The Role of County-Level Socioeconomic Characteristics in Low-Income Women's Use of Screening Mammography in Kansas

By

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Abstract

In the U.S., low-income, uninsured women have used mammography less frequently and have experienced higher breast cancer mortality rates than their wealthier and insured counterparts (Harper et al., 2009; National Center for Health Statistics, 2013). These discrepancies are problematic because low-income, uninsured women often rely on community resources, such as free screening programs, to obtain healthcare services (Daniels, 2008; Link & Phelan, 1995; Lynch & Kaplan, 2000). Although researchers have investigated person- and area-level factors that may influence mammography use in the general U.S. population, little research to-date has examined how socioeconomic characteristics of communities, which represent shared exposures of all who live there, may affect mammography use among low-income, uninsured women (Pruitt, Shim, Mullen, Vernon, & Amick, 2009; Schueler, Chu, & Smith-Bindman, 2008). Moreover, despite policy attempts to increase access to mammography services, low-income, uninsured women remain at risk for not receiving timely mammograms, particularly in states not expanding Medicaid such as Kansas (Howard et al., 2015; Kaiser Family Foundation, 2013). Therefore, the purpose of this dissertation was to explore the relationship of county-level socioeconomic characteristics and mammography use by low-income, uninsured women in Kansas.

Using a combination of multiple linear regression analyses and hierarchical generalized linear models (HGLM), three related studies analyzed the association of county-level socioeconomic characteristics and mammography use among women who participated in a free screening program in Kansas, known as Early Detection Works (EDW), from 2009-2014. These studies found that county-level uninsurance and socioeconomic deprivation were significantly associated with mammography use, such that counties with higher levels of uninsurance and

lower levels of socioeconomic deprivation exhibited higher mammography use in the EDW program. These results suggest that even when mammography screenings were free, characteristics of the broader environment may have influenced their utilization. Moreover, the EDW program may have been acting as a ‘pseudo insurer’ by converting uninsured women into patients with contracted payments for mammogram services. Collectively, these findings imply that research and policy efforts to expand health insurance may extend comprehensive coverage to previously uninsured low-income women and free-up limited EDW resources to target other women in need of mammography services.

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Table of Contents

Chapter 1: Introduction

Background

Over the past three decades, low-income, uninsured women in the U.S. have used mammography screening less frequently and have experienced higher breast cancer mortality rates than their wealthier and insured counterparts (Harper et al., 2009; National Center for Health Statistics, 2013). This discrepancy is problematic because low-income, uninsured women often must rely on community socioeconomic resources to obtain healthcare services, such as mammography screenings (Lynch & Kaplan, 2000). Prior researchers have investigated the person- and area-level factors that may influence mammography use in the general U.S. population, finding that area-level measures of socioeconomic deprivation, uninsurance, and healthcare supply, were important predictors (Pruitt et al., 2009; Schueler et al., 2008). However, no research to-date has examined how the socioeconomic characteristics of communities may affect mammography use among low-income, uninsured women specifically. Moreover, despite several policy attempts to increase mammography access, including providing free screening through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) and expanding insurance coverage via the Patient Protection and Affordable Care Act (ACA), low-income, uninsured women remain a vulnerable population at risk for not receiving timely mammograms, particularly in states choosing not to expand Medicaid such as Kansas (Howard et al., 2015; Kaiser Family Foundation, 2013). Therefore, having a better understanding of the community-level correlates of utilization of a free mammography screening program among low-income, uninsured women may provide important insights about how to mitigate morbidity and mortality associated with breast cancer health disparities for this vulnerable population.

With more than 40,000 deaths and 200,000 new cases each year, breast cancer comprises nearly one-third of all malignancies diagnosed in U.S. women (DeSantis, Siegel, Bandi, & Jemal, 2011; Howlader et al., 2013). Over the past three decades, breast cancer-related mortality rates have declined by nearly one-third, with researchers attributing this decrease to improvements in both early detection and treatments (Berry et al., 2005; Howlader et al., 2013). However, these reductions have not been experienced similarly across all population groups. In particular, researchers have documented higher rates of advanced-stage breast cancer and less pronounced mortality reductions among women residing in lower income areas compared to women living in wealthier neighborhoods (Coughlin et al., 2009; DeSantis et al., 2011; Harper et al., 2009; Klassen & Smith, 2011; Lobb, Ayanian, Allen, & Emmons, 2010; Morris et al., 2015; Ward et al., 2004).

One of the most important factors influencing breast cancer survival is regular screening and early detection with mammography, which often identifies cancer several years before symptoms develop (American Cancer Society, 2014; Gotzsche & Jorgesen, 2013; Nelson et al., 2009). Although nearly two-thirds of U.S. women over the age of 40 have reported receiving a mammogram in the past two years, this level of screening also has not been experienced equally among all women (National Center for Health Statistics, 2013). Over the past decade, national health surveys have revealed that poor (<100% federal poverty level [FPL]) and near-poor (100-199% FPL) women reported nearly 30% fewer mammograms than non-poor women (>400% FPL) (Breen, Gentleman, & Schiller, 2011; National Center for Health Statistics, 2013). Likewise, these findings also have been replicated at the state level, with low-income, uninsured Kansas women over the age of 40 reporting three times fewer mammograms compared to wealthier and insured women (Behavioral Risk Factor Surveillance System, 2013).

These discrepancies in the use of screening mammography are especially problematic for low-income, uninsured women. Because their reduced personal resources both increase the likelihood of negative health exposures and decrease access to resources to address health issues, these women often must rely on community resources, such as free screening programs, to obtain healthcare services (Daniels, 2008; Link & Phelan, 1995; Lynch & Kaplan, 2000). There is reason to believe that mammography use among low-income, uninsured women may be particularly impacted by the collective socioeconomic characteristics of their communities (Lynch & Kaplan, 2000; Pagan & Pauly, 2006). Subsequently, over the past decade, researchers have been increasingly interested in the role broader social conditions that represent shared exposures of all members who live in a area, such as the socioeconomic position (SEP) and insurance coverage of a community, may play in the facilitation of mammography use among individual women (Calo, Vernon, Lairson, & Linder, 2016; Dailey et al., 2011; Pagan, Asch, Brown, Guerra, & Armstrong, 2008; Pruitt et al., 2009). However, no research to-date has examined how community-level socioeconomic characteristics may influence mammography use among low-income, uninsured women.

