of availability, accommodation, and overall access to care. Statistical tests indicate that compared to

U.S. born Hispanic women, foreign-born non-citizens in the U.S. less than 15 years ($p<0.001$), foreign-born non-citizens in the U.S. 15 years or more ($p<0.001$), and foreign-born Citizens in the U.S. less than 15 years ($p=0.03$), report higher mean levels of difficulty with availability of care. No statistically significant differences were found in mean levels of accommodation to care by immigration status. Foreign-born non-citizens in the U.S. less than 15 years ($p<0.001$) and foreign-born non-citizens in the U.S. 15 years or more ($p<0.001$) reported statistically significant higher mean levels of difficulty accessing care.

Socioeconomic status of Hispanic women in the U.S.

Most women had lower levels of education (approximately 62% high school education or less), were low income (approximately 48% have a household income 200% below the federal poverty level), and unemployed (about 52% report being currently unemployed) (Table 3.2).

Analyses comparing poverty level by country of origin indicated that a large proportion of Dominican women (approximately 67.17%) face the highest levels of poverty (less than 200% above the federal poverty level) (Table 3.6). Slightly less than half of Puerto Rican, Mexican, Cuban, and Central/South American women are estimated to be either 99% or less, or 100 to 199% above the federal poverty level. “Other” Hispanic women (composed of multi-ethnic Hispanic women, those with descendants from Spain, or those who did not identify a country of origin) had the smallest proportion of women in the lowest poverty categories. A Chi-Square test indicated that there were significant differences in the distribution of poverty levels by country of origin ($X^2= 65.97$, $df=15$, $p<0.001$).

When assessing federal poverty level by immigration status, we found that the majority of foreign-born non-citizens, whether in the U.S. less or more than 15 years, are 99% or less, or 100% to 199% of the federal poverty level (69.12% and 67.68% respectively) (Table 3.7).

Approximately half of foreign-born citizens in the U.S. less than 15 years (50.75%) are estimated to be in greatest poverty, while a little less than half (45.02%) of foreign-born citizens in the U.S. more than 15 years are in the two greatest poverty categories. U.S. born Hispanic women had the lowest proportion of women in greatest poverty (33.34%). Chi-square test indicate that there are significant differences in the distribution of poverty levels by immigration status (X^2=806.36, df=20, p<0.0001).

Mammography use among Hispanic women in the U.S. by Country of Origin

Overall, 76.42% (95% CI: 74.80%, 78.04%, n=3121) of Hispanic women, aged 40 to 75, reported having a mammogram in the last 2 years, while 23.73% (95% CI: 22.38%, 25.08%, n=1173) reported having never had a mammogram or it being more than 5 years since their last mammogram. Dominican women had the highest proportion getting mammograms consistent with recommendations (86.50%, 95% CI: 83.46%, 89.55%), followed by Puerto Rican women (77.86%, 95% CI:74.08%, 81.46%), Central/South American women (77.53%, 95% CI:73.65%, 81.41%), Cuban women (75.70%, 95%CI: 69.21%, 82.19%), Mexican women (75.49%, 95% CI: 73.41%, 77.57%), and "other" Hispanic women (72.40%, 95% CI: 64.88%, 79.91%) (Figure 3.5a). Results of a Chi-Square test indicated that screening rates significantly differ by country of origin (X^2= 23.93, df=5, p=0.0004).

The highest proportion of women who were rarely or never screened were Mexican (26.51%, 95% CI: 24.73%, 28.30%), followed by Cuban women (24.16%, 95% CI: 14.84%. 33.48%), Puerto Rican women (21.52%, 95% CI: 17.38%, 25.66%), Central/South American women (18.86%, 95% CI: 15.83%, 21.89%), Dominican women (18.86%, 95%CI: 15.83%, 21.89%), and "other" Hispanic women (16.07%, 95% CI: 9.95%, 22.19%). Results of a Chi-

Square test indicated that rates of being rarely or never screened significantly varied by country of origin (X^2= 27.93, df=5, p<0.0001).

Mammography use among Hispanic women in the U.S. by Immigration Status

The proportion of Hispanic women who were screened within the last 2 years was highest among foreign born women who have been in the U.S. less than 15 years (83.05%, 95% CI: 75.09%, 91.01%), followed by foreign born non-citizens who have been in the U.S. 15 years or more (80.09%, 95% CI: 77.48%, 82.70%), U.S. born women (75.66%, 95% CI: 73%, 78.33%), foreign-born non-citizens in the U.S. more than 15 years (72.04%, 95% CI: 67.57%, 76.50%), and lowest among foreign-born non-citizens (71.07%, 95% CI: 65.15%, 76.98%). Results of a Chi-Square test indicated that the proportion of women screened in\ the past 2 years significantly varied by immigration status (X^2= 16.46, df=4, p=0.0029).

The proportion of Hispanic women who were rarely or never screened was highest among foreign-born non-citizens who had been in the U.S. less than 15 years (39.67%, 95% CI: 34.28%, 45.01%), followed by foreign-born non-citizens who have been in the U.S. 15 years or more (31.69%, 95% CI: 27.90%, 35.47%), U.S. born women (21.89%, 95% CI: 19.37%, 24.40%), foreign-born citizens who have been in the U.S. less than 15 years (18.49%, 95% CI: 11.61%, 25.37%), and foreign-born citizens who have been in the U.S. 15 years or more (15.48%, 95% CI: 13.19%, 17.76%) (Figure 3.5b). Results of a Chi-Square test indicated that the proportion of Hispanic women who have been rarely or never screened by mammography varied significantly by immigration status (X^2= 94.42, df=4, p<0.0001).

Does immigration status contribute to mammography use beyond access to care and socio-economic status?

Predictors of recent mammography screening

In unadjusted models, women reporting greater issues with health care access, namely issues associated with care availability, had significantly lower odds of having been screened in accordance with breast cancer screening recommendations (Table 3.8). Similarly, Hispanic women with lower levels of education, greater levels of poverty, and who were unemployed had significantly lower odds of having received a mammogram in the last two years. Hispanic women in the South also had lower odds of having received a mammogram in the last two years, while women in the Northeast had significantly greater odds, compared to Hispanic women in the West. Dominican women had significantly greater odds of having been screened in the last two years, compared to Puerto Rican women. Non-U.S. citizens were had approximately 30% lower odds of having been up to date on mammography screening than U.S. citizens. Time spent living in the U.S. and nativity were not significant predictors. In the combined variable, foreign-born U.S. citizens, who had been in the U.S. more than fifteen years, had significantly greater odds of having been screened than U.S. born women.

After including demographic characteristics [Model 1], foreign born, non-citizens, in the U.S. more than 15 years has approximately 26% lower odds of being up to date with mammography screening compared to U.S. born Hispanic women. After adding access to care to the model [Model 2], foreign-born U.S. citizens, regardless of length of stay in the U.S., had greater odds of being up-to date with mammography screening. Hispanic women who reported greater issues with access to care had approximately 33% lower odds of having received a mammogram in the last two years. After adjusting for SES [Model 3], odds of being up to date with mammography screening by immigration status were similar to those from model 2. Compared to Hispanic women with household incomes at 400% or more of the federal poverty

line (FPL), those making less faced an estimated 28% to 39% lower odds of being up to date with mammography screening. Model fit indices indicate that model 3 provides the best fit.

Predictors of being rarely or never screened

In unadjusted models, non-U.S. citizens had two-fold greater odds (OR=2.34) of having been rarely or never screened for breast cancer, compared to U.S. citizens, while those in the U.S. less than fifteen years had almost two-fold increased odds (OR=1.89), compared to those in the U.S. more than 15 years. In the combined variable, foreign-born non-citizens in the U.S. less than fifteen years, or fifteen years or more, had significantly greater odds of being rarely or never screened for breast cancer compared to U.S. born Hispanic women (Table 3.9). Hispanic women reporting greater issues with overall access to care also had significantly greater odds of being rarely or never screened. While access to care factors associated with availability of care were significantly associated with greater odds of being rarely or never screened, access factors related to care accommodation were not significantly associated. Women with lower levels of education, higher levels of poverty, and who are unemployed had significantly greater odds of being rarely or never screened. Mexican women, compared to Puerto Rican women, were the only Hispanic subgroup with significantly greater odds of being rarely or never screened. Women who have never been married, and women who reside in the South also had significantly greater odds of being rarely or never screened. Women who are age 50-59, and 60-69 had significantly lower odds of being rarely or never screened.

After including demographic factors (Hispanic subgroup, age, marital status, region, and data year) [Model 1], immigration status remained a significant predictor of being rarely or never screened. Specifically, foreign born non-citizens who had been in the U.S. less than fifteen years, as well as those who had been in the U.S. fifteen years or more, had significantly greater

odds of being rarely or never screened. When access to care was added to the model along with demographic characteristics [Model 2], odds of being rarely or never screened were attenuated for both foreign born non-U.S. citizens in the U.S. less than 15 years, and 15 or more years. After adding measures of socioeconomic status to the model [Model 3], the magnitude of effect for immigration status was completely attenuated apart from foreign-born naturalized citizens, who had lower odds of being rarely or never screened (compared to U.S. born Hispanic women) across all models. In the final model, Hispanic women experiencing barriers in access to care, those with lower education levels, and high levels of poverty, had increased odds of being rarely or never screened for breast cancer with mammography.

US Citizenship and mammography use

After matching participants on predicted probabilities of being citizens given socio-demographic characteristics, access to care, and SES-related measures, we found that Hispanic women who are non-citizens had significantly greater odds of being rarely or never screened (OR= 1.765, 95%CI (1.258, 2.476) p=0.0012). Citizenship status was not a significant predictor of having received a mammogram in the last 2 years (OR=0.728, 95%CI (0.505, 1.053), p=0.0914). Figure 3.6 presents a plot of the distribution of the predicted probabilities of being a non-citizen/Citizen.

V. Discussion

This study sought to examine the impact of immigration status on access to care and socioeconomic status, and in turn, assess their effect on mammography use among Hispanic women in the U.S. First, we estimated the proportion of Hispanic women who received a mammogram in the last two years as well as the proportion who are rarely or have never been screened. Results indicated that the proportion of Hispanic women aged 40-75 who have been

screened in the last two years was not all that different compared to non-Hispanic white women (76.4% vs. 76.7%) and were fairly similar across country of origin (72.4% - 77.7%), with the exception of Dominican women who reported being screened at a higher rate than all other Hispanic women (86.5%). However, when assessing the proportion of women who are rarely or never screened, differences were more evident. Hispanic women had the highest proportion reporting that they were rarely or never screened compared to women of other racial/ethnic backgrounds (23.7% vs. 17.95% - NH white). When broken down by country of origin, Mexican (26.5%) and Cuban (26.2%) women had the highest proportion of being rarely or never screened. An analysis of mammography use by immigration status and found that foreign-born non-citizen women who had been in the U.S. less than 15 years had the lowest proportion being screened in the last two years (71.07%) and the highest proportion being rarely or never screened (39.67%).

Next, we explored the relationship between immigration status and structural factors that may limit or impede the ability of a woman to receive a mammogram, specifically access to care and socioeconomic status. Our assessment of access to care by country of origin indicated that in terms of availability of health care, and accommodation of health care, as well as overall access to care, Mexican women faced the greatest barriers in accessing care. Hispanic women who are foreign-born non-citizens, regardless of length of time spent in the U.S., faced reported significant challenges with care availability and overall access to care compared to U.S. born Hispanic women. Hispanic women who are foreign-born non-citizens did not fare much better in terms of socio-economic status with almost 63% reporting that they are 99% or less above the federal poverty level.

Levels of access to care were higher than expected, but this may be due to the sample of Hispanics in the NHIS being mostly citizens and having resided in the U.S. for a minimum of

fifteen years. While the sampling of the NHIS goes to great lengths to be representative of the U.S. population, it may be that more recent immigrants are a hard to reach population or are more likely to refuse participation for in person or phone-based survey research. In addition, access to care measures may not have been the best suited to understand challenges or limitations in access to care in this particular population. For example, items on accommodation of care that asked about difficulty communicating with doctors and office staff in English or ability to locate a doctor that spoke Spanish, may have been better suited to assess limitations with care accommodation.

In multivariable logistic regression models assessing predictors of having received a mammogram in the last 2 years, immigration status was not a strong predictor. The marginal effects exhibited by immigration status were further attenuated as variables addressing access to care and socioeconomic status were added to the model. However, models assessing predictors of being rarely or never screened indicated that women who are foreign-born and non-citizens had significantly greater odds of being rarely or never screened. The effect of immigration status was again attenuated as access to care and socioeconomic status variables were added to the model. Additional logistic regression models were then conducted by matching Hispanic women on their predicted probabilities of being citizens/non-citizens, given their access to care, socioeconomic status, country of origin, time spent living in the U.S., and sociodemographic characteristics. Results indicated that while citizenship status was not a significant predictor of having been screened in the past two years, it was significant predictor of being rarely or never screened. The model indicated that non-citizens had 1.77 greater odds of being rarely or never screened than Hispanic women who are citizens. This indicates that components of immigration

status, namely citizenship status, may likely contribute to mammography use beyond access to care and socioeconomic status.

Previous studies have found inconsistent results on the role of immigration status on mammography use. An analysis using data from the 1991 NHIS, similarly fount that citizenship status was not associated with being compliant with mammography screening recommendations after adjusting for access to care and socioeconomic status (Abraido-Lanza, et al., 2005). Analysis of the 2000 NHIS found that there was a 14% difference in the proportion of noncitizens having received a mammogram, compared to citizens; however, these effects were significantly attenuated after adjusting for access to care (Echeverria, et al., 2006). In contrast, an analysis of data from the California Health Interview Survey, found that Hispanic women who are U.S. citizens were about 1.38 times more likely to have received a mammogram recently, compared to non-citizens (De Alba., et al., 2005). A qualitative study by Shelton (2011) also found that immigration status was a barrier to screening. Similar to our results, a previous study by Rodriguez (2005) found that immigration status was a significant predictor of being rarely or never screened, even after adjusting for structural factors, but was not a significant predictor of having been screened in the last year after adjustment. These inconsistencies in results may be explained by differences in study methodology, sampling, or measurement between studies.

The differing results on the effect of immigration status on mammography use based on the type of mammography outcome being modeled are intriguing. Given that our results indicate non-citizens face challenges accessing health care, it is not surprising that they have greater odds of being rarely or never screened. While, in adjusted models, immigration status was not a significant predictor of having been recently screened, it is possible that this was due to the variability of statuses that might be contained under “non-citizen.” There are a myriad of legal

statuses in U.S. immigration laws that may be granted to non-citizens, such as refugee, someone who has claimed political asylum, permanent resident, protected status, or undocumented and in the U.S. illegally. Access to public health care programs, like Medicaid and Medicare, or eligibility for programs like the National Breast and Cervical Cancer Detection Program, can vary based on type of non-citizen or on the state or territory in which one is located. These potential differences in access to care based on type of non-citizenship status may have made results on the mammography use somewhat murky.

This study was interested in providing context into the mechanisms through which immigration status may affect mammography use. Our results indicate that immigration status is associated with structural factors (access to care and SES) that may then lead to limited screening test use. Since the relationship between immigration status and mammography use were attenuated by the addition of access to care and SES, this may suggest a mediation effect, although one was not directly tested. In other words, access to care and SES may be intermediary variables in the relationship between immigration status and mammography. This is a question that future research will need to more thoroughly explore using longitudinal data and more detailed measures of immigration status, access to care, and SES. While acculturation as a broader concept has been considered a social variable with more psychological or behavioral underpinnings, the immigration status domain may be more adequately described as a structural factor given that it is a potential doorway to access to care and improved SES.

Most research that has used immigration status as their principal acculturation measure have characterized it as a characteristic or feature of the individual. However, this may be a misguided approach. Citizenship status is decided based on immigration laws and those laws dictate much, if not most, of an immigrant’s life including whether they can have a job, the type

of job, ability to attend school, their ability to access social programs that provide access to health care, or their ability to purchase health insurance. Studies using immigration status may be better suited to take a policy-based approach to understand how legal status, and the rights and privileges that status confers, affects health service use, health behaviors, or health outcomes. Similarly, country or origin could also be considered a policy level variable because legal status and the kinds of immigration programs available to a person. In addition, country or origin and immigration status, in the context of Hispanic women, are difficult to disentangle. For example, Puerto Rican women, regardless of where they are born, are U.S. citizens. From birth, they have different access and rights than other Hispanic women. Cuban women, on the other hand, while not U.S. citizens from birth, do benefit from a different set of policies concerning their immigration and citizenship status making it possible for them to apply for citizenship status quicker than other permanent residents do and they can even take the citizenship test in Spanish. This also emphasizes the limitations associated with creating homogenous groups of Hispanic women.

Limitations

While this study utilized a large representative sample and was able to explore multiple outcomes associated with mammography use, it is not without limitations. The NHIS is a cross-sectional survey and does not allow us to make causal inferences. In addition, it is self-reported data and are therefore subject to bias. Previous research has indicated that accuracy of self-repots of screening behavior may vary by race/ethnicity (Rauscher, et al. 2008; Cronin, et al., 2009). While a study by Cronin (2009) found that Hispanic women were least likely to over-report screening compared to non-Hispanic white and Black women, a meta-analysis found that Hispanic women had lower sensitivity and specificity in self-reports of mammography use

(Rauscher, 2008). This meta-analysis estimated that in the 2000 NHIS the difference in mammography use between non-Hispanic white and Hispanic women was likely 30% (after adjusting for over-reporting), as opposed to the 11% estimated directly from the survey (Rauscher, 2008). A study seeking to confirm mammography use among women in Medicare found that while 46% of Hispanic women reported having had a mammogram in a survey, mammography related claims were only available for 30% (Holt, et al., 2006). Mammography use may also be over-estimated because we are unable to distinguish between a mammogram done for screening purposes versus one done for diagnostic purposes.

In addition, there is some evidence that self-reported citizenship status may not be very reliable. Previous studies have estimated that false-reports of citizenship status can range from 30% to as high as 75%, with the highest rates of incorrect reporting being among recent immigrants and those from Mexico or Central America (Passel, et al., 1997; Brown, et al., 2019; Van Hook, et al, 2013). It should also be taken into account that most of the Hispanic women in our sample reported having been in the U.S. for fifteen years or more, indicating that the sample may be biased towards long-term immigrants or individuals are inaccurately reporting their length of residence in the U.S. Unfortunately, even combining four years of data, stratification by country of origin was limited due to small sample size for some groups. A high level of missing data for measures used to calculate the ratio of household income to poverty level is also a limitation of the study.

The access to care measures utilized in this study were developed specifically for this study and have not been validated. While the individual items have all appeared on the NHIS for several cycles and have received cognitive testing, their use as summed scales has not been tested. No other published literature using these items as a summed score was identified,

although these items are routinely used individually. These summed scores were created to address concerns of multi-collinearity in logistic regression models as most items were highly correlated. However, their use as continuous scores or indexes may cause additional measurement error.

Conflicting recommendations on age to start mammography screening may have impacted results. Women in their 40's were included in this analysis because of inconsistent recommendations on when to start breast cancer screening with mammography, provider beliefs on when women should start screening, and health insurance coverage policies on age to start screening (USPSTF 2013, 2016; Meissner, et al., 2011; Corbelli, et al., 2014). However, women ages 40-49 may choose not to be screened, or have received guidance from a provider to wait until older to be screened. In addition, women in their early 40's may not necessarily be overdue for screening since they just entered the recommended age. However, use of baseline mammography screening in women's late 30's and early 40's may also occur (Horsley et al., 2019). Therefore, results about mammography use among women 40-49 should be interpreted with caution. Sensitivity analyses for age were conducted to determine if including women ages 42-75 or 50-75 would change the interpretation of results (Appendix 1 and Appendix 2). While limiting age to 42-75 would not significantly change the interpretation of results, limiting age to 50-75 would result in a different interpretation on the effects of age.

The propensity score model may be underspecified. The distribution of predicted probabilities presented in Figure 3.6 indicates that the model was able to predict being a U.S. citizen rather well, indicated by a right-skewed distribution (i.e. predicted probabilities closer to 1). However, the model may not have been as successful in predicting non-citizenship. It is possible that the measures used in this model may not have been the best predictors of being a

non-citizen. In addition, error in the reporting of citizenship status may also affect our ability to adequately predict citizenship status. While citizenship status appears as though it is a binary choice, there are many possible categories to non-citizenship (e.g. refugee, resident, undocumented, protected status, etc.) that may require different variables or measures to adequately predict.

Finally, while the NHIS is intended to produce a sample that is representative of the U.S. population and Hispanic populations are over sampled, it is unclear if those recruited for the survey are representative of the Hispanic population. This may especially be a concern for undocumented immigrants. Given that this is an in-person survey conducted by a government representative, undocumented immigrants may have valid reasons and concerns associated with participation.

Public health Implications

Previous analyses using data from the 2000 National Health Interview Survey have indicated that Hispanic women, and women born outside the U.S. tend to be rarely or never screened (Meissner, et al., 2007). Results from the present study indicate that interventions seeking to increase breast cancer screening among Hispanic women may have not been able to reach the most needy Hispanic women in the intervening 15 years.

These results may inform the development of interventions intended to increase use of breast cancer screening among Hispanic women and assist programs better target high need sub-populations. Foreign-born Hispanic women, Mexican women, more recent immigrants, and non-U.S. citizens may benefit from targeted efforts to provide access to breast cancer screening services. In addition, there is a pressing need to identify Hispanic women over age 40 who have never been, or rarely been screened, for breast cancer. Programs need to consider addressing

challenges associated with access to care and limited financial means, while ensuring patient confidentiality and security. This may especially be important for non-citizens who may have legal impediments accessing public services. Given that citizenship status, and potential challenges associated with it, may be a sensitive or fearful subject to address, screening programs could consider lay health workers, or a "promotora" based intervention strategy to increase use of mammography screening. This mode has been previously found effective in the AMIGAS intervention study working with Hispanic women who have rarely or never screened for cervical cancer (Byrd, et al., 2013). In addition, programs who rely on federal dollars to fund screening services may not be well positioned to target a sub-population of women with questionable legal status. Funding from foundations, or other non-governmental entities, may allow the necessary flexibility to cover the cost of screening services for non-citizens.

Considerations for Future Research

While this study focused on the role of immigration status on use of mammography screening, future studies should consider the role other domains of acculturation may have on health service use. Other facts of acculturation, such as the ability to speak and communicate effectively with a medical provider in English, may be important facets to access to care. These results can help health systems and public health programs working with Hispanic populations understand the kinds of resources and infrastructure needed to address the needs of this population. In addition, understanding contextual factors associated with acculturation, specifically place-based characteristics, may also provide pertinent information for interventions designed to increase health service use. For example, previous studies have found that certain Hispanic communities, namely those with more recent Hispanic immigrants, have less access to care and may be less likely to use health care services (Gresenz, et al., 2012). Given that they

type of community one settles in can guide or drive acculturation, or lack thereof (Abriado-Lanza, et al., 2006), exploring place-based effects may provide new targets for intervention.

Results from this study have highlighted that looking at similar outcomes through more than one perspective may yield different insights. If we had only assessed compliance with mammography screening recommendations, results would have suggested that the proportion of Hispanic women being screened was more or less in the same range as other racial/ethnic groups and that acculturation factors, like immigration status, were potentially not as relevant. However, by assessing how many Hispanic women had been rarely or never screened, we were able to better characterize the screening needs of this population. One area of research on mammography use that has been rarely studied is re-screening, or being screened again. By its nature, cancer screening is a process that must be repeated with some regularity; yet there is a paucity of research on cancer screening that use longitudinal study designs. These studies may help provide insights on how to ensure that women continue to get screened regularly and avoid large gaps, like 3 to 5 years, between mammograms. Future research may also consider if factors associated with immigration status extend to other immigrant women beyond Hispanic women.

Conclusions

Results suggest that increasing breast cancer screening among Hispanic women may take dedicated efforts to reach specific subgroups of women, namely recent immigrants and other non-U.S. citizens. Further research on immigration status and citizenship status may help us understand the impact of immigration policy on health care access and utilization. Immigration status may be an important determinant of access to care and socioeconomic status to further explore in future studies. Screening programs should consider the role of citizenship status in

their eligibility criteria. This may be especially difficult for programs operating solely with public funds.

VI. Tables and Figures

Figure 3.1. NHIS sample size per core section, per survey year, 2008, 2010, 2013, 2015, and combined

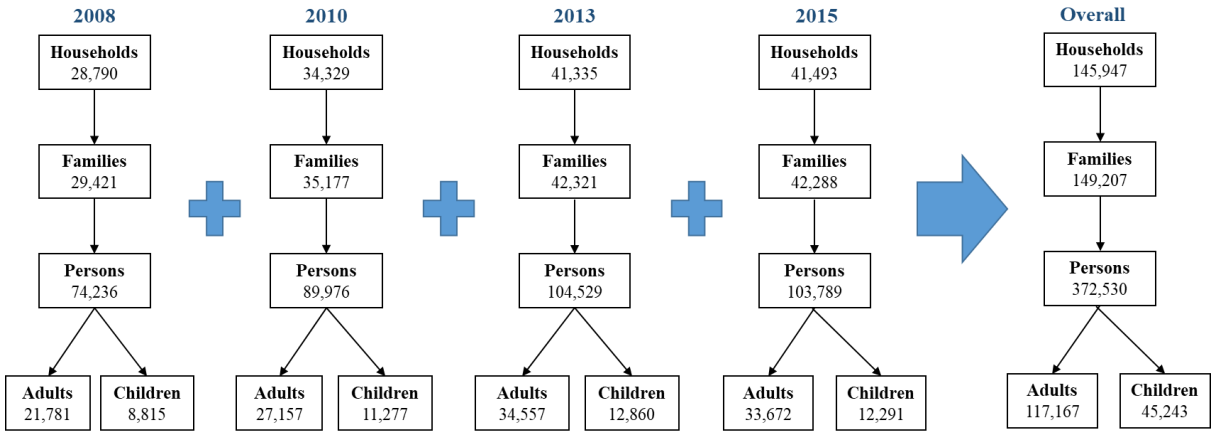

Figure 3.2. Trends in mammography use over data years among women aged 40 or older, NHIS 2008, 2010, 2013, 2015.
Up to date: received a mammogram in the last two years; never/rarely: have never had a mammogram, or last mammogram was five or more years ago.

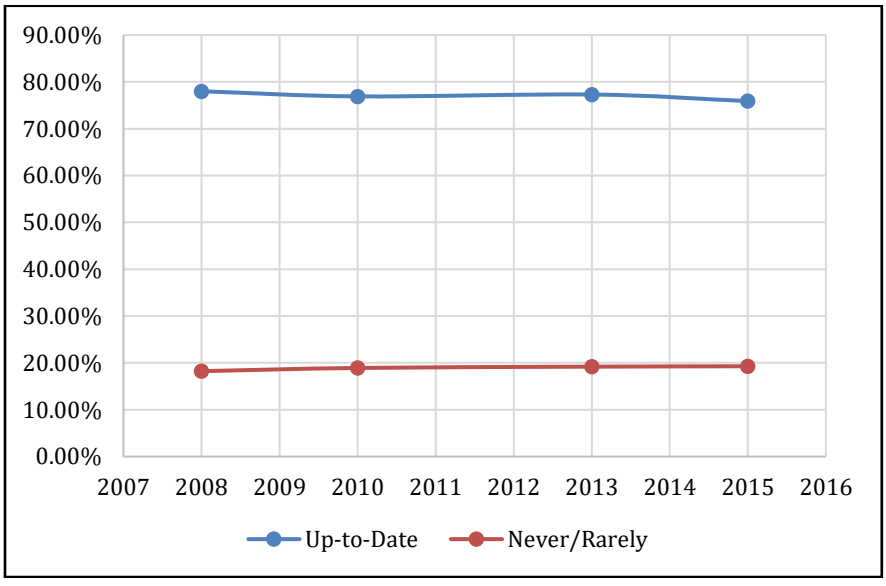

Figure 3.3. Trends in mammography use over data years among Hispanic women aged 40 or older, NHIS 2008, 2010, 2013, 2015.

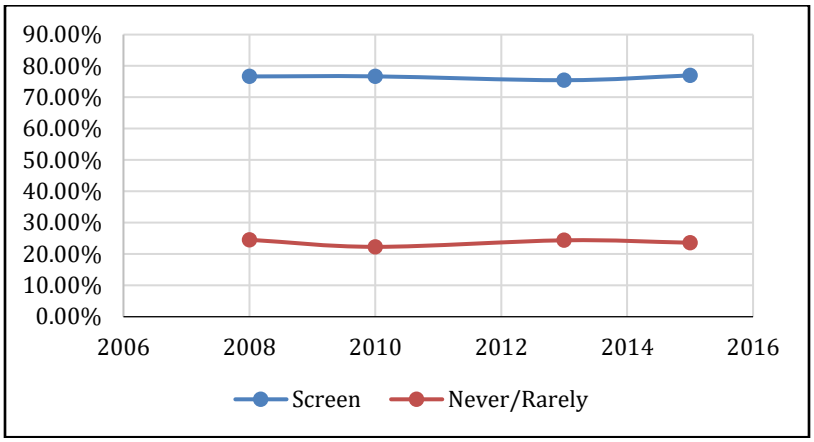

Figure 3.4. Proportion of Hispanic women aged 40-75 who are up to date with mammography, and are rarely or never screened by race/ethnicity, NHIS 2008, 2010, 2013, 2015 *(NH=Non-Hispanic)*

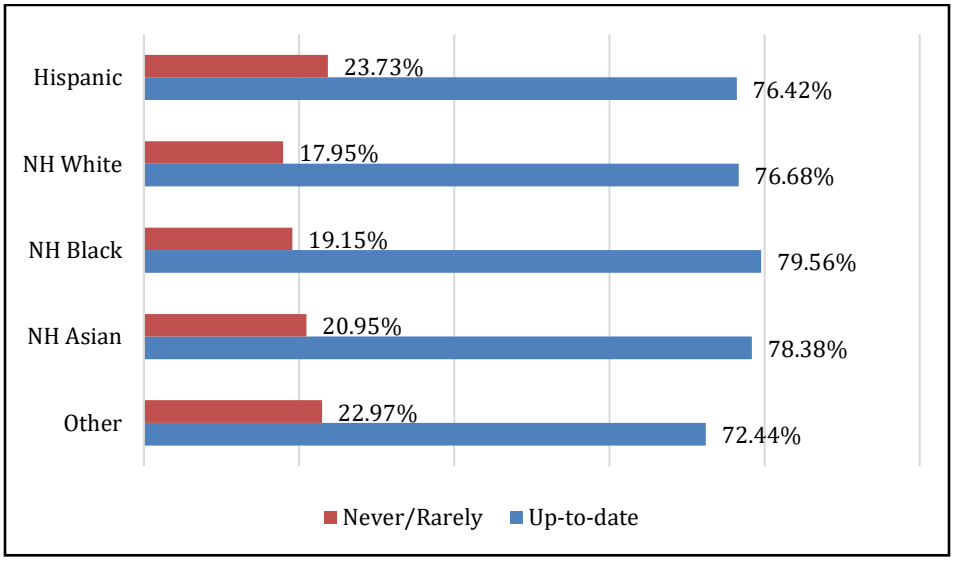

Figure 3.5a. Proportion of Hispanic women aged 40-75 who are up-to-date with mammography, and are rarely or never screened by country of origin.

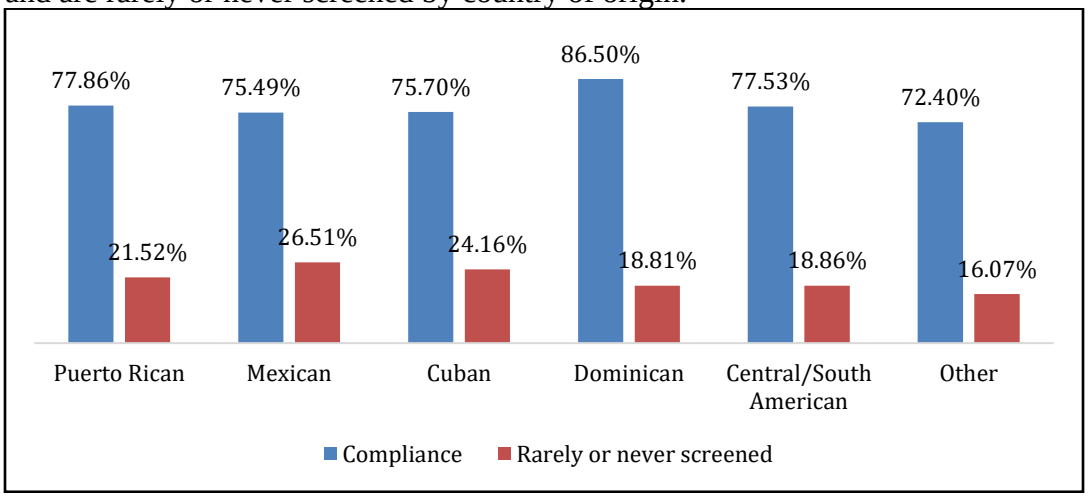

Figure 3.5b. Proportion of Hispanic women aged 40-75 who are up to date with mammography, and are rarely or never screened by immigration status. *(FB=Foreign Born; NonC= Non-citizen; C=citizen)*

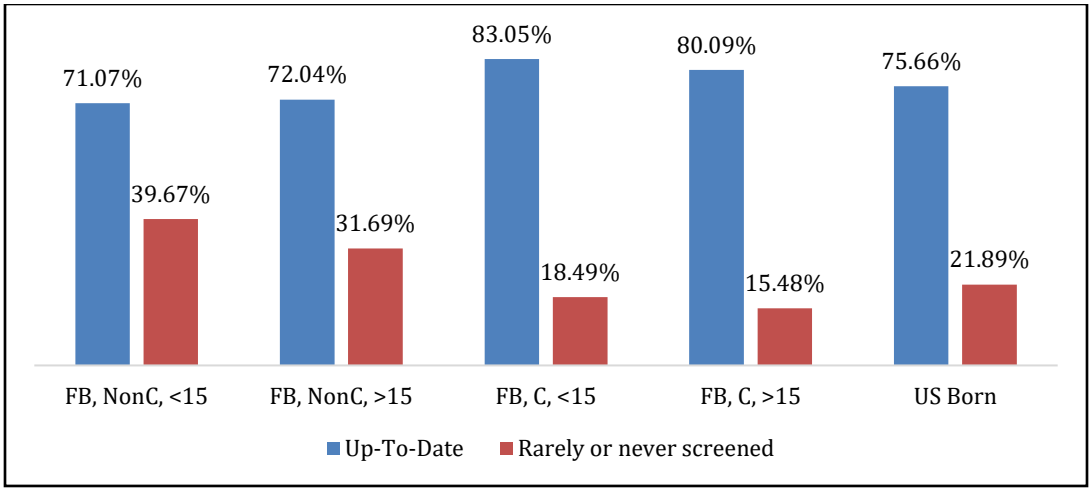

Figure 3.6. Plot of predicted probabilities of being a citizen/non-citizen given sociodemographic characteristics, access to care, and socio-economic status.