Acknowledging the critical role insurance plays in facilitating access to cancer screening services (Institute of Medicine, 2009), policymakers have made several attempts to expand access to mammography for low-income, uninsured women in the U.S. Although not comprehensive insurance coverage, the NBCCEDP program was established in 1991 to provide free breast and cervical cancer screening services and direct links to treatment via Medicaid, with each state operating its own local program (Centers for Disease Control and Prevention, 2015). While some research has indicated NBCCEDP has improved access to mammography for low-income, uninsured women (Hoerger et al., 2011; Howard et al., 2010), other sources have

estimated the program serves only 10-15% of eligible women annually (Howard et al., 2015; Snyder, October 15, 2014).

More recently, the ACA has attempted to increase national health insurance coverage by expanding state Medicaid programs, providing subsidies for individuals to purchase insurance, and building on the employer-based insurance system (U.S. Department of Health & Human Services, 2015). Although the legislation had well-intentioned objectives, only two-thirds of states have chosen to expand their Medicaid programs, which has left the poorest women (with incomes under 100% FPL) in a coverage gap between governmental programs and private insurance (Kaiser Family Foundation, 2014). Consequently, in Medicaid non-expansion states such as Kansas, NBCCEDP programs have become especially important conduits to help women in these coverage gaps access mammography screening (Levy, Bruen, & Ku, 2012).

When taken together, this information suggests that low-income, uninsured women may be a vulnerable population at risk of not receiving timely mammograms, particularly in states choosing not to expand their Medicaid programs (Kaiser Family Foundation, 2013; Levy et al., 2012). Despite prior research and policy efforts, questions remain about how to most effectively narrow breast cancer screening inequalities in the U.S. In particular, there is growing interest among researchers and policymakers to better understand how specific community characteristics might influence access to and use of mammography services for vulnerable populations in order to most effectively allocate limited resources (Pruitt et al., 2009). Doing so, however, requires a more detailed understanding of the complex community-level socioeconomic characteristics that may extend beyond the influence of personal resources to facilitate use of screening mammography for low-income, uninsured women.

Research Aims

To more effectively develop strategies to narrow breast cancer screening inequalities, a deeper understanding of the interplay between community socioeconomic characteristics and mammography use among vulnerable populations, including low-income, uninsured women, is needed. There are two primary reasons driving the need for this investigation: 1) no research has specifically explored the influence of the social context on mammography use among low-income, uninsured women, and 2) low-income women in Medicaid non-expansion states, such as Kansas, have limited insurance options with which to access healthcare services, including mammography. Therefore, the purpose of this dissertation is to examine the relationship between county-level socioeconomic characteristics, primarily deprivation and uninsurance, and mammography use among low-income, uninsured women in Kansas who participated in a free mammography screening program.

The research questions in this dissertation were designed to iteratively build upon one another as three separate studies in order to explore the county-level characteristics under which low-income, uninsured women may be likely to participate in a free mammography screening program. Person-level data on mammography use among low-income, uninsured women will be derived from the Early Detection Works (EDW) program, the Kansas division of the NBCCEDP, while county-level information will be primarily gathered from Area Health Resource Files (AHRF). The specific research questions and associated hypotheses investigated in this dissertation are as follows:

- **Research Question 1**: To what extent are county-level socioeconomic characteristics associated with screening mammography use among low-income women in Kansas over multiple screening intervals?

- **Hypothesis 1:** As county-level socioeconomic deprivation and uninsurance levels increase, so will mammography use among free screening program participants at two-, four-, and six-year screening intervals.

- **Research Question 2**: To what extent is county-level socioeconomic deprivation associated with use of screening mammography among low-income women in Kansas?
  - **Hypothesis 2**: Counties with greater socioeconomic deprivation (as measured by an SEP index) will have lower recent mammography use in the free screening program than counties with lower socioeconomic deprivation, when controlling for person-level characteristics.
- **Research Question 3**: To what extent is county-level uninsurance associated with use of screening mammography among low-income women in Kansas?
  - **Hypothesis 3A**: Counties with higher levels of uninsurance will have lower recent mammography use in a free screening program than counties with lower levels of uninsurance, when controlling for person-level characteristics.
  - **Hypothesis 3B**: Counties with higher levels of uninsurance will have correspondingly higher recent mammography use in a free screening program than counties with lower levels of uninsurance, when controlling for person-level characteristics.

Since there is no research to-date on the association of area-level characteristics and mammography use among low-income women, Research Question 1 seeks to establish a foundational understanding about the relationship between county-level socioeconomic characteristics and county-level mammography rates among low-income, uninsured women in Kansas who participated in the EDW program. Because this study will provide baseline county-

level associations for mammography use among low-income, uninsured women that do not currently exist, it is intended this information will be a new contribution to the literature. Next, Research Question 2 will hierarchically build upon the first question by investigating the association of county-level socioeconomic deprivation and mammography use above and beyond personal characteristics. By applying a nationally-validated SEP index to mammography use in a new population of low-income, uninsured women, this study will likely add to the current limited literature on area-level socioeconomic deprivation and mammography use. Finally, Research Question 3 will advance the second question by exploring the relationship of county-level uninsurance and mammography use among low-income, uninsured women, while controlling for both personal characteristics and county-level socioeconomic deprivation. Because only one other study has examined the association of area-level uninsurance and mammography use, this question is intended to expand this budding area of research.