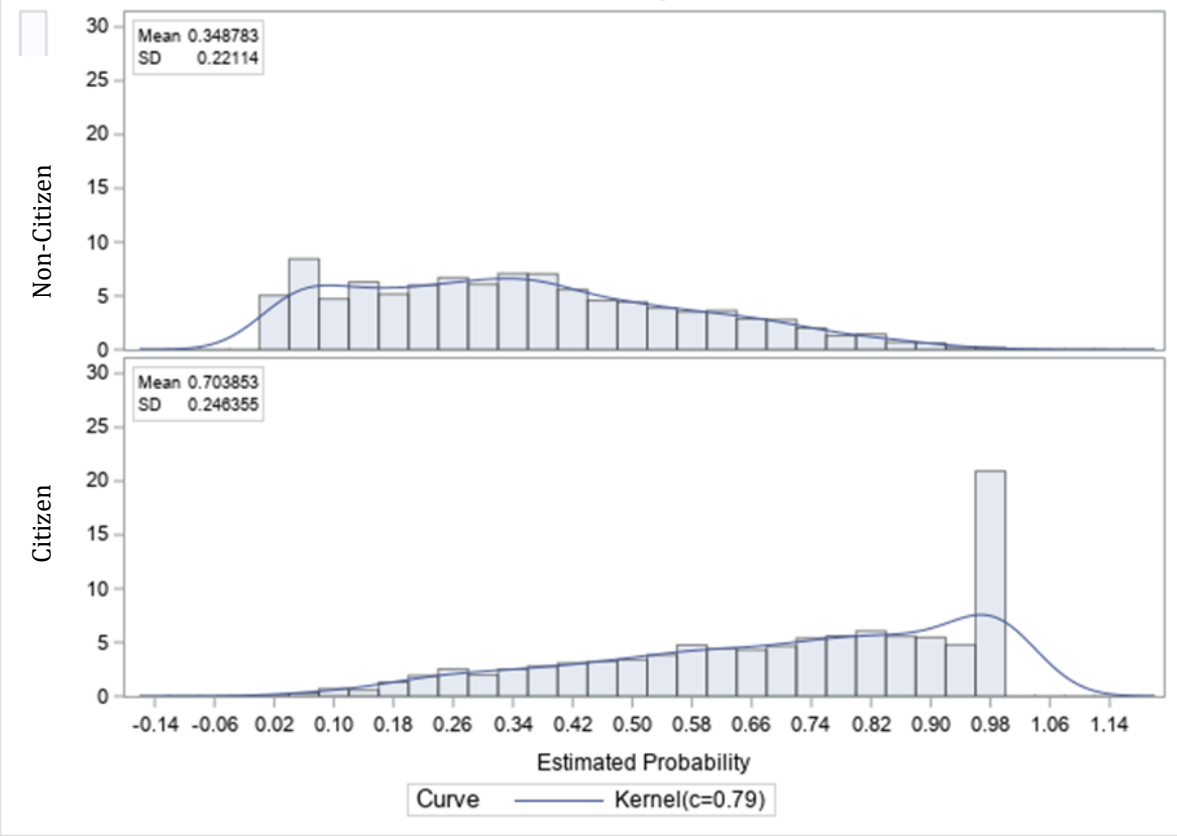

Table 3.1. NHIS Conditional and final response rates per core section, per survey year (2008, 2010, 2013, 2015)

	2008	2010	2013	2015
Household	84.90%	79.50%	75.70%	70.10%
Conditional Family	99.50%	99.10%	99.00%	98.90%
Final Family	84.50%	78.70%	74.90%	69.30%
Conditional Adult	74.20%	77.30%	81.70%	79.70%
Final Adult	62.60%	60.80%	61.20%	55.20%

Table 3.2. Characteristics of Hispanic Women in the U.S., aged 40-75, per data year and overall

	2008 n= 934		2010 n=1290		2013 n=1538		2015 n=1521		Combined Sample n=5283	
	n	Weighted %	n	Weighted %	n	Weighted %	n	Weighted %	n	Weighted %
Immigration Status										
Nativity										
U.S. Born	339	38.23%	447	35.40%	533	33.55%	497	31.51%	1816	34.38%
Foreign Born	594	61.77%	843	64.60%	1004	66.45%	1023	68.49%	3464	65.62%
Citizenship Status										
Citizen	675	70.09%	905	69.89%	1103	70.27%	1045	67.94%	3728	69.47%
Non-Citizen	259	29.90%	385	30.11%	435	29.73%	476	32.06%	1555	30.53%
Length of US Residence										
Less than 15 years	126	23.65%	172	22.82%	191	22.01%	182	18.12%	671	21.34%
15 or more years	454	76.35%	659	77.18%	802	77.99%	826	81.88%	2741	78.66%
Access to Care Measures										
Usual Source of Care										
Yes	810	85.86%	1050	81.90%	1290	84.56%	1339	88.49%	4489	85.38%
No	114	14.14%	227	18.10%	241	15.44%	167	11.51%	749	14.62%
Health Insurance Coverage										
Yes	702	71.84%	921	72.15%	1122	72.05%	1236	81.07%	3981	74.65%
No	231	28.16%	365	27.85%	409	27.95%	276	18.93%	1281	25.35%
SES Measuers										
Education										
12th grade or less	382	38.62%	536	39.23%	581	35.98%	599	36.93%	2098	37.56%
High School Grad/GED	224	25.02%	310	24.71%	362	25.02%	349	25.11%	1245	24.98%
Some college/Associated	196	21.61%	270	21.92%	368	24.30%	360	24.47%	1194	23.23%
Bachelors or Gradute Ed.	119	14.75%	164	14.14%	213	14.70%	200	13.49%	696	14.28%
Income to Poverty Level Ratio										
99% or less	198	19.08%	278	20.67%	385	20.77%	406	22.19%	1267	20.82%
100 to 199%	208	26.62%	304	27.42%	376	25.81%	419	29.25%	1307	27.36%
200 to 399%	227	27.86%	309	31.35%	388	31.32%	343	28.72%	1267	29.83%
400% or more	166	26.45%	196	20.55%	251	22.11%	248	19.84%	861	21.99%
Employment Status										

	Employed	454	47.86%	647	51.06%	781	53.92%	745	52.18%	2637	47.62%
	Unemployed	480	52.14%	642	48.95%	756	46.08%	775	47.82%	2653	52.38%
Mammography use Measures											
Mammography Recommendation											
	Compliance	569	76.64%	756	76.68%	906	75.45%	890	76.97%	3121	76.42%
	Non-Comliance	164	23.35%	253	23.32%	312	24.55%	266	23.03%	995	23.58%
Rarely or Never Screened											
	Rarely or never screened	197	24.54%	264	22.30%	385	24.38%	327	23.61%	1173	23.73%
	Often screened	682	75.46%	924	77.70%	1108	75.62%	1081	76.39%	3795	76.27%
Socio-Demographic Characteristics											
Hispanic Subgroup											
	Puerto Rican	143	12.56%	151	11.95%	177	10.91%	196	12.90%	667	12.08%
	Mexican	493	55.76%	708	57.15%	857	58.17%	831	57.93%	2889	57.35%
	Cuban	52	5.16%	88	5.68%	98	5.95%	85	4.20%	323	5.21%
	Dominican	40	3.54%	66	3.82%	74	4.26%	64	3.67%	244	3.83%
	Central/South American	154	16.87%	214	16.45%	262	17.44%	262	17.38%	892	17.07%
	Other	52	6.10%	63	4.96%	70	3.27%	83	3.92%	268	4.45%
Age											
	40 - 49 years old	390	47.27%	552	44.63%	605	42.85%	590	42.06%	2137	43.98%
	50-59 years old	279	30.63%	356	28.45%	459	31.74%	442	32.52%	1536	30.98%
	60-69 years old	171	14.86%	280	20.12%	343	19.14%	346	18.11%	1140	18.14%
	70-75 years old	94	7.24%	102	6.79%	131	6.28%	143	7.31%	470	6.90%
Marital Status											
	Married or Partnered	493	66.32%	667	64.56%	795	66.13%	776	64.33%	2731	65.29%
	Never Married	96	8.36%	166	8.79%	189	8.84%	207	9.56%	658	8.94%
	Div/Widow/Sep	338	25.31%	455	26.65%	546	25.04%	535	26.11%	1874	25.77%
Region											
	Northeast	175	16.07%	213	14.93%	226	14.41%	257	16.21%	871	15.41%
	Midwest	61	5.63%	71	6.09%	101	6.92%	93	7.51%	326	6.63%
	South	338	36.86%	478	36.70%	576	38.21%	520	36.65%	1912	37.12%
	West	360	41.43%	528	42.28%	635	40.46%	651	39.63%	2174	40.84%

Table 3.3. Frequency of last having seen a doctor among U.S. Hispanic women, aged 40-75

	n	W %
6 months or less	3675	69.56%
More than 6mo, but not more than 1yr	659	13.29%
More than 1yr, but not more than 2yrs	379	7.85%
More than 2 years, but not more than 5	229	4.35%
More than 5 years ago, or never seen	255	4.95%

Table 3.4. Mean availability, accommodation, and overall access to care scores by country of origin.

	Availability	Accomodation	Access
	Mean (st.err.)	**Mean (st.err.)**	**Mean (st.err.)**
Puerto Rico	1.56 (0.056)	0.18 (0.03)	1.73 (0.06)
Mexican	2.14 (0.039)*	0.31 (0.02)*	2.45 (0.04)*
Cuban	2.09 (0.08)*	0.15 (0.04)	2.23 (0.09)*
Dominican	1.74 (0.132)	0.16 (0.04)	1.9 (0.13)
Central/South American	2.1 (0.068)*	0.25 (0.03)*	2.35 (0.08)*
Other	1.61 (0.066)	0.31 (0.05)*	1.9 (0.08)

**Indicates a statistically significant difference in mean score compared to Puerto Rican women*

Table 3.5. Mean availability, accommodation, and overall access to care scores by immigration status.

	Availability	Accommodation	Access
	Mean (st.err.)	**Mean (st.err.)**	**Mean (st.err.)**
FB, NonC, <15	3.05 (0.107)*	0.3 (0.04)	3.35 (0.11)*
FB, NonC, >15	2.47 (0.077)*	0.27 (0.03)	2.74 (0.08)*
FB, C, <15	1.97 (0.12)*	0.28 (0.07)	2.25 (0.14)
FB, C, >15	1.73 (0.04)	0.23 (0.02)	1.95 (0.05)
US Born	1.7 (0.035)	0.29 (0.02)	1.98 (0.04)

**Indicates a statistically significant difference in mean score compared to U.S. Born Hispanic women (FB=Foreign Born; NonC= Non-citizen; C=citizen)*

Table 3.6. Federal poverty level by country of origin for U.S. Hispanic women

	99% or less		100 to 199%		200 to 399%		400% or more	
	n	**W%**	**n**	**W%**	**n**	**W%**	**n**	**W%**
Puerto Rican	200	22.63	146	23.15	123	26.2	125	28.02
Mexican	655	20.55	755	29.11	722	29.62	453	20.73
Cuban	84	23.16	67	21.91	74	28.95	61	25.98
Dominican	99	34.82	61	32.35	39	19.38	19	13.46
Central/South American	198	19.73	223	26.48	226	33.62	136	20.17
Other	31	8.34	55	21.27	83	38.44	67	31.94

Table 3.7. Federal poverty level by immigration status for U.S. Hispanic women

	99% or less		100 to 199%		200 to 399%		400% or more	
	n	**W%**	**n**	**W%**	**n**	**W%**	**n**	**W%**
FB, NonC, <15	161	31.08%	172	38.04%	91	24.27%	29	6.59%
FB, NonC, >15	343	31.33%	324	36.35%	200	26.74%	35	5.57%
FB, C, <15	49	25.15%	43	25.60%	38	32.97%	17	16.28%
FB, C, >15	419	19.39%	392	25.63%	425	32.29%	296	22.69%
US Born	275	12.19%	366	21.15%	505	30.59%	479	30.07%

(FB=Foreign Born; NonC= Non-citizen; C=citizen)

Table 3.8. Predictors of being up to date with mammography among Hispanic women in the U.S. aged 40-75

	OR (95% CI) Unadjusted	p-value	OR (95% CI) Model 1*	p-value	OR (95% CI) Model 2*	p-value	OR (95% CI) Full Model*	p-value
Immigration Status								
Nativity		0.467						
U.S. Born	Ref		-		-		-	
Foreign Born	1.069 (0.893, 1.280)		-		-		-	
Citizenship Status		0.001						
Citizen	Ref		-		-		-	
Non-Citizen	0.707 (0.573, 0.873)		-		-		-	
Time spent in US		0.296						
Less than 15 years	0.863 (0.655, 1.138)		-		-		-	
15 or more years	Ref		-		-		-	
Combined variable		0.004		0.004		0.049		0.018
FB, NonC, <15	0.790 (0.566, 1.102)		0.725 (0.518, 1.013)		1.101 (0.759, 1.597)		1.239 (0.823, 1.864)	
FB, NonC, >15	0.829 (0.638, 1.076)		0.743 (0.568, 0.971)		0.955 (0.720, 1.266)		1.154 (0.861, 1.546)	
FB, C, <15	1.575 (0.886, 2.796)		1.527 (0.884, 2.638)		1.978 (1.064, 3.678)		2.089 (1.073, 4.066)	
FB, C, >15	1.294 (1.047, 1.598)		1.206 (0.967, 1.503)		1.317 (1.049, 1.654)		1.483 (1.165, 1.888)	
US Born	Ref		Ref		Ref		Ref	
Access to Care								
Availability	0.617 (0.577, 0.661)	<0.001	-		-		-	
Accomodation	0.948 (0.827, 1.086)	0.438	-		-		-	
Access	0.683 (0.644, 0.723)	<0.001	-		0.668 (0.631, 0.707)	<0.001	0.687 (0.647, 0.728)	<0.001
Socioeconomic Status								
Education		0.005						0.716
12th grade or less	0.631 (0.468,		-		-		0.832 (0.591,	

	0.852)						1.173)	
High School Grad/GED	0.807 (0.570, 1.143)		-		-		0.911, 0.628, 1.322)	
Some college/Assoc	0.859 (0.618, 1.193)		-		-		0.865 (0.612, 1.223)	
Bachelors or Gradute Ed	Ref		-		-		Ref	
Income to Poverty Level Ratio		<0.001						0.042
99% or less	0.459 (0.330, 0.639)		-		-		0.651 (0.435, 0.856)	
100 to 199%	0.482 (0.353, 0.657)		-		-		0.608 (0.433, 0.856)	
200 to 399%	0.630 (0.473, 0.839)		-		-		0.711 (0.530, 0.954)	
400% or more	Ref		-		-		Ref.	
Employment Status		0.003						0.777
Employed	Ref		-		-		Ref	
Unemployed	0.768 (0.644, 0.915)		-		-		0.968 (0.771, 1.215)	
Socio-demographics								
Hispanic Subgroup		<0.001		0.021		0.065		0.072
Puerto Rican	Ref		Ref		Ref		Ref	
Mexican	0.876 (0.687, 1.117)		1.191 (0.872, 1.628)		1.305 (0.968, 1.884)		1.564 (1.094, 2.236)	
Cuban	0.886 (0.602, 1.303)		1.216 (0.770, 1.920)		1.293 (0.770, 2.171)		1.401 (0.844, 2.235)	
Dominican	1.822 (1.348, 2.463)		1.816 (1.310, 2.517)		1.684 (1.186, 2.393)		1.767 (1.147, 2.722)	
Central/South Am	0.981 (0.732, 1.315)		1.237 (0.903, 1.695)		1.338 (0.966, 1.855)		1.431 (1.016, 2.015)	
Other	0.746 (0.480, 1.158)		0.975 (0.626, 1.519)		1.048 (0.669, 1.643)		1.201 (0.728, 1.983)	
Age		0.066		0.086		<0.001		0.029
40 - 49 years old	Ref		Ref		Ref			
50-59 years old	1.159 (0.925, 1.454)		1.130 (0.907, 1.409)		1.139 (0.903, 1.437)		1.085 (0.861, 1.368)	
60-69 years old	0.862 (0.694, 1.070)		0.865 (0.697, 1.074)		0.784 (0.619, 0.994)		0.788 (0.598, 1.368)	

70-75 years old	0.876 (0.651, 1.178)		0.859 (0.634, 1.163)		0.659 (0.479, 0.907)		0.665 (0.466, 0.947)	
Marital Status		0.035		0.022		0.065		0.533
Married or Partnered	Ref		Ref		Ref		Ref	
Never Married	0.831 (0.601, 1.150)		0.800 (0.584, 1.095)		0.874 (0.650, 1.177)		0.906 (0.668, 1.230)	
Div/Widow/Sep	0.792 (0.661, 0.949)		0.783 (0.652, 0.939)		0.795 (0.655, 0.964)		0.884 (0.705, 1.107)	
Region		0.001		0.002		0.03		0.013
Northeast	1.461 (1.095, 1.949)		1.397 (0.986, 1.979)		1.23 (0.854, 1.771)		1.369 (0.957, 1.958)	
Midwest	1.033 (0.675, 1.579)		1.048 (0.767, 1.432)		0.998 (0.714, 1.394)		1.130 (0.764, 1.671)	
South	0.772 (0.630, 0.945)		0.768 (0.626, 0.943)		0.775 (0.619, 0.971)		0.783 (0.612, 1.000)	
West	Ref		Ref		Ref		Ref	
(-2) log likelihood			6115233.1		5718562.1		3551668.9	
AIC			6115275.1		5718606.1		5081412.5	

** adjusted for survey year*

Table 3.9. Predictors of being rarely or never screening among Hispanic women in the U.S., aged 40-75

	OR (95% CI) Unadjusted	p-value	AOR (95% CI) Model 1*	p-value	AOR (95% CI) Model 2*	p-value	AOR (95% CI) Model 3*	p-value
Immigration Status								
Nativity		0.095						
U.S. Born	Ref		-		-		-	
Foreign Born	1.171 (0.973, 1.410)		-		-		-	
Citizenship Status		<0.0001						
Citizen	Ref		-		-		-	
Non-Citizen	2.336 (1.934, 2.821)		-		-		-	
Time spent in US		<0.0001						
Less than 15 years	1.893 (1.489, 2.406)		-		-		-	
15 or more years	Ref		-		-		-	
Combined variable		<0.001		<0.0001		<0.0001		0.0018
FB, NonC, <15	2.347 (1.760, 3.129)		2.291 (1.691, 3.104)		1.402 (1.017, 1.932)		1.089 (0.769, 1.544)	
FB, NonC, >15	1.655 (1.314, 2.086)		1.719 (1.350, 2.188)		1.300 (1.004, 1.682)		0.909 (0.676, 1.221)	
FB, C, <15	0.81 (0.509, 1.289)		0.771 (0.481, 1.237)		0.606 (0.368, 1.000)		0.571 (0.334, 0.976)	
FB, C, >15	0.653 (0.518, 0.824)		0.752 (0.599, 0.945)		0.693 (0.548, 0.877)		0.627 (0.483, 0.813)	
US Born	Ref		Ref		Ref		Ref	
Access to Care								
Availability	1.705 (1.626, 1.788)	<0.0001	-		-		-	
Accomodation	0.865 (0.743, 1.006)	0.06	-		-		-	
Access	1.550 (1.478, 1.626)	<0.0001	-		1.507 (1.432, 1.586)	<0.0001	1.459 (1.378, 1.545)	<0.0001
Socioeconomic Status								
Education		<0.000						0.005

		1						
12th grade or less	2.316 (1.747, 3.069)		-		-		1.690 (1.196, 2.388)	
High School Grad/GED	1.956 (1.411, 2.711)		-		-		1.857 (1.307, 2.637)	
Some college/Assoc	1.327 (0.949, 1.858)		-		-		1.327 (0.943, 1.866)	
Bachelors or Gradute Ed	Ref		-		-		Ref	
Income to Poverty Level Ratio		<0.000 1						0.01
99% or less	3.585 (2.647, 4.857)		-		-		1.925 (1.296, 2.859)	
100 to 199%	2.745 (1.978, 3.810)		-		-		1.732 (1.182, 2.538)	
200 to 399%	2.218 (1.614, 3.047)		-		-		1.667 (1.207, 2.303)	
400% or more	Ref		-		-		Ref	
Employment Status		0.028						
Employed	Ref		-		-		Ref	0.245
Unemployed	1.183 (1.019, 1.374)		-		-		1.135 (0.916, 1.406)	
Socio-demographics								
Hispanic Subgroup		0.0002		0.002		0.0008		0.002
Puerto Rican	Ref		Ref		Ref		Ref	
Mexican	1.316 (1.010, 1.714)		0.824 (0.605, 1.121)		0.715 (0.517, 0.988)		0.605 (0.427, 0.856)	
Cuban	1.162 (0.651, 2.073)		0.800 (0.430, 1.488)		0.754 (0.382, 1.488)		0.799 (0.392, 1.626)	
Dominican	0.845 (0.482, 1.480)		0.724 (0.377, 1.388)		0.742 (0.416, 1.323)		0.697 (0.431 1.127)	
Central/South Am	0.848 (0.613, 1.172)		0.516 (0.360, 0.741)		0.459 (0.316, 0.667)		0.419 (0.279, 0.629)	
Other	0.698 (0.411, 1.188)		0.612 (0.362, 1.035)		0.544 (0.325, 0.911)		0.510 (0.301, 0.864)	
Age		<0.000 1		<0.000 1		<0.000 1		<0.000 1
40 - 49 years old	Ref		Ref		Ref		Ref	

50-59 years old	0.403 (0.332, 0.489)		0.417 (0.346, 0.502)		0.400 (0.329, 0.486)		0.391 (0.318, 0.481)	
60-69 years old	0.423 (0.338, 0.530)		0.470 (0.373, 0.592)		0.512 (0.396, 0.662)		0.434 (0.320, 0.589)	
70-75 years old	0.440 (0.331, 0.586)		0.501 (0.366, 0.686)		0.692 (0.507, 0.944)		0.603 (0.417, 0.870)	
Marital Status		0.064		0.035		0.167		0.656
Married or Partnered	Ref		Ref		Ref		Ref	
Never Married	1.339 (1.015, 1.767)		1.437 (1.072 1.925)		1.286 (0.941, 1.758)		1.166 (0.839, 1.621)	
Div/Widow/Sep	0.950 (0.798, 1.131)		1.174 (0.962, 1.431)		1.167 (0.944, 1.443)		1.035 (0.823, 1.301)	
Region		0.0001		0.001		0.045		0.132
Northeast	0.788 (0.619, 1.003)		0.921 (0.693, 1.225)		1.044 (0.765, 1.425)		0.905 (0.642, 1.274)	
Midwest	1.153 (0.801, 1.661)		1.070 (0.752, 1.523)		0.983 (0.707, 1.367)		0.964 (0.725, 1.282)	
South	1.316 (1.116, 1.552)		1.376 (1.161, 1.630)		1.298 (1.074, 1.568)		1.241 (0.990, 1.556)	
West	Ref		Ref		Ref		Ref	
(-2) log likelihood			7041362.1		6453085.8		5643388.2	
AIC			7041404.1		6453129.8		5643446.2	

** adjusted for survey year*

VII. References

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VIII. Supplementary Materials

Sensitivity analysis for age 42-75

Table 3.S1. Frequency and Weighted percentages of mammography use for age 42-75

	Overall	**Screened in the past 2 years**	**Never/rarely screened**
	n (Weighted % w/ 95% CI)	*n (Weighted % w/ 95% CI)*	*n (Weighted % w/ 95% CI)*
Age group			
42-49	1641 (38.08%, 36.40% - 39.75%)	901 (34.36%, 32.20% - 36.55%)	432 (51.07%, 47.29% - 54.84%)
50-59	1536 (34.24%, 32.70% - 35.78%	986 (36.99%, 35.03% - 38.96%)	262 (26.50%, 23.13% - 29.88%)
60-69	1140 (20.05%, 18.73% - 21.37%)	730 (20.45%, 18.88% - 22.02%)	170 (15.99%, 13.42% - 18.73%)
70-75	470 (7.63%, 6.8% - 8.44%)	306 (8.17%, 7.15% - 9.21%)	80 (6.44%, 4.90% - 7.99%)

Table 3.S2. Unadjusted Odds Ratios and 95% confidence intervals of mammography use for aged 42-75

	Screened in the past 2 years	**Never/rarely screened**
	OR (95% CI)	*OR (95% CI)*
Age group		
42-49	Ref	Ref
50-59	1.144 (0.897 – 1.459)	0.499 (0.406 – 0.614)
60-69	0.851 (0.674 – 1.073)	0.524 (0.413 – 0.665)
70-75	0.864 (0.635 – 1.176)	0.545 (0.404 – 0.735)

Sensitivity analysis for age 50-75

Table 3.S3. Frequency and weighted percentages of mammography use for age 50-75

	Overall	**Screened in the past 2 years**	**Never/rarely screened**
	n (Weighted % w/ 95% CI)	*n (Weighted % w/ 95% CI)*	*n (Weighted % w/ 95% CI)*
Age group			
50-59	1536 (55.30%, 53.25% - 57.34%)	986 (56.38%, 54.10% - 58.65%)	262 (54.16%, 48.64% - 59.68%)
60-69	1140 (32.38%, 30.46% - 34.30%)	730 (31.67%, 28.95% - 33.38%)	170 (32.67%, 27.79% - 37.55%)
70-75	470 (12.32%, 11.06%- 13.59%)	306 (12.46%, 10.95% - 13.97%)	80 (13.17%, 10.99% - 16.24%)

Table 3.S4. Unadjusted Odds of Mammography Use Ratios and 95% Confidence Intervals for Ages 50-75

	Up-to-Date Screening	**Never/rarely screened**
	OR (95% CI)	*OR (95% CI)*
Age group		
50-59	Ref	Ref
60-69	0.743 (0.586, 0.942)	1.050 (0.811 – 1.359)
70-75	0.755 (0.554, 1.029)	0.440 (0.799 – 1.493)

Chapter Four

Mammography capacity in primarily Hispanic communities in the U.S.

I. Introduction

Screening for breast cancer through regular mammography use is currently the most effective way to detect breast cancer at earlier stages and decrease mortality (Nelson et al, 2016; Morris et al, 2015). Multiple clinical guideline issuing organizations recommend yearly or bi-annual mammography for women starting at between ages 40 to 50 (USPSTF, 2016; ACS, 2019; Lee et al, 2010). However, breast cancer screening rates for all women aged 40 or above remain below Healthy People goals and are lower for Hispanic women overall, and especially for women of Mexican descent and more recent immigrants (White et al., 2017; Sabatino et al., 2015; HHS, 2014). Hispanic women in the U.S. may face many barriers to obtaining regular mammograms, among them being uninsured, lacking a regular source of care, and not being a U.S. citizen (Adunlin et al, 2019; De Alba et al, 2005; Miller et al, 2019). Previous studies have suggested that area-level or contextual factors also impact mammography utilization (Mobley et al, 2009; Coughlin et al, 2008). However, physical access to mammography facilities and having the capacity for an area to screen their eligible population is an under-explored barrier for Hispanic women.

Previous government reports and studies have indicated that in some areas in the U.S. there is insufficient capacity to screen all the eligible women in the population and capacity has been decreasing over time (Peipins et al, 2012; Eberth et al, 2013). Assuming adequate staffing, this indicates that there may be a shortage of facilities and machines to perform enough mammograms during standard working hours to reliably screen all the women for whom screening is appropriate. Conceptual frameworks focused on access to care often include

physical access as important components of health care utilization. For example, the five-factor framework of access to care by Pechansky and Thomas posits that availability of care, or the supply of health care services, is an integral component of health care access (1981). Similarly, Andersen's behavioral model of health care access and utilization framework considers health care supply, or the amount and distribution of health services facilities, as core components of contextual enabling characteristics of access (Andersen et al, 2013). Lack of mammography capacity has been linked to increased wait times for screening (Elkin et al, 2012), transportation challenges (Graham et al., 2015), decreased odds of mammography use (Elkin et al, 2010), and increased odds of late-stage breast cancer (Elting et al, 2009).

Hispanic communities may specifically face limited mammography capacity due to where Hispanic immigrants settle. Since the 1980's Hispanic immigrants to the U.S. have been routinely settling in non-metropolitan areas of the country (Kandel & Cromartie, 2004; Johnson & Lichter, 2008; Lichter & Johnson, 2009). Rural communities, and particularly racial and ethnic minority members of these communities, face significant challenges in obtaining access to health care services (James et al, 2017; Cladwell et al, 2016). In addition, previous research has found that a greater proportion of non-metropolitan counties have limited or no mammography capacity than metropolitan or suburban areas (Peipins et al, 2018).

The goal of this study is to explore mammography capacity in Hispanic communities in the United States (U.S.) and describe the communities facing challenges in availability of screening. Thus, the proposed research will asses the following questions:

1. Do Hispanic women living in primarily Hispanic areas have similar access to mammography facilities as those who do not live in mostly Hispanic areas?
2. What are the characteristics of Hispanic areas with limited mammography capacity?

3. What proportion of Hispanic women live in areas with limited or no mammography capacity?

II. Methods

An ecological study using data from mammography facilities across the U.S., and population level data from the U.S. Census bureau, was conducted to explore mammography capacity in Hispanic communities in the U.S.

Mammography Capacity

Data on certified mammography facilities in the U.S. in 2009 was obtained from the Food and Drug Administration (FDA) mammography program reporting and information system (MPRIS) authorized under the Mammography Quality Standards Act (FDA, 2018). The data provided each mammography facility geocoded to the county level, with details on the number of traditional film, digital, mobile, and computed radiology mammography units per facility. To estimate mammography capacity, facilities were summed within counties and mammography units across all facilities in each county were summed. In order to estimate the ability of mammography facilities to screen their eligible population, a mammography capacity ratio was calculated by dividing the expected number of mammograms that could be performed in a particular county by the total female population aged 40 and older in that county. The expected number of mammograms that could be performed in a given county was calculated by multiplying the number of mammography units in a given county by 6,000. The Government Accountability Office (GAO) estimated that each mammography machine has the potential to perform approximately 24 mammograms in a given workday, which would yield 6,000 mammograms per year (assuming operation 5 days a week and 50 weeks per year) (GAO, 2006). The mammography capacity ratio is a continuous measure that starts at 0, indicating no

mammography capacity, and has no upper bound. A mammography capacity ratio of 1 or greater indicates that there is sufficient mammography capacity in the county to screen all eligible women. A ratio less than 1 indicates insufficient mammography capacity.

The eligible screening population was considered to be all women aged 40 and older. In 2002, the United States Preventive Services Taskforce (USPSTF) recommended that women 40 and older be screened every 1-2 years for breast cancer with mammography (USPSTF, 2002). While an updated guideline was issued in November of 2009 that increased the screening initiation age to 50 and recommended stopping screening at age 74 (USPSTF, 2009), the late release may be unlikely to have impacted screening practices for that year.

The mammography capacity ratio was grouped into four categories: 1) no mammography capacity (capacity ratio of 0), 2) limited mammography capacity (ratio greater than 0, but less than 0.49), 3) some capacity (ratio between 0.5 and 0.79), and 4) at or above capacity (0.80 or greater). The cut-point for the "at or above capacity" category was set at 0.8 because Healthy People objectives set population-based screening goals at approximately 80% (DHHS, 2014). The capacity ratio was further dichotomized into limited to no capacity (ratio between 0 and 0.49) and some to above capacity (ratio greater than 0.5).

Hispanic Population

Using data from the 2000 and 2010 Decennial Census, three measures of Hispanic population density were calculated. First the percent of the 2010 U.S. population per county that is Hispanic was calculated by dividing the total number of Hispanic individuals per county by the total population of the county. They were then classified into a five-level categorical variable based on cut-points used by Lim and colleagues (2017) and the Pew Research Center (Stepler and Lopez, 2016). These categories include: 50% or more of the county population are Hispanic,

49.99% to 35%, 34.99% to 20%, 19.99% to 5% and 4.99% or less. In addition, the percent of Hispanic women aged 40 and over per county was calculated by dividing the number of Hispanic women aged 40 and over by the total number of women aged 40 and older.

A measure of Hispanic population settlement patterns based on those used by Lichter and Johnson (2009) was also calculated. This measure classified U.S. counties into three categories: 1) traditional settlement areas, 2) emerging settlement areas, and 3) non-Hispanic destinations. Counties were classified as traditional settlement areas if at least 20% of the county's population was Hispanic in the 2000 decennial census. Emerging settlement areas were those that experienced a 150% or larger growth in their Hispanic population between the 2000 and 2010 census. To calculate this measure, we subtracted the number of Hispanic individuals per county in 2010 from those in the corresponding county in 2000, and then divided by the county Hispanic population in 2000. All other counties were classified as non-Hispanic settlement destination. All analyses including this measure excluded eight counties in Alaska due to changes in county status between the 2000 and 2010 census.

County Characteristics

County level measures of socioeconomic status, employment and occupation, access to care, and acculturation were compiled from a variety of data sources. Five-year estimates from the 2010 American Community Survey (ACS) of the U.S. Census Bureau (2011) were used to estimate county level measures of educational attainment, household income, median household income, percent of households below the poverty line, and percent of households receiving Supplemental Nutrition Assistance Program (SNAP) benefits. A ratio of household income inequality was calculated by dividing the number of households with incomes of $75,000 or greater by the number of households with incomes below $25,000. This ratio is intended to

compares the number of households with incomes in the upper fifth in a county to those in the lowest fifth and provide a descriptor of the gap between high and low income households. A value of one indicates parity in the number of high income and low-income households, while a value greater than one indicates a greater proportion of high-income households and a value less than one indicates a greater proportion of households with low-income.

In addition, ACS data estimates on the percent of those aged 16 or older who were unemployed, and the percent employed across five occupational categories (management, business, science, and arts; service; sales and office; natural resources, construction, and maintenance; and production, transportation, and material moving) were also included. Proxy measures of acculturation, specifically measures of nativity and language proficiency, were also obtained from the ACS. They include estimates of the percent of U.S. born individuals, foreign born individuals, naturalized citizens, non-U.S. citizens, English only speakers, those who speak a language other than English, Spanish speakers, those who speak a language other than English and speak English less than very well, and those who speak Spanish and speak English less than very well.

The number of primary care providers per county was obtained from the Health Resource and Services Administration (HRSA) 2010 Area Health Resource File (AHRF) (HRSA, 2019). The number of primary care providers per county providing patient care in 2010 (including family medicine, general practice, general internal medicine, and general obstetrics and gynecology) were divided by the total county population in 2010 and multiplied by 100,000 to estimate the primary care provider density per 100,000 county residents. The 2010 Small Area Health Insurance Estimates (SAHIE) program were used to obtain estimates on the percent of uninsured residents per county (U.S. Census Bureau, 2016).

The 2006 National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties was used to identify counties into one of six urbanity categories: large central metro, large fringe metro, medium metro, small metro, micropolitan, and non-core (NCHS, 2013). These categories were then collapsed into metropolitan (large central metro, large fringe metro, medium metro, and small metro) and non-metropolitan (micropolitan, and non-core).

III. Statistical Analysis

To assess if Hispanic women living in mostly Hispanic areas have similar physical access to mammography facilities as those who do not live in mostly Hispanic areas, the mean mammography capacity ratio was compared across the five Hispanic population density categories and Hispanic settlement pattern categories using one-way analysis of variance with post-hoc Tukey tests. Uncorrected p-values were set at an alpha at 0.05 and a Bonferroni correction for multiple comparisons were also taken into account (set at alpha=0.005 for Hispanic density categories and alpha=0.02 for Hispanic settlement destinations) (Abdi, 2007). Cross-tabulations for categories of mammography capacity and categories of Hispanic population density and settlement patterns with Chi-Square tests were also calculated. To identify characteristics of counties with the lowest mammography capacity, dichotomous mammography capacity categories were used in unadjusted logistic regression models to assess odds of limited to no mammography capacity among Hispanic density categories and settlement patterns.