Although not a true evaluation of the EDW program, this dissertation aims to further enhance understanding about the complex role area-level socioeconomic characteristics may play, above and beyond limited personal resources, in the use of screening mammography. In particular, these three studies are designed to provide information about the specific county characteristics under which low-income, uninsured women may be most likely to participate in free mammography screening programs. By doing so, this dissertation may help advance future research agendas, policy efforts, and program administration. For researchers, these findings could be beneficial because they extend several current lines of inquiry and provide nuanced insight for how county-level characteristics may differentially affect mammography use among vulnerable populations compared to the general U.S. population. For policymakers and screening program administrators, this information could be helpful to devise strategies to help target

recruitment efforts, guide resource allocation, and deliver limited breast cancer screening resources to vulnerable populations in ways that benefit all members of a community.

Chapter 2: Literature Review

Socioeconomic Position (SEP) and Mammography Use

As a product of the broader environment, health often is socially patterned, rather than simply resulting from chance or being purely dictated by biological mechanisms. As such, researchers have consistently documented that most diseases and health behaviors are highly sensitive to social environments and are shaped by the conditions in which individuals grow, live, work, and interact with other members of society (Dahlgren & Whitehead, 1991; Raphael, 2006; Syme, 2004; Tarlov, 1999; Wilkinson & Marmot, 2003). In particular, individuals' social and economic standing within their broader social hierarchy, known as socioeconomic position (SEP), is thought to impact health through its ability to facilitate or inhibit exposures and access to resources (Lynch & Kaplan, 2000). This exposure-resource perspective suggests that individuals' positions in the social hierarchy often determine access to resources, which are important in shaping life opportunities and ultimately health outcomes (Daniels, 2008; Link & Phelan, 1995; Lynch & Kaplan, 2000).

More specifically, researchers have hypothesized that SEP plays an important role in health status because it can 1) directly affect the material conditions necessary for survival, and 2) impact individuals' ability to participate in their social structure and have control over their life circumstances (Marmot, 2002). Thus, inequalities in health outcomes can be conceptualized as socially-constructed relationships attributable to unequal distributions of resources, including income, education, and insurance coverage (Braveman & Gruskin, 2003; Starfield, 2001; Whitehead & Dahlgren, 2006). Although it remains unclear which social and economic forces are chiefly responsible for the association between socioeconomic deprivation and poor health,

multiple factors likely work in tandem to contribute to social differences in ways that influence health behaviors such as mammography screening (Wilkinson & Pickett, 2006).

In particular, social conditions, particularly poverty and uninsurance, have been increasingly recognized for their negative relationship with breast cancer inequalities at both the individual and area level. Over the past two decades, low-income and uninsured women have consistently experienced lower mammography use and higher breast cancer-related mortality than their wealthier and insured counterparts (American Cancer Society, 2014; Klassen & Smith, 2011; Missinne, Daenekindt, & Bracke, 2015; Singh, Miller, Hankey, & Edwards, 2003). Because their low SEP both increases the likelihood of negative health exposures and decreases access to resources such as mammography screening, low-income, uninsured women are particularly vulnerable to poor breast health outcomes (Lynch & Kaplan, 2000; Marmot, 2002). The persistence of these mammography screening inequalities suggests that additional efforts to better understand the relationship between social conditions and mammography use may be necessary in order to begin mitigating the underlying social inequalities.

Mammography Research Challenges

Although numerous studies have examined mammography use in the U.S., synthesizing salient conclusions, particularly for subpopulations such as low-income, uninsured women, has been difficult due to frequent modifications to mammography screening guidelines and variable measurement of mammography outcomes. Because screening guidelines have evolved over time, they often have resulted in conflicting recommendations between professional organizations regarding the optimal frequency of screening. Moreover, comparatively evaluating prior mammography research has been complex because of differences in outcome measurement,

which may have contributed to the paucity of mammography systematic reviews and meta-analyses. Consequently, these guideline changes and outcome measurement differences have created challenges assessing the frequency of and adherence to mammography use, leading to ambiguity about the true rates of mammography screening among U.S. women over time.

Mammography Screening Guidelines. Mammography screening is most effective when used regularly to compare changes in the breasts over time in order to detect cancers earlier in the disease process (American Cancer Society, 2014). The definition of 'regular' use, however, has fluctuated. Beginning in the 1980s, national organizations recommended that women over age 40 obtain annual mammograms (National Institutes of Health, 1997). Subsequently, over the next twenty years, multiple organizations including the American Cancer Society (ACS), modified their screening recommendations regarding the definition of proper mammography screening intervals for various age groups, frequently changing from annual to biennial and back to annual again (American Cancer Society, 2015).

In the 2000s, new studies began to emerge providing more information about the long-term efficacy of mammography, with some questioning whether mammography reduced breast cancer-related mortality and many emphasizing increases in false positive rates (Alexander et al., 1999; Gotzsche & Nielsen, 2009; Miller et al., 2014; Nelson et al., 2009). As such, professional organizations began revising their guidelines to better balance the risks and benefits of mammography screening based on these systematic evidence reviews. In 2009, the U.S. Preventive Services Task Force (USPSTF) modified its screening guidelines from annual mammograms for all women over age 40 to biennial mammograms for women ages 50-74 and encouraged women ages 40-49 to speak with their providers about personal risk factors (U.S. Preventive Services Task Force, 2009).

Consequently, many professional and government organizations also modified their recommendations to align with the USPSTF, but the ACS and American College of Radiology continued to advocate for annual mammograms for women over age 40 (American Cancer Society, 2015; American College of Radiology, 2012). In 2015, the ACS modified its mammography screening guidelines, recommending that women ages 45-55 obtain annual mammograms and transition to biennial mammograms at age 55, while also having the option to initiate screening earlier and perform it more often (Oeffinger et al., 2015). Although USPSTF and ACS guidelines are now beginning to align, their prior differences have fostered confusion for women and raised concerns among clinicians and advocacy groups about appropriate intervals for breast cancer screening (Allen et al., 2013). In turn, these changing guidelines also have created challenges for researchers attempting to measure mammography screening adherence in the U.S. (Jiang, Hughes, Appleton, McGinty, & Duszak, 2015).