In order to describe characteristics of counties by mammography capacity categories, descriptive statistics were calculated for all county level measures. Measures of interest were focused on socio-economics status (income and education), occupation (occupation category and

employment status), access to care (health insurance status, and availability of primary care providers), and proxy measures of acculturation (citizenship status and language use). In addition, the characteristics of counties with little to no mammography capacity and at least 20% Hispanic population were also described. Unadjusted and adjusted logistic regression models assessing odds of a county having limited or no mammography capacity were run. Due to significant overlap between variables, only select variables were selected for inclusion in regression models. Predictors selected included percent of non-U.S. citizens, percent who speak English less than well, percent living below the poverty line, income inequality ratio, percent unemployed, percent blue collar, percent uninsured, primary care provider density ratio, metropolitan or non-metropolitan county, Hispanic population density, and Hispanic settlement pattern. Variable selection was guided by their use in previous studies of mammography capacity (Peipins et al., 2012) and avoiding variables that addressed the same area. For example, household income consisted of ten different variables, and would have significant shared variance between them. Instead income inequality, a calculated ratio based on those ten variables was chosen for modeling instead. Pearson correlations were calculated between variables to test for multicollinearity. Large Pearson correlations between percent of population below the poverty level and the income inequality ratio ($r=-0.61$, $p<0.001$) and Hispanic population density and settlement patterns ($r=0.73$) raised concerns and, therefore, were entered into separate regression models (*Supplemental Table 4.S2*).

The numbers of Hispanic women aged less than 39, and 40 and over living in counties with limited to no mammography capacity were calculated. Analyses were conducted using Microsoft Excel, SAS v9.4 (Cary, NC) and IBM SPSS Statistics (Armonk, NY). Data

management and cleaning and analyses were performed in SAS, while data for mapping was prepared in SPSS for upload into ArcGIS.

Maps were produced using ArcGIS Pro 2.5 (Redlands, CA) using 2010 county-level Shapefiles provided by the U.S. Census Bureau (2012). Maps generated include Hispanic population density by U.S. counties, settlement destinations by U.S. counties, and mammography capacity by U.S. counties. In addition, two bivariate choropleth maps overlaying county Hispanic population density and mammography capacity were generated. The first presents all overlapping categories between Hispanic population density and mammography capacity, and the other only presents those counties with high density and low capacity.

IV. Results

Hispanic population density and settlement patterns in the U.S.

Three hundred forty-two counties (11% of all U.S. counties) had a Hispanic population that accounted for at least 20% of their total county population (*Supplement Table 4.S1*). These counties are mostly along the southwest border in Texas, New Mexico, and Arizona, and in California (*Supplemental Figure 4.S1*).

Two hundred forty-five counties (7.8%) were classified as traditional Hispanic settlement destinations and six hundred seventy-five (21.5%) counties were classified as emerging Hispanic settlement destinations (*Supplement Table 4.S1*). Traditional settlement counties were primarily located through Texas, New Mexico, Arizona, and California, while emerging settlement counties were found spread throughout the U.S., particularly in the South (*Supplemental Figure 4.S2*).

Mammography Capacity in the U.S.

Overall, in 2009, the U.S. has 8,505 certified mammography facilities with a total of 12,098 mammography units, including traditional film, digital, computed tomography, and mobile units. The U.S. has the capacity to perform approximately 72 million mammograms per year. On average, each U.S. county has 3.8 mammography units (Stnd Err= 0.2), with some counties having as many as 313 units and others having none. Eight hundred and seventy-three counties (27.8% of all U.S. counties) have no mammography units available (Table 4.1). An additional thousand counties have only one mammography unit available. However, on average, U.S. counties have the mammography capacity to screen their underlying population with a mean mammography capacity ratio of 1.04 (Stnd Error= 0.02) (Table 4.1). More than half of U.S. counties have the capacity to screen their eligible population, while approximately 45% lack the sufficient capacity (Table 4.1). A map of U.S. counties by capacity categories indicates that counties with no mammography capacity are generally located in the Southwest, Midwest, and North West regions (Figure 4.1).

Mammography Capacity in Hispanic Communities in the U.S.

Approximately forty-five percent of counties with the largest Hispanic populations in the U.S. have no mammography units, and an additional two percent have limited capacity (Table 4.1). Overall, of the three hundred forty-two counties whose Hispanic populations make up at least twenty percent of their overall population, one hundred and twenty one (35.4%) have no mammography capacity, eleven (3.2%) have limited mammography capacity, fifty-five (16.1%) have some capacity, and one hundred and fifty five (45.3%) are at or above capacity. Among traditional settlement destinations, ninety-five counties (38.8%) have no mammography capacity, and ten (4.1%) have limited capacity. Of counties classified as emerging settlement destinations,

one hundred and fifty-five (23%) had no mammography capacity and forty-one (6.1%) had limited capacity (Table 4.1).

Results of a one-way analysis of variance indicated that mean mammography ratios varied significantly by Hispanic population density ($F=5.714$, $df=4$, $p<0.001$) and Hispanic settlement patterns ($F=9.067$, $df=2$, $p<0.001$). Post-hoc Tukey tests showed that counties whose populations were fifty percent or more Hispanic, have significantly lower mean mammography capacity levels than counties with less than twenty percent Hispanic populations and those with less than five percent Hispanic populations at both levels of alpha tested (p-value set at 0.005 for Hispanic Density and 0.02 for settlement type) (Table 4.2). In addition, those living in traditional settlement destinations had on average lower mean levels of mammography capacity than those living in emerging settlement destinations and non-settlement destinations at both levels of alpha tested (Table 4.2).

In unadjusted logistic regression models, counties with populations that were fifty percent or more Hispanic, had almost double (OR=1.78; 95% CI: 1.15, 2.78) the odds of having no capacity or limited mammography capacity compared to counties with the smallest Hispanic populations (Table 4.3). Traditional settlement destinations had just over one and half greater odds (OR=1.64; 95% CI:1.25, 2.14) of having no or limited mammography capacity compared to non-Hispanic settlement destinations (Table 4.3).

A bivariate choropleth map limited to only counties that have no or limited mammography capacity and have a Hispanic population that is 50% or more, 49.9% to 35%, or 34.9% to 20% of the total county population (n=112 counties) indicates that most of these counties are located close to the Mexican border in southwestern Texas and in west Texas

(Figure 4.2). A full bivariate choropleth map with all mammography capacity and Hispanic population groups mapped can be found in the supplement section (*Figure 4.S3*).

Characteristics of U.S. counties by mammography capacity and Hispanic population density

Counties with no mammography capacity tend to be more rural counties, have the lowest ratio of primary care providers per 100,000 citizens, have the highest rate of uninsured citizens, and have the largest proportion of residents living below the poverty line (Table 4.4). Results of logistic regression models suggest that counties with a larger proportion of residents living below the poverty level, blue collar workers, uninsured, and not having completed a high school education had greater odds of having no or limited mammography capacity (Table 4.3). After adjusting for all variables in the model, Hispanic population density and settlement patterns were no longer significant predictors of mammography capacity.

Counties whose Hispanic populations accounted for at least 20% of their overall population and had no or limited mammography capacity, had, on average, 8% non-U.S. citizens, 38.04% Spanish speakers who spoke English less than very well, 17.4% living below the poverty level, about 52% blue collar workers, 28.2% uninsured, and approximately 29 primary care providers per 100,000 county residents. Most of these counties were also rural (75.8% non-core) (Table 4.5).

Hispanic women living in no and limited capacity counties

We calculated that of approximately 7.7 million screening eligible Hispanic women in the U.S., 1.4% live in counties with no mammography capacity, and an additional 2.4% live in counties with limited capacity (Table 4.6). Overall, this indicates that 294,826 Hispanic women may face physical access challenges in accessing mammography screening. While these counties have concentrated Hispanic populations, they are not very populous counties.

V. Discussion

Results indicate that counties whose populations are more than half Hispanic are more likely to have no capacity or limited mammography capacity. Approximately forty-five percent of these counties had no mammography units available to screen the underlying eligible population. The mean mammography capacity ratio for these counties indicates that on average, they are only able to screen about half of their eligible populations. In addition, the generated maps indicate that many of these counties, especially those in southwest and western Texas, are contiguous and may require extensive travel times to reach the nearest mammography facility. These findings may suggest that lower mammography rates may be in part, due to contextual factors related to mammography access (Coughlin et al, 2008; Mobley et al, 2009). Interventions, such as health fairs or other special events with mobile mammography units may be an effective strategy to increase physical access to mammography in these communities (Vyas et al, 2012; Escoffery et al, 2014). Additional strategies to consider may also include the use of full service models of cancer screening to facilitate getting screened for multiple cancers at the time of one medical visit (Sella et al., 2013; Bobridge et al., 2017). Federal and state programs, such as the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) have provided potential for screening for breast and cervical cancer for eligible women (CDC, 2019). However, Hispanic women not considered ‘classified aliens’ may not be eligible to access programs funded with federal or state dollars (ASPE, 2009).

Results also indicate that counties having a larger proportion of their population not have completed high school, have a household income below the poverty line, be blue collar workers, and lack health insurance had greater odds of having limited mammography capacity. Previous studies have identified these characteristics as also being individual level barriers to

mammography use (Adulin et al., 2019; Miller et al., 2019). It should be noted that while these p-values were significant, the effect sizes were rather small, with the exception of urbanity. High Hispanic density and low mammography capacity counties had a greater mean level of percent of uninsured individuals (28%) and a lower rate of primary care providers (28.49 per 100,000) compared to the average U.S. county (18.54% and 48.86 per 100,000, respectively). In addition to lack of physical access, residents of these counties may face multiple barriers to obtaining a mammogram. Addressing these individual, structural, and geographic barriers to mammography use will require multi-pronged, multi-level interventions and the building of health care infrastructure.

Most low capacity counties and counties that are both high Hispanic density and low capacity are rural counties. This may reflect the growing Hispanic population in rural America. Hispanic population growth has provided a reprieve for many of the small dying towns of the rural U.S. landscape and led to new urbanization of certain areas (Lichter, 2012). Previous research has found that women in rural America have lower screening rates than those in urban areas (Tran & Tran, 2019), and Hispanic women in rural areas are screened less often than Hispanic women in urban areas (Nuño et al., 2012). In addition, breast cancer mortality rates are higher in rural areas (Henley et al, 2017). Community health worker, or *Promotora* based interventions have shown success at increasing breast cancer screening uptake among Hispanic women in the U.S. (Nuño et al, 2011). In addition, creating community-clinical linkages may offer opportunities to bring Hispanic women into screening through community events and immigrant serving organizations (AHRQ, 2016). However, the implementation of these interventions requires sufficient mammography capacity to screen eligible women.

Counties with Hispanic individuals making up at least 20% of their population and having no or limited mammography capacity had a greater mean level of non-U.S. citizens (7.97%) compared to the average U.S. county (2.79%). This may indicative of an additional barrier for obtaining screening and accessing health care more broadly. Previous studies have shown that among foreign-born Hispanic women, non-U.S. citizens are less likely to have received a recent mammogram (De Alba et al, 2005; Reyes & Miranda, 2015). Given that several of these counties are along the U.S./Mexico border and the challenges posed by lack of U.S. citizenship, some of these women may consider returning to Mexico to receive health care services (Su et al, 2011; Nuño et al, 2011). Measures of language use were similar between high Hispanic population density and low mammography capacity counties and the average U.S. county. While high density, low capacity counties had an average of 31% of residents who were Spanish speakers (compared to 6% nationally), the mean percent who spoke English less than very well was 38%; comparable to the 35% seen nationally. However, rural hospitals and health care centers may be less prepared to deal with patient populations with limited English proficiency than their urban counterparts (Casey et al, 2004; Torres, 2008).

Finally, our results revealed that 294,896 (3.84%) Hispanic women aged 40 and older live in no capacity or low mammography capacity counties. Given that the Hispanic population is the youngest racial or ethnic group in the U.S. (Patten, 2016), in future years, the number of women lacking capacity may increase. As of 2010, there were approximately 715,922 women aged 39 or younger living in counties with no capacity or limited mammography capacity. Increases in health care infrastructure will be needed as the demand for mammography capacity increases in these counties over the next ten to twenty years. These results also present positive news: the vast majority of Hispanic women in the U.S. live in areas where there is more or

sufficient mammography capacity. It should be noted, however, that national statistics indicate that some Hispanic women are not being screened routinely (White et al., 2015). This indicates that while physical mammography access may be a required element of receiving a mammogram, there are many additional barriers that Hispanic women face in obtaining regular breast cancer screening.

Limitations

While this study was able to assess national mammography capacity as well as capacity in Hispanic communities in the U.S., there are several limitations to consider. This study contains several limitations. The FDA data on mammography facilities is from 2009 and may not reflect current mammography capacity or facility locations today. Between 2000 and 2010, the U.S. lost almost 1000 mammography facilities and it is unclear if the downward trend continued into the current decade (Elkin et al., 2013). However, these results appear to be the first to describe mammography capacity in primarily Hispanic communities and can inform future studies. Also, our study focused on county of residence, but it is possible that women can travel to neighboring counties for mammography screening. We did not assess mammography capacity in counties contiguous to those with limited capacity. The level of measurement for Hispanic communities may also have benefited from being at the census tract level. While previous studies on population density of racial and ethnic minority groups are often conducted at the county level, counties can be large and may contain multiple neighborhoods and communities within them. Studies at the census tract level may be better able to understand issues of proximity and access, and their impact on health outcomes (IOM, 2002; Lim et al., 2017). While this study was able to assess physical access to mammography in U.S. counties and Hispanic communities, we were unable to link mammography access to mammography use. Previous

studies have found that limited mammography capacity is associated with decreased screening use (Elkin et al., 2010). Maps generated by a study using small area estimation methodology to assess mammography use at the county level, indicate that there may be overlap between counties that have lower screening rates and those we identified as having limited mammography capacity and high Hispanic population density (Berkowitz et al., 2018).

Future research

Future studies can improve on the current study in several ways. To directly address the limitations described, future studies would benefit from linking individual level mammography behavior, as well as additional individual level characteristics, to area-level mammography capacity. These analyses may be possible through state and national probability surveys, such as state Behavioral Risk Factor Surveillance Survey (BRFSS) (CDC, 2019) and the National Health Interview Survey (NHIS) (NCHS, 2020). Including additional variables in similar analyses may also provide relevant information. Specifically, previous studies have found that availability to radiologists and radiology technicians or mammography technologists, is also an important determinant to mammography availability (D'Orsi C, et al., 2005; Collie-Akers et al., 2012; Rosenkrantz et al., 2018). In addition, conducting similar research at the census tract or block group level will allow for better definition of Hispanic communities in the U.S. and allow for the use of spatial methods, such as two-step floating catchment area methods (McGrail and Humphreys, 2009), that would allow for assessment of travel time and access to services in contiguous areas. Finally, conducting this research with more recent data would allow us to assess changes in mammography capacity in the U.S. and how it has affected availability for Hispanic and other racial/ethnic minority communities.

Conclusions

Our study found that some of the counties with the largest Hispanic populations in the U.S. lack the capacity for women to receive needed breast cancer screening. The women in these counties may also face socio-economic, geographic, and acculturation related barriers to screening. While the number of Hispanic women living in these primarily rural counties may only account for less than 5% of the total population of Hispanic women, there are almost 1 million under age 40 living in these counties that may require mammography access in the next decade. Public health efforts should consider interventions that will increase access, such a mobile mammography units and multiple cancer screening models to increase screening uptake. These efforts may lead to decreased disparities in breast cancer stage at diagnosis and mortality for Hispanic women.

VI. Tables and Figures

Table 4.1. Mammography Capacity of U.S. Counties by Hispanic Population Density and Settlement Pattern

	Mammography Capacity Ratio		**Mammography Capacity Category**			
	Mean (St. Er)	*Min, Max*	*No capacity n(%)*	*Limited capacity n(%)*	*Some capacity n(%)*	*At or above capacity n(%)*
All U.S. Counties	1.035 (0.02)	0, 16.17	873 (27.8%)	130 (4.1%)	424 (13.5%)	1716 (54.6%)
Hispanic Population Density						
50% or more	0.525 (0.062)	0, 1.90	37 (45.1%)	2 (2.4%)	18 (22%)	25 (30.5%)
49.99% to 35%	0.963 (0.112)	0, 5.41	29 (32.6%)	3 (3.4%)	11 (12.4%)	46 (51.7%)
34.99% to 20%	0.850 (0.070)	0, 4.78	55 (32.2%)	6 (3.5%)	26 (15.2%)	84 (49.1%)
19.99% to 5%	1.03 (0.042)	0, 16.17	142 (17.6%)	57 (7.1%)	155 (19.2%)	454 (56.2.5%)
4.99% or less	1.08 (0.027)	0, 12.08	610 (30.6%)	62 (3.1%)	214 (10.7%)	1107 (55.5%)
Hispanic Settlement Pattern						
Traditional	0.754 (0.058)	0, 5.4	95 (38.8%)	10 (4.1%)	38 (15.5%)	102 (41.6%)
Emerging	0.998 (0.043)	0, 9.2	155 (23%)	41 (6.1%)	129 (19.1%)	350 (51.9%)
Non-Destination	1.08 (0.026)	0, 16.17	618 (27.9%)	78 (3.5%)	257 (11.6%)	1264 (57%)

Table 4.2. Mean Differences in Mammography Capacity in U.S. Counties by Hispanic Population Density and Hispanic Settlement Patterns

	50% or more	**49.99% to 35%**	**34.99% to 20%**	**19.99% to 5%**
	mean diff (p-value)	*mean diff (p-value)*	*mean diff (p-value)*	*mean diff (p-value)*
50% or more				
49.99% to 35%	-0.438 (p=0.102)			
34.99% to 20%	-0.325 (p=0.231)	0.113 (p=0.95)		
19.99% to 5%	-0.507 (p=0.002)*	-0.069 (p=0.984)	-0.182 (p=0.344)	
4.99% or less	-0.552 (p<0.001)*	-0.113 (p=-.897)	-0.227 (p=0.106)	-0.045 (p=0.89)

	Traditional	**Emerging**	**Non-Destination**
	mean diff (p-value)	*mean diff (p-value)*	*mean diff (p-value)*
Traditional			
Emerging	-0.244 (p=0.014)*		
Non-Destination	-0.325 (p<0.001)*	-0.082 (p=0.249)	