Mammography Outcome Measurement. Attempts to synthesize research on mammography screening use in the U.S. have also been challenging due to lack of consistency in outcome measurement. Prior research has employed multiple methods to measure mammography use, primarily focusing on the concepts of ever, recent, and repeat mammography. Early investigations initially placed an emphasis on the proportion of women ever receiving a mammogram (Clark, Rakowski, & Bonacore, 2003). Over the past several decades, most mammography research has transitioned to focusing on the timeliness of screening by measuring recent mammogram use, typically defined as having at least one or more mammograms within the past one or two years (Schueler et al., 2008). Discrepancies in the definition of recent mammograms, however, have contributed to difficulties comparing 'timely' use of mammograms across studies with estimates ranging from 30% to 83% depending on age

and poverty level (American Cancer Society, 2014). As a result, many investigators have now advocated for the use of a two-year measure in an attempt to encompass recommendations from most professional organizations (Rakowski et al., 2004).

More recently, researchers have become interested in investigating repeat mammography use as a measure of adherence to screening recommendations. Yet, estimates of repeat use have ranged from 27% to 72% due to variance in screening intervals of 12, 15, 18, 24, and 27 months (Bobo, Shapiro, Schulman, & Wolters, 2004; Clark et al., 2003; Engelman, Ellerbeck, Mayo, Markello, & Ahluwalia, 2004; Rakowski et al., 2004; Ulcickas Yood, McCarthy, Lee, Jacobsen, & Johnson, 1999). When taken together, this information suggests researchers and policymakers should be cognizant of the wide variability in mammography outcomes when comparing study findings and developing efforts to improve mammography screening across the U.S.

Factors Associated with Mammography Use

Individual-Level Factors. Despite these challenges, researchers have documented that many individual-level factors can influence the use of mammography both recently and over time. In a major meta-analysis synthesizing over 200 studies, Schueler et al. (2008) calculated the strongest predictors of mammography use among the general U.S. population were having insurance coverage, a physician recommendation for mammography, and prior cancer screenings (e.g., mammograms, clinical breast exams, pap tests). Moreover, for low-income women, researchers have found that health insurance coverage was significantly associated with their ability to obtain mammograms, suggesting that insurance coverage may play an important role beyond that of income in the attainment of mammography screenings. For instance, Rakowski, Wyn, Breen, Meissner, and Clark (2010) found that near-poor women with incomes 200-299%

FPL had the highest likelihood of irregular mammography screening, compared to poor (<100% FPL) and non-poor women (>300% FPL), with authors suggesting these differences were due to insurance coverage gaps.

Area-Level Factors. Building on previous individual-level studies, researchers have expressed a growing interest over the past decade in the influence of area-level factors, which represent shared life exposures of all who live in a community, on mammography use. Most research exploring this relationship has found area-level measures of SEP, uninsurance, healthcare supply, urbanicity, and minority population composition to be important predictors of mammography use among the general U.S. population (Dailey et al., 2011; Pagan et al., 2008; Pruitt et al., 2009). To date, however, no research has examined the association of area-level characteristics with mammography use in vulnerable populations, including low-income, uninsured women.

Socioeconomic Position (SEP). Several prior studies (*n*=14) have assessed the association of area-level SEP with mammography use, typically finding that as indicators of area-level SEP improved, so did mammography use (Pruitt et al., 2009). Although these studies often tested multiple measures of SEP, the majority (*n*=9) found only one single-dimension measure of area-level SEP to be significantly associated with mammography use, such as poverty level (Calo et al., 2016; Schootman, Jeffe, Baker, & Walker, 2006), household income (Jackson et al., 2009; Rahman, Dignan, & Shelton, 2003; Sabogal, Merrill, & Packel, 2001), or educational attainment (Engelman et al., 2002; Kothari & Birch, 2004; Parker, Gebretsadik, Sabogal, Newman, & Lawson, 1998; Wells & Horm, 1998). The remaining studies (*n*=5) did not document any significant relationships between area-level SEP measures and mammography use (Benjamins,

Kirby, & Bond Huie, 2004; Coughlin & King, 2010; Lian, Jeffe, & Schootman, 2008; Rahman et al., 2003; Rosenberg, Wise, Palmer, Horton, & Adams-Campbell, 2005).

The mixed associations of area-level SEP measures and mammography use may be attributable to differences in study design, statistical modeling (e.g., inconsistent use of multi-level analysis techniques), and outcome measurement (e.g., never, recent, repeat). Although the majority of studies found at least one single-dimension measure of area-level SEP to be significantly associated with mammography use, deriving definitive conclusions about the relationship between area-level SEP and mammography use remains difficult (Pruitt et al., 2009). Moreover, other investigators have suggested that the complexity of the SEP concept may be better captured by using a technique that combines multiple SEP domains into a single measure, such as an index (O'Campo & Burke, 2004; Oakes & Rossi, 2003).

As a result, an emerging area of investigation, with only two studies in the U.S. to-date, has used a nationally-validated SEP composite measure (Krieger et al., 2002) to assess the association of area-level socioeconomic position and mammography screening. Researchers have documented that women living in more disadvantaged areas were 23-37% less likely to engage in repeat mammography screening, regardless of their individual-level characteristics (Dailey et al., 2011). When examining race-specific mammography use, non-Hispanic black women and non-Hispanic white women living in more disadvantaged areas were 1.47-2.51 and 1.36-2.30 times more likely to be nonadherent to age-specific ACS mammography guidelines, respectively (Dailey, Kasl, Holford, Calvocoressi, & Jones, 2007). Collectively, the complexity of these findings suggest that additional research is needed to better understand the relationship between the socioeconomic position of the community and use of mammography screening by residents.

Uninsurance. Health insurance coverage is a critical mechanism facilitating access to healthcare services, including mammography screening (Institute of Medicine, 2009). As such, an emerging area of inquiry has begun exploring the relationship between the proportion of uninsured residents in a community and corresponding healthcare utilization. Researchers have documented that as the uninsurance rate of the community increased, the likelihood of insured adults living there accessing services and feeling satisfied with their care decreased (Gresenz & Escarce, 2011; Pagan & Pauly, 2006; Pauly & Pagan, 2008).