** Indicates statistical significance at alpha=0.005 or alpha=0.02, respectively*

Table 4.3. Odds of Counties Having No or Limited Mammography Capacity

	Unadjusted Models			Model 1A			Model 1B		
	OR	*95% CI*	*p-value*	*AOR*	*95% CI*	*p-value*	*AOR*	*95% CI*	*p-value*
%Non-Citizen	0.95	0.929, 0.973	<0.001	0.900	0.866, 0.935	<0.001	0.894	0.860, 0.931	<0.001
%English less than well	0.984	0.979, 0.990	<0.001	0.985	0.979, 0.992	<0.001	0.986	0.979, 0.992	<0.001
%Less than H.S.	1.039	1.031, 1,048	<0.001	1.015	1.005, 1.025	0.005	1.015	1.004, 1.025	0.005
%Below Poverty Level	1.024	1.012, 1.037	<0.001	0.992	0.973, 1.013	0.464	-	-	-
Income Inequality Ratio	0.804	0.756, 0.855	<0.001	-	-	-	1.069	0.984, 1.162	0.114
%Percent Unemployed	0.951	0.929, 0.973	<0.001	0.897	0.868, 0.926	<0.001	0.893	0.868, 0.919	<0.001
%Percent Blue Collar	1.051	1.039, 1.062	<0.001	0.995	0.979, 1.012	0.57	0.999	0.982, 1.017	0.955
%Percent Uninsured	1.113	1.096, 1,129	<0.001	1.140	1.114, 1.166	<0.001	1.143	1.118, 1.170	<0.001
%Provider Density	0.963	0.960, 0.967	<0.001	0.965	0.961, 0.969	<0.001	0.966	0.962, 0.970	<0.001
Metro/Non-metro									
Metropolitan	REF			REF			REF		
Non-metropolitan	1.468	1.248, 1,726	<0.001	0.703	0.568, 0.870	0.001	0.721	0.581, 0.895	0.003
Settlement Pattern									
Traditional	1.639	1.253, 2.144	<0.001	1.128	0.736, 1.728	0.580	1.127	0.735, 1.727	0.583
Emerging	0.894	0.740, 1.080	0.246	0.992	0.783, 1.257	0.948	0.976	0.769, 1.238	0.841
Non-Destination	REF			REF					
Hispanic Density									
50% or more	1.783	1.145, 2.777	0.011	-	-	-	-	-	-
49.99% to 35%	1.104	0.709, 1.718	0.663	-	-	-	-	-	-
34.99% to 20%	1.09	0.787, 1.511	0.604	-	-	-	-	-	-
19.99% to 5%	0.642	0.534, 0.773	<0.001	-	-	-	-	-	-
Less than 5%	REF			-	-	-	-	-	-

Note: Models 1A and 1B focused on Hispanic Settlement Pattern and did not include Hispanic Population Density. Model 1A included the proportion of residents living below the poverty level, and excluded income inequality ratio. Model 1B excluded the proportion below the poverty level and included the calculated income inequality ratio.

Table 4.3 cont. Odds of Counties Having No or Limited Mammography Capacity

	Model 2A			Model 2B		
	AOR	*95% CI*	*p-value*	*AOR*	*95% CI*	*p-value*
Non-Citizen	0.916	0.881, 0.953	<0.001	0.910	0.874, 0.948	<0.001
English less than well	0.987	0.980, 0.993	<0.001	0.987	0.980, 0.993	<0.001
Less than H.S.	1.014	1.004, 1.025	0.006	1.014	1.004, 1.025	0.006
Below Poverty Level	0.981	0.961, 1.002	0.074	-	-	-
Income Inequality Ratio	-	-	-	1.109	1.024, 1.202	0.012
Percent Unemployed	0.901	0.872, 0.930	<0.001	0.891	0.866, 0.917	<0.001
Percent Blue Collar	0.992	0.976, 1.008	0.333	0.998	0.980, 1.016	0.820
Percent Uninsured	1.157	1.130, 1.185	<0.001	1.160	1.133, 1.188	<0.001
Provider Density	0.967	0.963, 0.971	<0.001	0.967	0.963, 0.971	<0.001
Metro/Non-metro						
Metropolitan	REF			REF		
Non-metropolitan	0.720	0.583, 0.891	0.002	0.740	0.597, 0.917	0.006
Settlement Pattern						
Traditional	-	-	-	-	-	-
Emerging	-	-	-	-	-	-
Non-Destination	-	-	-	-	-	-
Hispanic Density						
50% or more	1.013	0.523, 1.962	0.969	0.959	0.495, 1.857	0.901
49.99% to 35%	0.575	0.316, 1.045	0.069	0.581	0.319, 1.058	0.076
34.99% to 20%	0.747	0.455, 1,226	0.248	0.730	0.443, 1.201	0.215
19.99% to 5%	0.664	0.516, 0.854	0.001	0.657	0.511, 0.845	0.001
Less than 5%	REF			REF		

Note: Models 2A and 2B focused on Hispanic Population Density and did not include Hispanic Settlement Patterns. Model 2A included the proportion of residents living below the poverty level, and excluded income inequality ratio. Model 2B excluded the proportion below the poverty level and included the calculated income inequality ratio.

Figure 4.1. Mammography Capacity of U.S. Counties

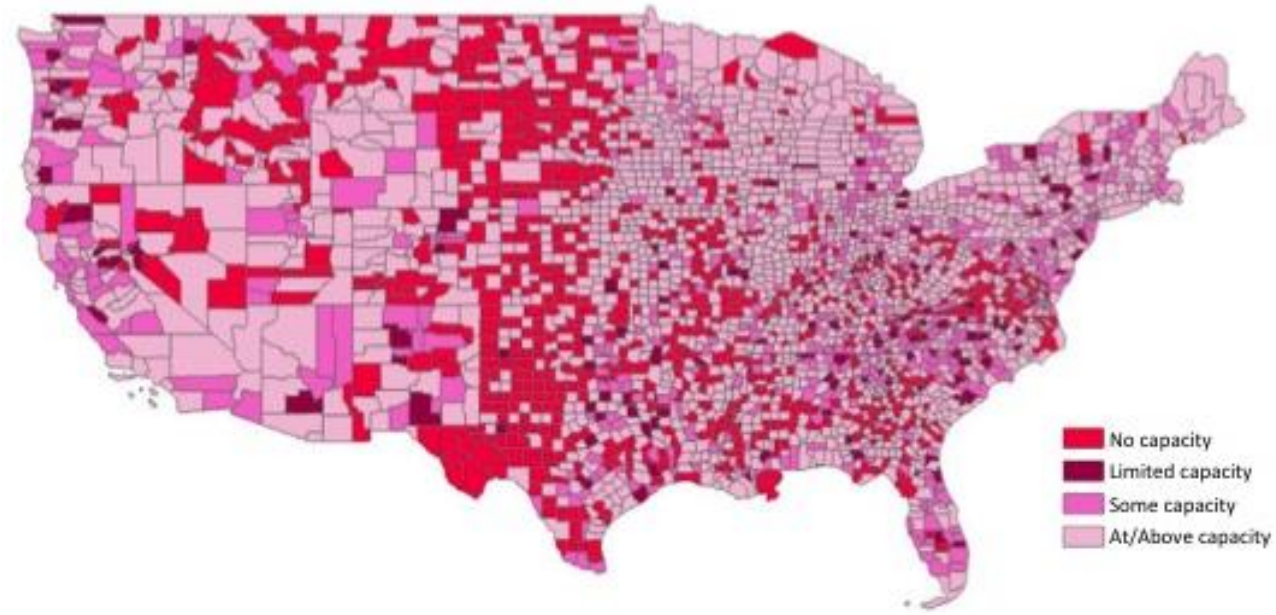

Figure 4.2. Bivariate Choropleth Map of Counties with No and Limited Mammography Capacity and 20% or More Hispanic Population Density (n=132) *(grey counties are those with less than 20% Hispanic population density)*

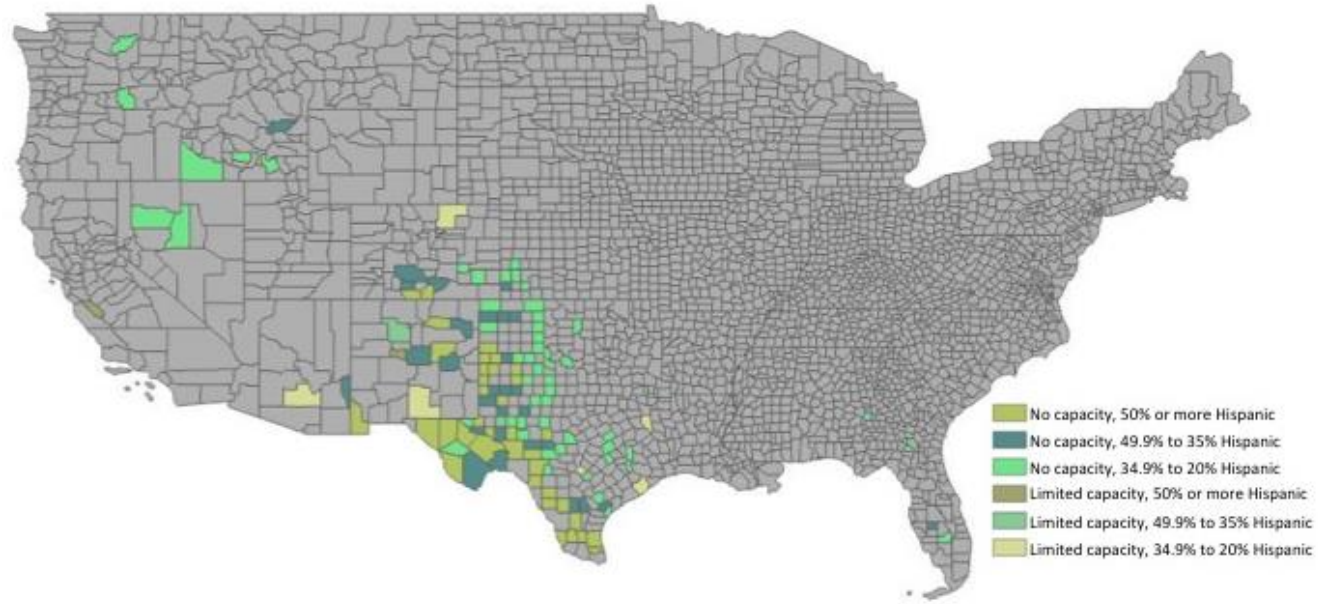

Table 4.4. County Characteristics by Mammography Capacity Categories

			Mammography Capacity				
	All counties		**No Capacity Counties**	**Limited Capacity**	**Some Capacity**	**At/Above Capacity**	
	Mean (Std. Er)	*Min, Max*	*Mean (Std. Er)*	*Mean (Std. Er)*	*Mean (Std. Er)*	*Mean (Std. Er)*	*p-value*
Citizenship Status and Nativity (%)							
US Born (%)	95.63 (0.1)	27.76, 100	96.69 (0.2)	95.29 (0.3)	93.61 (0.4)	95.61 (0.1)	*p<0.001*
Foreign-Born (%)	4.37 (0.1)	0, 72.24	3.3 (0.2)	4.71 (0.3)	6.39 (0.4)	4.39 (0.1)	*p<0.001*
Naturalized U.S. Citizen (%)	1.58 (0.039)	0, 25.5	1.03 (0.05)	1.8 (0.1)	2.5 (0.2)	1.61 (0.05)	*p<0.001*
Non U.S. Citizen (%)	2.79 (0.07)	0, 59.01	2.28 (0.2)	2.9 (0.2)	3.91 (0.2)	2.77 (0.8)	*p<0.001*
Language use							
English Only (%)	90.94 (0.2)	4, 100	91.33 (0.4)	91.55 (0.6)	88.13 (0.7)	91.39 (0.2)	*p<0.001*
Language other than English (%)	9.06 (0.2)	0, 96	8.67 (0.5)	8.45 (0.6)	11.87 (0.7)	861 (0.2)	*p<0.001*
Spanish (%)	6.08 (0.2)	0, 95.7	6.55 (0.42)	5.84 (0.53)	7.90 (0.6)	5.41 (0.2)	*p<0.001*
Speak language other than English (%)							
English less than very well (%)	35.28 (0.3)	0, 100	32.38 (0.6)	37.39 (0.9)	38.38 (0.5)	35.82 (0.3)	*p<0.001*
Spanish Speakers							
English less than very well (%)	38.52 (0.3)	0, 100	35.90 (0.8)	40.54 (1.0)	41.76 (0.7)	38.86 (0.4)	*p<0.001*
Educational Attainment							
Less than High School (%)	21.19 (0.18)	0, 80.5	24.31 (0.4)	19.93 (0.5)	19.9 (0.4)	20.02 (0.2)	*p<0.001*
High School Graduate (%)	36.37 (0.17)	0, 95.5	38.28 (0.4)	35.87 (0.5)	35.60 (0.3)	35.63 (0.2)	*p<0.001*
Some College (%)	36.88 (0.22)	0, 100	32.98 (0.5)	38.39 (0.7)	38.35 (0.5)	38.38 (0.3)	*p<0.001*
Bachelors Degree or more (%)	5.56 (0.08)	0, 51.7	4.43 (0.2)	5.8 (0.3)	6.14 (02)	5.97 (0.1)	*p<0.001*
Household Income (%)							
Less than $10,000 (%)	8.69 (0.07)	0, 30.4	9.42 (0.2)	7.09 (0.2)	7.77 (0.2)	8.67 (0.09)	*p<0.001*
$10,000 to $14,999 (%)	7.06 (0.05)	0, 20.7	7.82 (0.1)	5.79 (0.2)	6.28 (0.1)	6.97 (0.05)	*p<0.001*
$15,000 to $24,999(%)	13.15 (0.06)	0, 30	14.16 (0.1)	11.33 (0.3)	12.20 (0.1)	13.24 (0.08)	*p<0.001*
$25,000 to $34,999 (%)	12.19 (0.05)	0, 26	12.88 (0.1)	11.20 (0.2)	11.34 (0.1)	12.12 (0.05)	*p<0.001*

$35,000 to $49,999 (%)	15.54 (0.05)	0, 27.4	15.82 (0.1)	15.03 (0.2)	15.00 (0.1)	15.6 (0.05)	*p<0.001*
$50,000 to $74,999 (%)	19.0 (0.06)	6.7, 44.6	18.77 (0.1)	19.73 (0.2)	19.18 (0.1)	19.02 (0.06)	*p=0.004*
$75,000 to $99,999 (%)	11.15 (0.06)	1, 59.1	10.44 (0.1)	12.66 (0.2)	11.99 (0.1)	11.19 (0.07)	*p<0.001*
$100,000 to $149,999 (%)	8.8 (0.07)	0, 27.1	7.40 (0.1)	11.25 (0.4)	10.66 (0.2)	8.86 (0.09)	*p<0.001*
$150,000 to $199,999 (%)	2.41 (0.03)	0, 15.9	1.84 (0.06)	3.32 (0.2)	3.19 (0.1)	2.43 (0.04)	*p<0.001*
$200,000 or more (%)	2.0 (0.04)	0, 19.6	1.46 (0.05)	2.60 (0.2)	2.62 (0.1)	2.08 (0.05)	*p<0.001*
Median Household Income	$44,270.30 (205.98)	19351, 115574	$40,849.19 (346.9)	$50,840.81 (1115.3)	$48,817.97 (655.6)	$44,389.33 (263.8)	*p<0.001*
Household Income Below poverty line (%)	15.13 (0.1)	0, 30.9	16.20 (0.2)	12.63 (0.4)	13.91 (0.3)	15.07 (0.1)	*p<0.001*
Income Inequality Ratio	1.79 (0.03)	0.08, 22.07	1.28 (0.04)	2.76 (0.2)	2.53 (0.1)	1.80 (0.04)	*p<0.001*
Households on Food Stamps/SNAP (%)	11.04 (0.11)	0, 50.41	11.53 (0.2)	9.9 (0.4)	10.5 (0.3)	11.02 (0.1)	*p=0.002*
Employment Status							
Unemployed (%)	7.53 (0.06)	0, 30.9	7.04 (0.2)	7.96 (0.2)	8.23 (0.2)	7.57 (0.07)	*p<0.001*
Occupation Category							
Management, business, science, and arts (%)	30.09 (0.1)	6.2, 67.3	29.54 (0.3)	31.09 (0.6)	30.7 (0.3)	30.17 (0.2)	*p=0.004*
Service (%)	17.54 (0.06)	0, 39.2	17.47 (0.2)	16.57 (0.2)	17.38 (0.2)	17.70 (0.08)	*p=0.002*
Sales and office (%)	22.80 (0.06)	0, 39.0	20.85 (0.1)	24.97 (0.2)	24.23 (0.1)	23.27 (0.07)	*p<0.001*
Natural resources, construction, and maintenance (%)	13.50 (0.08)	0, 60	16.16 (0.2)	12.25 (0.2)	12.28 (0.2)	12.55 (0.09)	*p<0.001*
Production, transportation, and material moving (5)	16.07 (0.1)	1.2, 72.8	15.99 (0.2)	15.12 (0.5)	15.43 (0.2)	16.34 (0.1)	*p=0.009*
White collar (%)	52.89 (0.2)	13.22, 82.75	50.39 (0.3)	56.07 (0.7)	54.96 (0.4)	53.41 (0.2)	*p<0.001*
Blue collar (%)	47.1 (0.1)	17.25, 86.78	49.61 (0.3)	43.93 (0.7)	45.04 (0.4)	46.59 (0.2)	*p<0.001*
Health Insurance Status							
Uninsured (%)	18.54 (0.1)	3.6, 41.4	21.21 (0.19)	17.46 (0.4)	17.84 (0.2)	17.4 (0.1)	*p<0.001*

Primary care provider density per 100,000 residents	48.86 (0.7)	0, 531	27.76 (1.2)	42.59 (2.0)	51.83 (1.2)	59.33 (0.9)	*p<0.001*
Percent Hispanic	8.28 (0.2)	0, 95.74	8.96 (0.5)	8.51 (0.9)	10.38 (0.8)	7.40 (0.3)	*p<0.001*
	# Counties (%)		*# Counties (%)*	*# Counties (%)*	*# Counties (%)*	*# Counties (%)*	
Urbanity							
Large central metro	63 (2.0%)		0	0	13	50	*p<0.001*
Large fringe metro	354 (11.2%)		55 (6.3%)	43 (33.1%)	107 (25.2%)	149 (8.7%)	
Medium metro	332 (10.5%)		57 (6.5%)	31 (23.8%)	68 (16%)	176 (10.6%)	
Small metro	341 (10.8%)		83 (9.5%)	21 (16.2%)	44 (10.4%)	193 (11.2%)	
Micropolitan	694 (22.0%)		85 (9.7%)	25 (19.2%)	131 (30.9%)	453 (26.4%)	
Non-core	1365 (43.3%)		593 (67.9%)	10 (7.7%)	61 (14.4%)	695 (40.5%)	
Metropolitan	1090 (34.6%)		195 (22.3%)	95 (73.1%)	232 (54.7%)	568 (33.1%)	*p<0.001*
Non-Metropolitan	2059 (65.4%)		678 (77.7%)	35 (26.9%)	192 (45.3%)	1148 (66.9%)	

Table 4.5. Characteristics of U.S. Counties with No or Limited Mammography Capacity and 20% or More Hispanic Population

	Low Capacity Hispanic Communities	
	Mean (Std. Error)	*Min, Max*
Citizenship Status and Nativity (%)		
US Born (%)	89.44 (0.6)	61.53, 100
Foreign-Born (%)	10.56 (0.6)	0, 38.47
Naturalized U.S. Citizen (%)	2.59 (0.2)	0, 9.8
Non-U.S. Citizen (%)	7.97 (0.5)	0, 36.99
Language use		
English Only (%)	67.12 (1.5)	12.3, 100
Language other than English (%)	32.88 (1.5)	0, 87.7
Spanish (%)	31.08 (1.5)	0.87.7
Speak language other than English (%)		
English less than very well (%)	37.37 (1.2)	0, 84.20
Spanish Speakers		
English less than very well (%)	38.04 (1.2)	0, 84.4
Educational Attainment		
Less than High School (%)	30.08 (1.2)	0, 78.2
High School Graduate (%)	38.63 (1.1)	0, 71.6
Some College (%)	27.89 (1.29)	0, 100
Bachelor's Degree or more (%)	3.40 (0.4)	0, 25
Household Income (%)		
Less than $10,000 (%)	9.32 (0.4)	0, 30.4
$10,000 to $14,999 (%)	7.99 (0.30)	0, 20.7
$15,000 to $24,999(%)	14.44 (0.4)	0, 27
$25,000 to $34,999 (%)	12.22 (0.3)	0, 19.6
$35,000 to $49,999 (%)	15.15 (0.3)	0, 25
$50,000 to $74,999 (%)	18.62 (0.4)	6.9, 44.6%
$75,000 to $99,999 (%)	10.57 0.5)	1, 59.1
$100,000 to $149,999 (%)	7.87 (0.3)	0, 18.7
$150,000 to $199,999 (%)	2.1 (.2)	0, 7.9
$200,000 or more (%)	1.71 (0.1)	0, 7.7
Median Household Income	$41, 501.20 (945.6)	19959, 83889
Household Income Below poverty line (%)	17.41 (0.6)	0, 41.7
Income Inequality Ratio	1.28 (0.09)	0.08, 6.22
Households on Food Stamps/SNAP (%)	12.13 (0.6)	0, 41.74
Employment Status		
Unemployed (%)	6.29 (0.3)	0, 15.3%
Occupation Category		
Management, business, science, and arts (%)	28.22 (0.5)	12.7, 58.3

Service (%)	18.59 (0.5)	0, 36.6%
Sales and office (%)	20.12 (0.4)	0, 30.7%
Natural resources, construction, and maintenance (%)	19.76 (0.6)	0, 60%
Production, transportation, and material moving (%)	13.31 (0.4)	2.6, 27.3
White collar (%)	48.34 (0.6)	32.36, 67.74
Blue collar (%)	51.66 (0.6)	32.36, 67.75
Health Insurance Status		
Uninsured (%)	28.22 (0.5)	15.1, 41.4
Primary care provider density per 100,000 residents	28.49 (2.1)	0, 122.17
Percent Hispanic	42.30 (1.7)	20.14, 93.87
	# Counties (%)	
Urbanity		
Large central metro	0.000	
Large fringe metro	7 (5.3%)	
Medium metro	6 (4.5%)	
Small metro	8 (6.1%)	
Micropolitan	11 (8.3%)	
Non-core	100 (75.8%)	
Metropolitan	21 (15.9%)	
Non-Metropolitan	111 (84.1%)	

Table 4.6. Female Hispanic Population by Mammography Capacity Category

	Female Hispanic Population			
	Total	Aged 39 and under	Aged 40 and up	Aged 75 and up
Mammography Capacity				
No Capacity	340,221 (1.37%)	232,698 (1.35%)	107,523 (1.40%)	10,985 (1.60%)
Limited Capacity	670,527 (2.70%)	483,224 (2.81%)	187,303 (2.44%)	13,097 (1.91%)
Some Capacity	6,567,157 (26.42%)	4,485,791 (26.12%)	2,081,366 (27.08%)	184,987 (26.98%)
At/Above capacity	17,280,889 (69.52%)	11,971,872 (26.12%)	5,309,017 (69.09%)	476,619 (69.51%)
Total	24,858,794	17,173,585	7,685,209	685,688

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VIII. Supplementary Materials

Table 4.S1. Number and Proportion of Counties by Hispanic Population Density and Settlement Destinations

	Number (%) of counties	Percent of Hispanic Population	Female Hispanic Population	Percent of Female Hispanic Population	Screening Eligible Female Hispanic Population	Percent of Screening Eligible Female Hispanic Population
Percent Hispanic						
50% or more	82 (2.6%)	16.4%	4,215,264	17%	1,607,881	20.9%
49.99% to 35%	89 (2.8%)	25.2%	6,289,948	25.3%	1,951,581	25.4%
34.99% to 20%	171 (5.4%)	26.9%	6,708,839	27%	2,055,611	26.7%
19.99% to 5%	808 (25.7%)	26.3%	6,405,743	25.8%	1,757,778	22.1%
4.99% or less	1993 (63.4%)	5.3%	1,239,000	5%	312,358	4.1%
Hispanic settlement destination						
Traditional	245 (7.8%)	56.3%	14,195,826	57.1%	4,705,164	61.2%
Emerging	675 (21.5%)	23.8%	5,825,947	23.4%	1,637,369	21.3%
Non-destination	2217 (70.7%)	19.9%	4,833,710	19.4%	1,341,730	17.5%

Table 4.S2. Pearson Correlation Coefficients for Variables in Regression Model

	Non-Citizen	English Less Than Well	Less than H.S.	Poverty	Income Inequality	Un-employed	Blue Collar	Uninsured	Provider Density	Metro/ Non-metro	Settlement Pattern	Hispanic Density
Non-Citizen												
English L Well	0.385											
Less than H.S.	0.088	0.060										
Poverty	-0.060	0.068	0.254									
Income Inequality	0.246	0.010	-0.243	-0.613								
Un-employed	-0.028	0.099	0.205	0.532	-0.233							
Blue Collar	-0.079	0.118	0.378	0.422	-0.599	0.275						
Uninsured	0.343	0.169	0.415	0.416	-0.374	0.151	0.345					
Provider Density	0.130	0.002	-0.246	-0.138	0.230	-0.101	-0.427	-0.224				
Metro/ Non-metro	-0.180	-0.078	0.221	0.281	-0.428	-0.013	0.432	0.228	-0.173			
Settlement Pattern	-0.570	-0.182	-0.160	0.012	-0.114	0.074	0.033	-0.358	0.018	0.100		
Hispanic Density	-0.700	-0.205	-0.160	-0.032	-0.089	0.026	-0.010	-0.453	-0.003	0.068	0.730	
Percent Hispanic	0.685	0.154	0.173	0.097	0.042	-0.010	0.047	0.462	-0.023	-0.043	-0.751	-0.935

Figure 4.S1. Hispanic Population Density in U.S. Counties

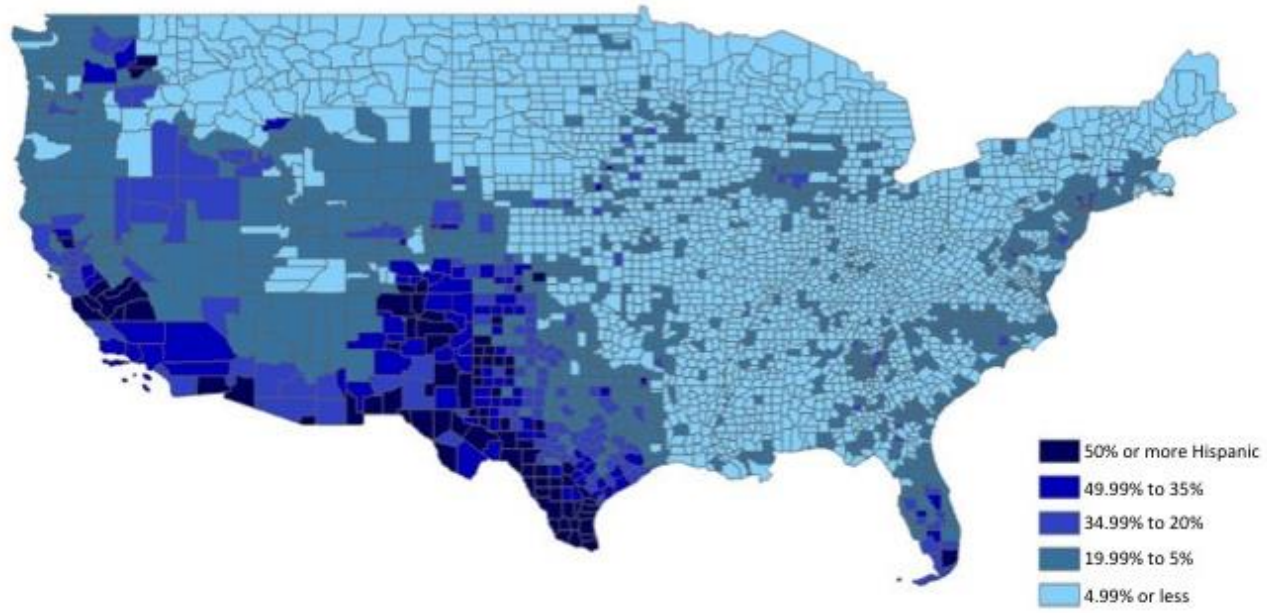


Figure 4.S2. Hispanic Settlement Patterns in U.S. Counties

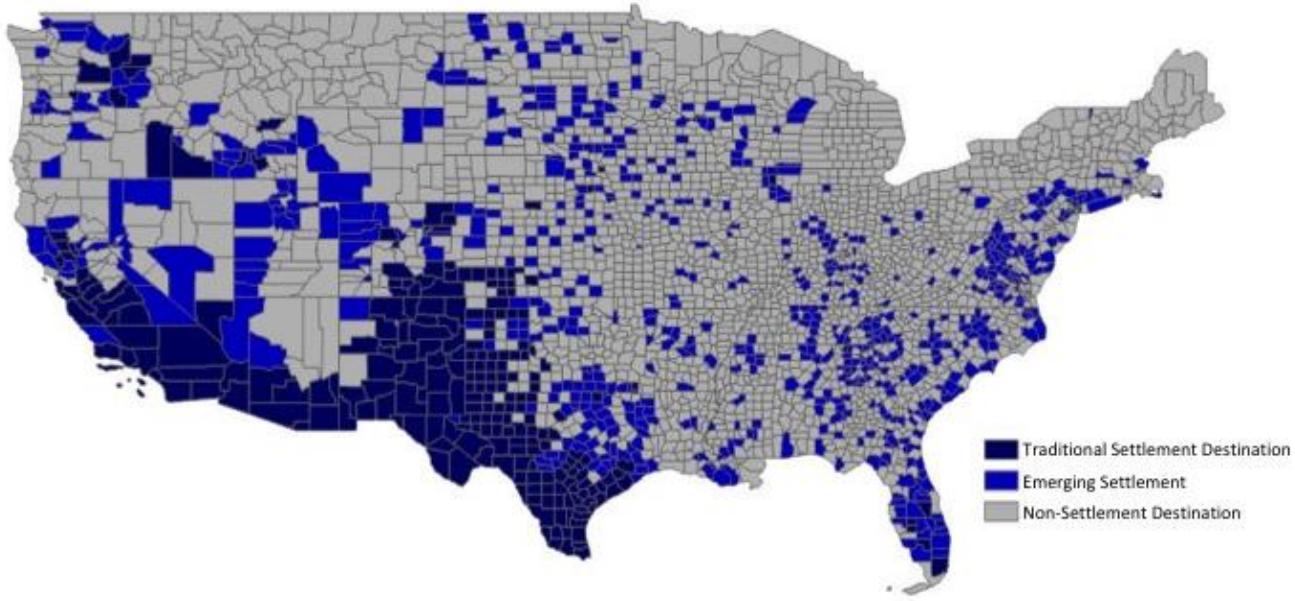
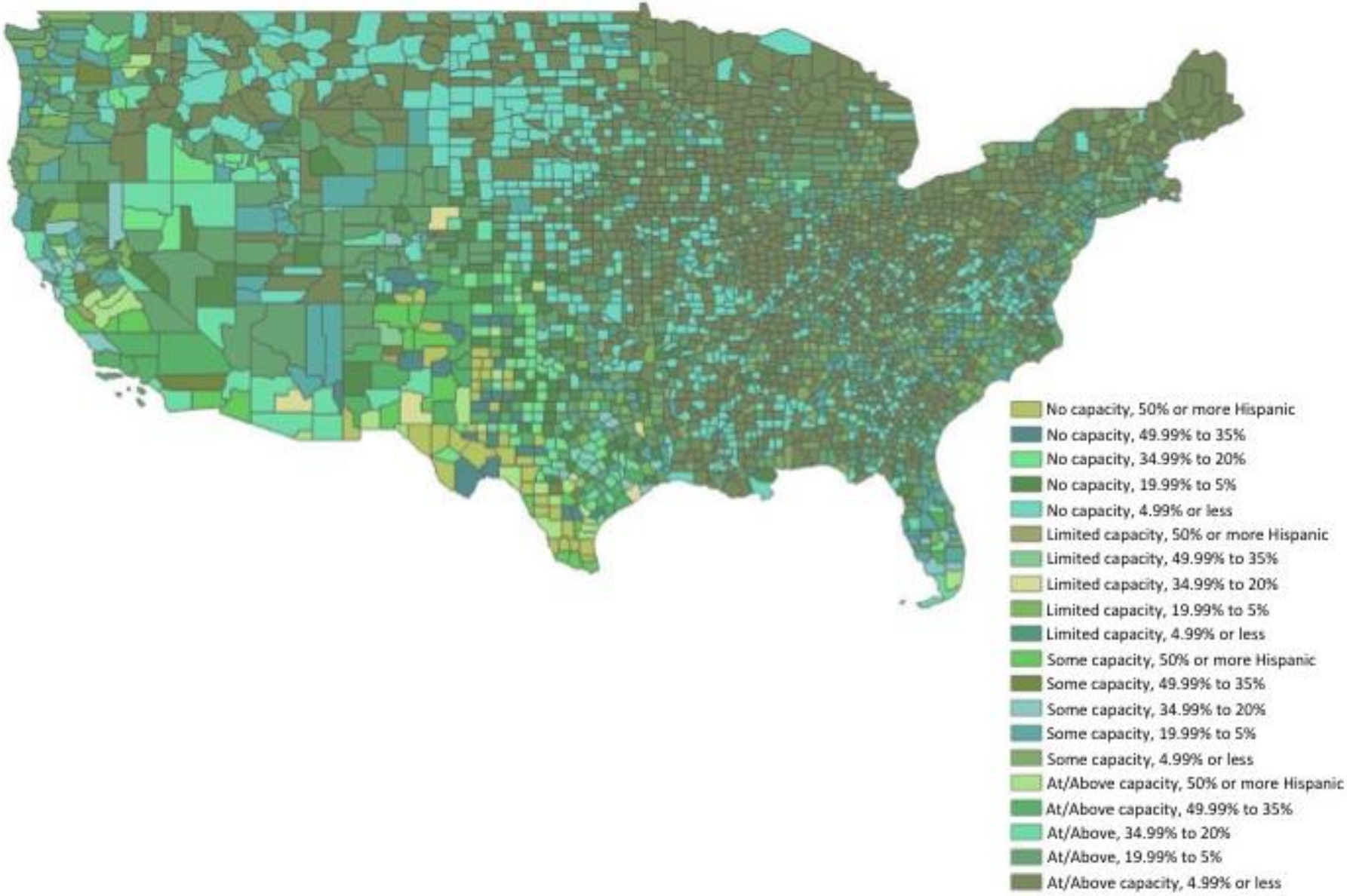


Figure 4.S3. Bivariate Choropleth Map of Hispanic Population Density and Mammography Capacity



Chapter Five - Conclusions

I. Main Findings

This dissertation project explored associations between acculturation and area-related factors and mammography utilization among Hispanic women living in the United States. Chapters Two, Three, and Four described research studies that (1) summarized conceptual definitions of acculturation and described their associations with mammography utilization, (2) explored the role of immigration status on the uptake of mammography, and (3) assessed population-level mammography capacity among Hispanic communities in the U.S., respectively.

Results identified challenges Hispanic immigrants, namely non-U.S. citizens, may face in obtaining mammography screening in the U.S. and described challenges Hispanic communities may face in accessing mammography screening. Results present multiple opportunities for further research and public health interventions to address disparities in mammography screening among Hispanic women. The following section describes key study findings related to acculturation and mammography use and are organized by the three aims of the dissertation.