Only one study to-date, however, has applied this concept to mammography screening. Pagan et al. (2008) found that for every 10% increase in the number of uninsured residents in a community, the odds of female residents having a recent mammogram (in the past year) decreased by 17%, regardless of individual insurance status or income level. Although the dynamics of community uninsurance require further investigation, these studies suggest that the financial pressures associated with increasing numbers of residents without insurance coverage may stress local healthcare systems and affect access to care for everyone in the community (Institute of Medicine, 2009).

Other Area-Level Measures. Prior research also has examined the association of non-socioeconomic area-level measures, such as healthcare supply, urbanicity, and minority population composition, with mammography use and has produced conflicting associations. When exploring area-level measures of healthcare supply, such as primary care physicians (PCPs) and mammography facilities, studies have documented inconsistent associations between area-level PCP measures and mammogram use. Some have found that a PCP shortage area (Phillips, Kerlikowske, Baker, Chang, & Brown, 1998) or the number of PCPs (Benjamins et al., 2004; Litaker & Tomolo, 2007) were significant indicators of mammography use, while others

have found no association (Baker, Phillips, Haas, Liang, & Sonneborn, 2004; Coughlin, Leadbetter, Richards, & Sabatino, 2008). Studies assessing area-level mammography facility measures have concluded there was no association between the quantity of facilities and mammography use (Breen et al., 2011; Engelman et al., 2002; Jackson et al., 2009), but did find greater distance to facilities was associated with a lower likelihood of obtaining mammograms (Engelman et al., 2002).

Moreover, although some research has documented no association between population density and mammography use (Engelman et al., 2002; Jackson et al., 2009), a prominent review synthesizing over 200 studies computed that women living in rural areas (compared to non-rural areas) were, on average, 25% less likely (95% CI: 10%-37% reduction) to obtain mammograms, even when accounting for personal characteristics (Schueler et al., 2008). When expanding this density concept to urbanicity, which also includes proximity to metro areas (U.S. Department of Agriculture, 2013b), other research has documented that women in metro and suburban areas were 1.18-1.28 times more likely (95% CI=1.10-1.26 and 95% CI=1.17-1.40, respectively) to receive recent mammograms than women in rural areas with decreased proximity to metro areas (Coughlin et al., 2008; Coughlin, Thompson, Hall, Logan, & Uhler, 2002).

Finally, several other studies have examined the association between measures of minority population composition and mammography use, producing conflicting results. Some studies reported mammography use increased as the non-Hispanic black population increased (Benjamins et al., 2004; Coughlin et al., 2008), while others documented decreased use as the Hispanic population increased (Calo et al., 2016; Parker et al., 1998; Wells & Horm, 1998). Moreover, other research has reported no association at all (Baker et al., 2004; Rosenberg et al., 2005; Sabogal et al., 2001). When taken together, these results suggest that researchers should

consider also accounting for non-socioeconomic characteristics of geographic areas to more comprehensively analyze characteristics associated with mammography use.

Mammography Policy Efforts

Over the past two decades, policymakers have made several attempts to expand access to mammography for low-income, uninsured women in the U.S. In 1991, the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) was established to provide free breast and cervical cancer screening and links to treatment for low-income women across the U.S. (Centers for Disease Control and Prevention, 2015). More recently, the Patient Protection and Affordable Care Act (ACA) was enacted in 2010 to expand insurance coverage nationally (U.S. Department of Health & Human Services, 2015). Despite these efforts, however, low-income, uninsured women remain a vulnerable population at risk of not receiving timely mammograms.

National Breast and Cervical Cancer Early Detection Program (NBCCEDP). While not comprehensive insurance coverage, the NBCCEDP program was established to provide free breast and cervical cancer screenings, diagnostic services, and direct links to treatment via state Medicaid programs for low-income, uninsured women in all fifty states (Centers for Disease Control and Prevention, 2015). Over the past three decades, NBCCEDP has served more than 4.6 million women, providing mammography services to nearly 350,000 in the 2013 fiscal year alone (Centers for Disease Control and Prevention, 2014). Although state programs operate under a national framework, they are allowed to modify eligibility criteria based on local need, preferences, and funding levels. In the Kansas program, known as Early Detection Works (EDW), women ages 40-64 with incomes under 225% FPL and no functional insurance (i.e., have no insurance or an unmet deductible over $2,500) are eligible to apply for mammography

services (Kansas Department of Health & Environment, 2014b). Even though the EDW Program follows the USPSTF biennial mammography screening recommendations, annual mammograms are provided for women who meet program eligibility criteria.

Although nearly five million women across the U.S. are projected to be eligible for NBCCEDP services (Howard et al., 2015), only a subset are actually receiving them. Current estimates suggest that 10-15% of eligible women are being served (Centers for Disease Control and Prevention, 2014; Howard et al., 2015), with rates varying substantially by race/ethnicity (3-49%) and across states (2-79%) (Tangka et al., 2006). In Kansas, EDW administrators have estimated that approximately 15% of eligible women have received mammography screening services annually via the program (Snyder, October 15, 2014). Even though NBCCEDP services are currently reaching only a small proportion of eligible women, researchers have estimated that if insurance coverage were fully expanded as the ACA had originally intended (e.g., best-case scenario), NBCCEDP still would be necessary to support nearly 1.7 million low-income women ages 40-64 who would fall into coverage gaps between Medicaid and private insurance coverage (Levy et al., 2012). In particular, the majority of women who would still qualify for NBCCEDP services would include those who could not purchase insurance with marketplace subsidies due to cost or who were ineligible for government insurance due to their immigrant status (Garfield, Damico, Cox, Claxton, & Levitt, 2016). Together, these estimates suggest that substantial need remains for mammography screening services among low-income women in the U.S.