Aim 1: Explore the role of acculturation on mammography screening among Hispanic women in the U.S.

Chapter Two of this dissertation explored the published literature on the effects of acculturation on mammography use through a systematic review. While some studies have found that lower levels of acculturation are associated with less use of mammography for breast cancer screening, other studies have found that the effects of acculturation are often explained by socio-economic factors or access to care. These inconsistencies may be the result of significant variation in measures of acculturation, relying on proxy measures, and lack of cross-cultural validity of measures (Algeria, 2009). Exploring the measures of acculturation employed in

studies of mammography use among Hispanic women may help us consider results in a new context and provide insights into the mechanisms through which culture may impact health service utilization. Specifically, the review sought to answer the following questions:

1. How has acculturation been operationalized and measured in research on mammography use among Hispanic women?
    a. To what extent are the measures of acculturation being utilized in research on mammography use multi-dimensional?
2. What is the effect of acculturation on mammography use and how does it vary by domain?

A conceptual framework defining domains of acculturation was developed to inform this dissertation and was used to organize measures and describe effects of studies included in this review. We identified eight distinct domains for the construct of acculturation (immigration and nativity, language use, tradition participation and maintenance, migration and settlement, identity and heritage, acculturation stress, interactions and social networks, and cultural beliefs and norms). These domains were then classified as being either at the person-level, practice or belief based, or place-based. Fields abstracted included study authors and title, study characteristics (location, population, Hispanic population of interest, setting or location), study design (observational/intervention), measures of acculturation (type, # of items, constructs measured, items, and psychometric properties), key covariates included in analyses, magnitude of effect (measures of association), conceptual frameworks or theory utilized, and results associated with acculturation.

While fifty-one articles met all the inclusion criteria, thirty-five (68.6%) utilized quantitative methods and were eligible for the review. Results indicate that the vast majority of research on

mammography use in Hispanic women that included an acculturation measure focused either on either factors associated with immigration status and nativity, or language use. Few studies addressed other domains of acculturation, such as acculturation stress and discrimination, cultural beliefs and norms, and interactions and social networks. The majority of studies used single items or a small collection of items to measure acculturation. Only 11% of studies utilized a multi-dimensional scale of acculturation. Most studies (approximately 62%) found no significant differences in mammography use based on acculturation level, while twelve studies found that acculturation levels were significantly associated with decreased mammography use and eleven found that acculturation level was associated with increased mammography use.

Studies on immigration status and nativity indicated that among foreign-born Hispanic women, non-U.S. citizens have a harder time obtaining regular mammography screening. Studies that included U.S. born Hispanic women in their analytic samples mostly found that citizenship status was not associated with mammography use. Similarly, time spent living in the U.S. also was associated with mammography use in studies of foreign-born women. Studies assessing country of origin often found that Hispanic women of Mexican descent routinely reported some of the lowest mammography screening rates among Hispanic women in the U.S., while Dominican women tended to report the highest use of screening. Few studies found that language use or preferences were associated with mammography use. Of the few studies including measures in other domains, only four studies showed significant effects, three of which were focused on cultural beliefs and norms. Two studies found that fatalistic beliefs about breast cancer were associated with decreased mammography use, while one study found that high levels of familism were associated with increased mammography screening.

Aim 2: Examine immigration status as a determinant of mammography use among Hispanic women in the U.S.

Chapter 3 examined the potential impact immigration status may have on mammography use among Hispanic women. Immigration status may be a particularly important determinant to breast cancer screening among Hispanic women because access to publicly funded health insurance programs may be denied to those who are non-citizens based on their legal status. This study sought to answer the following research questions:

1. What proportion of Hispanic women are being screened for breast cancer through mammography? Does test use vary by country of origin or immigration status?
2. Does access to care and socio-economic status among Hispanic women vary by country of origin and immigration status?
3. Does immigration status contribute to mammography use beyond access to care and socio-economic status?

This study analyzed data from the National Health Interview Survey (NHIS). Based on the results of Chapter Two, immigration status was defined as a composite of citizenship status, being foreign, or native-born, and amount of time spent living in the U.S. Quantitative analysis of a pooled sample of 5,283 Hispanic women, aged 40 to 75, who participated in the NHIS in 2008, 2010, 2013, and 2015 was conducted to assess their use of mammography. Results were weighted to be representative of the U.S. population. Mammography use was operationalized in two outcomes: having had a mammogram in the last two years (recent mammography) and never having been screened or being more than five years since their last mammogram (never/rarely screened). Results indicate that 76.42% of eligible Hispanic women (95% CI: 74.8%, 78.04%)

have been recently screened, while 23.73% (95% CI: 22.4%, 25.1%) have never been screened or are overdue for a mammogram.

In unadjusted logistic regression models, immigration status was not significantly associated with recent mammography screening. However, models of being rarely/never screened indicate that foreign born Hispanic women who are not U.S. citizens and have been in the U.S. less than fifteen years had over twice of the odds of being rarely or never screened then U.S. born Hispanic women (OR=2.4, 95% CI: 1.8, 3.1). These effects however, were attenuated after models were adjusted for access to care and socioeconomic status. This may suggest that the effects between acculturation and mammography use may be mediated or moderated by access to care and SES. Propensity score matched logistic regression models indicate that even after matching on key covariates, non-citizens had significantly greater odds of being rarely or never screened (OR=1.75, 95% CI: 1.2, 2.5). Citizenship status was not significant in models of being recently screened.

Our results also indicated that immigration status is significantly associated with access to care and socioeconomic status. Foreign-born non-U.S. citizens, regardless of length of time spent in the U.S., have greater issues accessing health care services and experience greater levels of poverty.

Aim 3: Assess mammography capacity in Hispanic communities in the United States and describe the communities facing challenges in availability of screening.

Chapter 4 described mammography capacity at the county level in the U.S. and focused on counties where Hispanic populations accounted for at least twenty percent of the overall county population. Lack of mammography capacity in Hispanic communities is concerning. Previous studies have found that lack of mammography capacity is associated with increased wait time for

screening (Elkin et al., 2012), decreased odds of mammography use (Elkin et al., 2010) and late stage breast cancer (Elkin et al., 2009). Research questions included:

1. Do Hispanic women living in primarily Hispanic areas have similar access to mammography facilities as those who do not live in mostly Hispanic areas?
2. What are the characteristics of Hispanic areas with limited mammography capacity?
3. What proportion of Hispanic women live in areas with limited or no mammography capacity?

This study utilized data from the Food and Drug Administration (FDA) Mammography Program Reporting and information System (MPRIS) to calculate county mammography capacity, data from the 2000 and 2010 decennial Census to calculate Hispanic population density and settlement patterns, and five year estimates from the 2010 American Community Survey, data from the 2010 Health Resource and Services Administration (HRSA) Area Health Resource File (AHRF), 2010 Census Bureau Small Area Health Insurance Estimates (SAHIE) and the 2006 National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties. Mammography capacity, a measure of a counties ability to screen all their underlying screening eligible population, was grouped into four categories: 1) counties with no mammography capacity (no mammography facilities or units within county borders); 2) limited mammography capacity (counties with mammography capacity to screen less than half their eligible population), 3) some mammography capacity (counties that can screen between 50% and 79% of their screening eligible population), and 4) counties at or above mammography capacity (counties that can screen over 80% of their eligible population).

Results indicated that approximately 39% of counties with at least 20% of the county population is Hispanic had no capacity or very limited capacity to screen their underlying,

screening eligible population. In addition, we found that counties where the Hispanic population accounted for 50% or more of the total county population had greater odds of being no capacity or limited capacity counties. These results build on previous research on mammography capacity in the U.S. by focusing on the characteristics of Hispanic communities facing limited access (Elkin et al., 2010; Peipins et al, 2012). While the number of Hispanic women living in counties with no capacity or limited capacity only accounted for approximately 4% of the screening eligible Hispanic population, an additional seven hundred thousand Hispanic women also live in those counties and will become eligible for mammography screening in the coming years.

Results from Chapter Three indicate that non-U.S. citizens may face challenges in obtaining regular mammography screening, particularly initiating screening in their forties. Results from Chapter Four indicate that on average, high Hispanic population density and low mammography capacity counties had a greater proportion on non-U.S. citizens than the average U.S. County. Non-U.S. citizens may face challenges accessing care based on their legal status and ability to prove that they are in the U.S. lawfully and therefore eligible for public service programs like Medicaid, or programs like the CDC funded Breast and Cervical Cancer Early Detection Program (ASPE, 2009). We also found that while these counties had a much larger proportion of the population that spoke Spanish than the average U.S. county, they had similar proportions who speak English less than very well.

Finally, high Hispanic density and low mammography capacity counties also had a greater mean level of percent of uninsured individuals (28%), had a lower rate of primary care providers (28.49 per 100,000) compared to the average U.S. county (48.86 per 100,000, respectively), and are primarily rural. This finding suggests that in addition to facing challenges physically

accessing mammography facilities, these populations are likely to face compounding barriers in accessing health care.

Findings from all three studies suggest that individual and area level factors are important considerations for promoting cancer screening among Hispanic women. The results of this dissertation provide insight into some of the barriers to mammography screening that Hispanic women experience. Given the lack of mammography availability in some Hispanic communities in the U.S. and the increased odds of non-U.S. citizens being rarely or never screened, we see that barriers for mammography use among Hispanic women will require multi-level interventions to address these barriers. Public policy associated with immigration and citizenship status may block access to health care services, such as mammography. Communities with high Hispanic population density may face shortages of mammography units and may contribute to a higher proportion of Hispanic women being rarely or never screened. These communities may also experience many more barriers to mammography use than just issues of care availability. Challenges associated with rural medicine will also need to be addressed to increase mammography use among Hispanic women.

II. Evaluation of Research: Limitations and Strengths

Limitations

There are several limitations to this dissertation to consider. The systematic review described in Chapter Two may have inadvertently left out relevant literature because of the databases searched and the search terms utilized. In addition, the eligibility criteria may have excluded studies that had relevant results. The studies included also used varying sampling methodologies and included differing Hispanic populations. This may impact the ability to compare results across studies and generalize results to any particular Hispanic sub-populations

in the U.S. In addition, the conceptual framework for acculturation developed for this study has not been previously validated. While the conceptual definitions are based on published literature (Zane & Mack, 2005; Sam, 2006; Abriado-Lanza et al., 2006; Abriado-Lanza et al., 2016; Schwartz et al., 2010; Acevedo-Garcia, 2012; Fox et al., 2017) not all domains have been linked to mammography use and the behavioral mechanisms through which they may impact mammography use are unclear.

The quantitative analysis presented in Chapter Three used data from a national household in-person survey (NHIS) consisting exclusively of self-reported data. In addition, survey respondents were asked to retrospectively report their screening behavior. Self-reported data are subject to several biases and survey questions on previous behaviors may lead to telescoping or other reporting errors (Fowler F.J., 2014). In addition, self-reports of citizenship status are also subject to bias. Previous studies have found that citizenship status can often be misreported (Brown et al, 2019). In addition, those with uncertain or unlawful legal status may feel intimidated by government interviewers knocking on their door and asking personal questions. Also sampling for the NHIS may be biased toward long-term immigrants and naturalized citizens given their distribution in the sample.

The ecological analysis presented in Chapter Four utilized historical data from 2009, which was the best available at the time of this dissertation. While these data are already somewhat out of date, results can serve as a baseline for future studies of mammography capacity in Hispanic communities. Our study evaluated mammography capacity based on county of residence at time of census interview; however, neighboring counties may have more or better mammography capacity. Also, our study conceptualized Hispanic communities in counties, which are large, especially in rural areas. Census tracts may be more appropriate for

conceptualizing communities and their access to health care services (IOM, 2002; Lim et al., 2017). In addition, this analysis only focused on physical access to mammography facilities and was not a direct measure of mammography use. Hispanic women living in large metropolitan areas with excess mammography access may still face significant challenges obtaining a mammogram. For example, a previous study indicated that Hispanic women living in urban areas face transportation challenges in accessing mammography (Graham et al, 2015).

Strengths

Despite these limitations, there are several strengths in the design and analyses of this dissertation. This study not only reviewed the published research, but also included quantitative analyses both at the individual and the ecological level to better explore the effects of acculturation and immigration related factors on access to and use of mammography. Our methods help identify constructs related to acculturation that informed future studies and measurement of acculturation. Findings identified potential interventions at the system and policy level that may lead to increased mammography use among Hispanic women in the U.S. In addition, the research questions explored in this dissertation provide new perspectives on acculturation and health service use. While literature reviews on cancer screening among Hispanic women have been conducted in the past (Aduln et al 2019; Ackerson & Gretebeck, 2007), Chapter Two included a focus on domains and measures of acculturation that can help guide future research by improving measure selection. In addition, Chapter Three utilized propensity score methods to account for sampling bias and provide less biased estimated on the impact citizenship status may have on mammography use (Parsons, 2001; Austin, 2011). Finally, Chapter Four built upon previous research by focusing assessment of mammography capacity on Hispanic communities as a dimension of healthcare access.

III. Implications for Public Health Research and Practice

Findings presented in this dissertation may have several implications for future public health practice and research.

Practice Implications

Results have highlighted the importance of policy concerning access to public or private health insurance for immigrants. Those who are not considered 'classified aliens' cannot access public service programs like Medicare or Medicaid, qualify for subsidies from the Healthcare Exchange, and are not eligible for employer based-insurance (ASPE, 2009). Addressing disparities in breast cancer screening, stage at diagnosis, and mortality may continue to be a challenge if unauthorized immigrants cannot access health care services (ACS, 2018; Cabral & Cuevas, 2020). It is estimated that unauthorized immigrants make up about a quarter of the Hispanic foreign-born population in the U.S. (Radford & Noe-Bustamante, 2019). Public health interventions will need to target unauthorized immigrants to connect them with care, however, health care systems and community clinics will need to seek private or foundation funds since federal funds cannot be used to provide health care for these populations. Strategies that have proven successful include use of *promotoras* or navigators; community-based events for recruitment, and availability of translators and educational materials in foreign languages in clinics and health systems. (Community Guide, 2019, 2016, 2012; Vyas et al, 2012; Escoffery et al, 2014; Marcus et al., 2014; Nuño et al, 2010).

Chapter Four identified several opportunities for public health intervention. Specifically, it highlighted the need for mobile mammography units to increase capacity for mammography screening. Coupled with special events, such as health fairs, or other community gatherings, mobile mammography units may provide new opportunities for screening of hard to reach

populations (Vyas et al, 2012; Escoffery et al, 2014). Programs like the Breast and Cervical Cancer Early Detection Program can serve as models for completing multiple cancer screening tests at the point of service or the in reach method (Sella et al., 2013; Bobridge et al., 2017; CDC, 2019). In addition, creating community-clinical linkages may offer opportunities to bring Hispanic women into screening through community events and immigrant serving organizations (AHRQ, 2016).

Research Implications

Results from the systematic review indicated that there is limited research on acculturation and mammography use aside from immigration status and language use. Future studies should consider including measures of acculturation from other domains in order to develop a better understanding of the behavioral mechanisms that underlie these relationships (Wallace et al, 2010). In addition, studies should consider utilizing validated multi-dimensional scales of acculturation rather than single item measures to reduce measurement error and improve internal validity.

The results of Chapter Three indicated that citizenship status may a barrier to mammography uptake for foreign-born women who are not U.S. citizens. Future studies should explore if citizenship status is also a barrier to cervical and colorectal cancer screening. Previous studies have found that Hispanic populations report lower cervical and colorectal cancer screening rates (White et al, 2017). Given that cervical cancer screening includes much younger women and colorectal cancer is also relevant for men, it is possible that results may vary from those observed for mammography. In addition, future studies may want to consider mammography re-screening as an outcome. Previous studies have found that Hispanic women were less likely to be re-screened than non-Hispanic white women (Bobo et al, 2004; Dailey et

al, 2011). However, the role of immigration status, or other proxy-measures for acculturation, in mammography re-screening require further exploration. In addition, future studies should consider assessing follow-up and diagnostic testing after abnormal mammogram results among Hispanic women. Previous studies have found that Hispanic women are less likely to have diagnostic follow-up after an abnormal mammogram (Yabroff et al, 2004). However, no studies that assessed the role of acculturation in follow-up diagnostic testing were identified.

Future studies building off the results from Chapter Four could consider linking individual level mammography behavior, as well as additional individual level characteristics and acculturation measures, to area-level mammography capacity. These studies would provide a multi-level perspective and could help elucidate relationships between individual and area level variables. Also, the inclusion of additional area level measures of access to care may provide clarity on mammography capacity. For example, previous studies have found that availability of radiologists and radiology technicians or mammography technologists, is also an important determinant to mammography availability (D'Orsi C, et al., 2005; Collie-Akers et al., 2012; Rosenkrantz et al., 2018). In addition, access domains for the framework used in this dissertation may also be valuable to explore in future research. For example, including measures of accessibility or transportation time, and accommodation, like working office hours may further address questions of access and present a multi-dimensional perspective on the role of access on mammography utilization among Hispanic women. Finally, future studies may benefit from defining Hispanic communities at an area level more localized than a county. Census tracts or block groups may allow for better definitions of Hispanic communities in the U.S. and allow for the use of spatial methods, such as two-step floating catchment areas to consider travel time and access to services in contiguous areas. (McGrail and Humphreys, 2009).

IV. Conclusions

This dissertation project reviewed the literature on the relationship between acculturation and mammography use among Hispanic women in the U.S., explored differences in mammography use by immigration status, and described mammography capacity in U.S. counties with large Hispanic populations. The results from this effort may be informative to public health programs that seek to increase mammography uptake among Hispanic women in the U.S. In addition, public health researchers may use results to inform conceptualization of acculturation, research design and selection of acculturation measures. Public heath efforts to address disparities in breast cancer related outcomes among Hispanic women in the U.S. should consider the access barriers among non-U.S. citizens and the limited physical access to mammography services and primary care in Hispanic communities in the U.S. Addressing all of these areas has the potential to promote Hispanic women's mammography use and reduce cancer health disparities.

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