Patient Protection and Affordable Care Act (ACA). More recently, the ACA has attempted to increase national health insurance coverage using a three-part approach of 1) expanding state Medicaid programs (up to 138% of the federal poverty level [FPL]), 2) providing subsidies for individuals 100-400% FPL to purchase insurance, and 3) building on the

current employer-based insurance system (U.S. Department of Health & Human Services, 2015). Although nearly nine million nonelderly adults have become insured under these changes since 2013, declines in uninsurance rates have varied widely across the U.S., primarily due to state Medicaid expansion decisions (Kaiser Family Foundation, 2015a).

For the poorest U.S. adults, uninsurance rates have dropped significantly in states expanding their Medicaid programs, while these rates have remained nearly unchanged in non-expansion states (Collins, Rasmussen, & Doty, 2014; Majerol, Newkirk, & Garfield, 2015). In the 19 non-expansion states, such as Kansas, the poorest women (with incomes under 100% FPL) fall into a coverage gap between governmental programs and private insurance (Kaiser Family Foundation, 2014). Although not an obvious consequence of non-expansion, recent research has extended the problem of insufficient Medicaid coverage beyond the individual, estimating that women living in non-expansion states had significantly lower odds of receiving mammograms than women living in states expanding Medicaid programs, regardless of their own insurance status (Sabik, Tarazi, & Bradley, 2015).

To apply for Medicaid coverage in Kansas, parents must have incomes below 38% FPL (under $10,000 annual income for a family of four), while adults without children remain ineligible regardless of their income level (Kaiser Family Foundation, 2014). Even though exchange marketplaces have been established for adults with incomes 100-400% FPL to purchase subsidized insurance, over 80,000 uninsured Kansas adults with incomes under 100% FPL (under $24,300 annual income for a family of four) have no health insurance options (Kaiser Family Foundation, 2014). Moreover, other Kansas women are also unable to obtain health insurance due to their immigrant status or relatively low incomes (100-250% FPL) that do not enable them to purchase subsidized insurance (Garfield et al., 2016). Consequently, in

Medicaid non-expansion states, NBCCEDP services have become especially important conduits to help women in these coverage gaps access mammography screening (Levy et al., 2012).

Conclusion

In the U.S., mammography screening among low-income, uninsured women continues to lag behind women with higher incomes and insurance coverage. Although many factors have been studied, researchers have been increasingly interested in the role of area-level characteristics in the use of mammography screening. In particular, low-income, uninsured women may have a greater need to rely on the resources in their communities, such as free screening programs, because they have fewer personal resources with which to access healthcare services. Despite NBCCEDP and ACA policy efforts to extend access to screening mammography to vulnerable populations, only a subset of eligible women are receiving them. Moreover, in Medicaid non-expansion states, such as Kansas, NBCCEDP services have become ever more critical to help women who fall into coverage gaps between government programs and private insurance access mammography screening. Therefore, having a better understanding of the role community-level SEP and uninsurance play in the use of screening mammography among this vulnerable population is an important step towards mitigating breast cancer-related health disparities.

Chapter 3: Mammography Utilization Among Low-Income Women in Kansas, 2009-2014 (Paper 1)

Introduction

Although breast cancer-related mortality rates have declined by nearly 30% over the past three decades, breast cancer continues to comprise nearly one-third of all malignancies diagnosed among U.S. women (Berry et al., 2005; Howlader et al., 2013). Early detection with mammography is one of the most important factors influencing survival (Berry et al., 2005; Breen et al., 2011). However, mammography screening has not been experienced consistently across all population groups. Over the past decade, national health surveys have revealed that poor (<100% federal poverty level [FPL]) and near-poor (100-199% FPL) women reported nearly 30% fewer mammograms than non-poor women (>400% FPL) (Breen et al., 2011; National Center for Health Statistics, 2013). These findings also have been replicated at the state level, with Kansas women reporting significantly fewer mammograms as their income and insurance coverage decreased (Behavioral Risk Factor Surveillance System, 2013). Because low-income and uninsured women continue to exhibit lower mammography use than their wealthier and insured counterparts, researchers have been increasingly interested in the role broader social conditions, such as the socioeconomic position (SEP) and insurance coverage of a community, may play in facilitating the use of screening mammography (American Cancer Society, 2014; Klassen & Smith, 2011; Singh et al., 2003).

Over the past decade, studies have explored the relationship of area-level characteristics and mammography use across the U.S., with most demonstrating that as area-level SEP improved, so did mammography use (Pruitt et al., 2009). However, the majority of these studies only examined the association of single-dimension measures of area-level SEP with

mammography use, such as poverty level (Schootman et al., 2006), household income (Jackson et al., 2009; Rahman et al., 2003), or educational attainment (Engelman et al., 2002; Parker et al., 1998; Wells & Horm, 1998). Although each study identified important associations, the complexity of the SEP concept suggests that the economic position of an area may be better captured by a more comprehensive measure that combines multiple domains into a single measure, such as an index (O'Campo & Burke, 2004; Oakes & Rossi, 2003). As a result, an emerging area of study has begun exploring the association of area-level SEP indices and mammography screening.

In the general U.S. population, researchers have documented that higher area-level socioeconomic deprivation (as measured by an SEP index) was independently associated with mammography screening non-adherence (Dailey et al., 2011; Dailey et al., 2007). Yet, there is reason to believe that the SEP of an community may particularly impact low-income women's use of preventive screening services. Because low SEP both increases the likelihood of negative health exposures and decreases access to healthcare resources, low-income women are at particular risk for poor health outcomes and often have to rely on healthcare and socioeconomic resources of the surrounding community (Daniels, 2008; Link & Phelan, 1995; Lynch & Kaplan, 2000). Additionally, because of the critical role insurance plays in facilitating access to healthcare services, including mammography screening, low-income women without health insurance are a highly vulnerable, policy-relevant group (Heymann, 2000; Starfield & Shi, 2004). Despite recent health reform efforts, low-income women still fall into coverage gaps between government programs and private insurance (Kaiser Family Foundation, 2013; Levy et al., 2012). To date, however, no studies (including the previously referenced studies) have examined how area-level SEP *and* area-level insurance coverage may affect mammography use

among low-income, uninsured women. Despite previous research, much remains to be understood about factors that influence low-income, uninsured women's use of mammography, particularly in Kansas, a predominantly rural state with potential mammography access challenges that has chosen not to expand Medicaid coverage to low-income adults (Kaiser Family Foundation, 2015c).

One opportunity to explore mammography utilization among low-income, uninsured women in the U.S. may be through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP). Instituted in 1991 and sponsored by the Centers for Disease Control and Prevention (CDC), the program is an attempt to increase access to cancer screening for low-income women. As such, NBCCEDP provides free breast and cervical cancer screenings, diagnostic services, and links to treatment via state Medicaid programs for low-income women in all fifty states (Centers for Disease Control and Prevention, 2002). However, NBCCEDP does not offer insurance coverage for other primary or preventive care services, leaving participants uninsured for all other health issues, potentially widening other health disparities (Agency for Healthcare Research and Quality, 2011; Centers for Disease Control and Prevention, 2014). Nevertheless, several researchers have documented that these state programs have increased mammography use and reduced breast cancer-related deaths nationally for more than 4.6 million low-income women over the past two decades (Hoerger et al., 2011; Howard et al., 2010).

Even though state NBCCEDP programs operate under a national framework, each has separate eligibility criteria based on local need, preferences, and funding (Centers for Disease Control and Prevention, 2015). In the Kansas program, titled Early Detection Works (EDW), mammography services have been provided to enrolled women ages 40-64 with incomes under 225% FPL and no functional insurance (i.e., no insurance or unmet deductible over $2,500) since

1997 (Kansas Department of Health & Environment, 2014b). Although the EDW program seeks to provide services to all eligible women, program administrators estimate it reaches nearly 15% of potentially eligible women per year. Moreover, the EDW program has experienced fiscal constraints that have resulted in program delivery limitations, such as capping enrollment in Program Year 2012 (7/1/2011-6/31/2012), which resulted in 20% reduced enrollment (Snyder, October 15, 2014). Yet, EDW remains an important conduit for many women to receive cancer screening services, as these limitations suggest substantial unmet need for mammography screening by low-income women continues to persist (Levy et al., 2012). As such, additional targeting strategies may be warranted to best utilize limited resources and identify geographic areas most in need. However, no research to-date (nationally or at the state level) has explored the relationship between area-level characteristics of where NBCCEDP participants reside and their use of screening mammography.

Although evidence suggests programs to reduce cancer health disparities, such as EDW, are improving access to mammography for women across the U.S. (Hoerger et al., 2011; Howard et al., 2010), many low-income women are still in need of screening services (Howard et al., 2015). As such, much remains to be learned about the use of breast cancer screening services among vulnerable populations, particularly low-income, uninsured women. Because these women are at greater risk for lower mammography use and poorer breast cancer prognosis than women with more economic resources or insurance coverage, improving understanding of the relationship between area-level socioeconomic deprivation, insurance coverage, and mammography use among low-income women is an important step toward increasing breast cancer screening and potentially reducing cancer disparities. Therefore, the purpose of this study was to examine to what extent county-level socioeconomic characteristics were associated with

screening mammography use among low-income, uninsured women in Kansas who participated in a free mammography screening program over multiple screening intervals.

Hypothesis

Because of greater need for cancer screening services in geographic areas with higher levels of socioeconomic deprivation and uninsured residents, this study hypothesized that as county-level socioeconomic deprivation and uninsurance levels increased, so would mammography use among EDW program participants at two-, four-, and six-year screening intervals. Both recent and repeat mammography outcomes were explored to determine if county-level characteristics were similarly associated for current and adherent mammography screening.

Methods

Study Design and Data Sources. A cross-sectional retrospective design was employed to assess the relationship of county characteristics and mammography use among low-income women in Kansas. To do this, data were obtained from three different sources to characterize each county. First, sociodemographic and economic information were gathered from the 2014 release of Area Health Resource Files (AHRF) for all 105 Kansas counties using the Federal Information Processing Standards (FIPS) code of 20 for Kansas. AHRF is a collection of socioeconomic and health resource measures that characterize the environment in which healthcare services are delivered across the U.S. New data are released annually and based on estimates from the most recent U.S. Census. For this study, estimates were based on the 2010 Census (Health Resources and Services Administration, 2013).

Next, since the U.S. Food and Drug Administration (FDA) requires radiation-emitting machines to be certified, counts of all mammography facilities (permanent and mobile units) in Kansas for 2013 were obtained from the FDA's Mammography Facilities Database using the zip code for each facility to classify it into the corresponding county. This database provides information only for current facilities, so no information was available for mammography facilities prior to 2013 (U.S. Food and Drug Administration, 2014). Finally, information on mammography use among low-income Kansas women (<225% FPL), ages 40-64, who were uninsured or underinsured (no insurance or hospitalization only insurance with deductible over $2,500) were obtained from clinical service data from the Kansas EDW program (Kansas Department of Health & Environment, 2014a). Encounter-level service claims data for all clinical breast exams (CBEs), mammograms, and pap tests performed by EDW providers were gathered for all women who had enrolled in the program from 2009-2014.

IRB Approval. This study was approved by the University of Kansas School of Medicine's Institutional Review Board (IRB) with a Health Insurance Portability and Accountability Act (HIPAA) privacy waiver (IRB #00002605). Access to the EDW program administrative and clinical service data was obtained through an approved data use agreement with the Kansas Department of Health and Environment (KDHE).

Dependent Variables. Clinical data on mammogram use by EDW program participants from 2009-2014 were used to construct three continuous dependent variables for this study in accordance with published literature using 24-month screening intervals: rates of recent mammograms at a two-year interval and repeat mammograms at four- and six-year intervals. First, encounter-level data on EDW mammograms performed from 2009-2014 were aggregated at the person-level and flags were created to obtain counts of mammograms per participant per

year. Next, participants were classified as 'recent users' if they had at least one EDW mammogram in the past 24 months (2013-2014) (Breen et al., 2011; Howard & Adams, 2012). Similarly, participants were classified as four-year 'repeat users' if they had at least one EDW mammogram every 24 months for the past 48 months (2011-2014) and six-year 'repeat users' if they had at least one EDW mammogram every 24 months for the past 72 months (2009-2014) (Rakowski et al., 2004; Rakowski et al., 2006). Participants without an EDW mammogram during the study years were excluded from analyses. Therefore, this study only focused on EDW mammography users and did not include information about non-users.

Counts of person-level mammogram use were then aggregated at the county-level by year based on each participant's most recent county of residence on file with the EDW program. These counts were appended to the county-level demographic and socioeconomic data using unique county FIPS codes (U.S. Census Bureau, 2010). Next, annual EDW mammogram rates for the six analysis years were calculated by summing the total number of participants who received EDW mammograms in each county, dividing by the total number of women ages 40-64 (i.e., the general mammogram-eligible population) residing in that county, and multiplying by 1,000 to enable valid cross-county and cross-year comparisons (Friis, 2010).[1] Finally, to create

[1] Two methods were explored to calculate the final mammogram rates for this study. Since annual population estimates are based on decennial U.S. Census data, county-level counts of women ages 40-64 in 2010 (most recent census population) were first used as a static denominator across the six analysis years (U.S. Census Bureau, 2014b). Then, unique annual county-level counts of women ages 40-64 were obtained and used as the denominator for the six analysis years. Overall, there were no significant differences between recent and repeat mammogram rates using the two different denominator methodologies. An alternative method to calculate rates of mammography use among low-income, uninsured women would have been to obtain counts of all EDW-eligible women (e.g., uninsured women ages 40-64 with incomes <225% FPL) to use as each county's denominator. However, public data was not available to precisely estimate these counts at the county level, so the unique annual county population counts for women ages 40-64 were retained as the final denominators for this study to ensure rate fluctuations were captured for each county.

county-level rates of recent, four-year repeat, and six-year repeat mammograms, each county's final denominator population was calculated as the average number of women ages 40-64 residing there during all corresponding years. For instance, for the recent mammogram outcome, the final denominator was the number of women ages 40-64 living in each county during the two analysis years (2013 and 2014), divided by two.

Independent Variables. Independent variables examined in this study were county socioeconomic deprivation, uninsurance level, urbanicity, healthcare supply, and minority composition. County socioeconomic deprivation and uninsurance variables were the primary focus of study analyses, while the other county characteristics were used as control variables. Each measure is described in detail below.

Socioeconomic Deprivation. To quantify the level of county socioeconomic deprivation, a composite measure of six social and economic variables, known as the socioeconomic position (SEP) index, was created for each county following the methodology of Krieger et al. (2002) and Dailey et al. (2011). Variables included in the index were: 1) median household income, 2) median housing value, 3) percentage of residents below FPL, 4) percentage without high school education (age 25+), 5) percentage unemployed, and 6) percentage working class. County-level five-year average values (2008-2012) were utilized for all six variables. The first four variables were obtained directly from AHRF data, while the fifth and sixth variables were constructed using only AHRF data in the calculations.

The percentage of unemployed workers for 2008-2012 was calculated by dividing the number of unemployed workers by the total civilian labor force during the same years. Similar to the methodology of other studies, the percentage of working class individuals was calculated by summing workers in agriculture/forestry/mining, construction, and manufacturing occupations

and dividing by the number of workers in all occupations during 2008-2012 (Becker, 2006). Measures for median household income and median home value were reversed, so that a higher index value would indicate a higher level of socioeconomic deprivation. Standardized z-scores were calculated for each variable and summed to create a total composite index score for each county. For ease of interpretation, the SEP index scores were centered and divided into quartiles with Q1 indicating the least socioeconomic deprivation and Q4 representing the most.

Uninsurance. Similar to the Pagan et al. (2008) study, proportions of uninsured residents under age 65 were obtained directly from AHRF data for each county for individual years from 2008 to 2012. To align with the other socioeconomic variables, five-year average estimates of the proportion of uninsured residents under age 65 were calculated for each county by summing uninsurance measures for all years and dividing by five. Resulting uninsurance percentages were then divided into quartiles with Q1 indicating least uninsurance and Q4 representing the most.

Urbanicity, Healthcare Supply, and Minority Composition. To account for county characteristics that may have represented shared exposures for all EDW participants (Benjamins et al., 2004; Litaker & Tomolo, 2007; Mobley, Kuo, Driscoll, Clayton, & Anselin, 2008), measures of county urbanicity, healthcare supply, and minority population composition were included as control variables. Counties were classified by urbanicity using the 2013 version of the Rural-Urban Continuum Code (RUCC), which is based on the most recent U.S. Census (U.S. Department of Agriculture, 2013b). Counties were first classified into one of nine categories from metro (1) to rural (9) based on a combination of population density and proximity to metro areas. For study analyses, counties were further grouped into metro (classifications 1-3), non-metro (classifications 4-7), and rural (classifications 8-9) categories using grouping definitions

provided by the U.S. Department of Agriculture (2013b).[2] Rural counties were chosen as the reference group because they were a large urbanicity group.

Measures of healthcare supply focused on availability of mammography facilities and primary care physicians (PCPs). Rates were calculated by dividing counts of mammography facilities and PCPs by the total number of adult women and total population per county, respectively, and multiplying by 10,000 to enable valid cross-county comparisons (Friis, 2010). Measures of minority population composition were obtained directly from 2010 AHRF data for the percentage of Black and Hispanic population in each county.

Study Analyses. Two-dimensional geographic maps of Kansas were first created to visualize the distribution of recent EDW mammogram use across the state. Only the recent mammogram outcome was mapped because it had the largest study population of the three mammogram outcomes, allowing for inclusion of the most counties. In the first map, counties were labeled with recent mammography rates and shaded by recent mammography rate quartiles, with the lightest color representing counties with the lowest rates (Q1) and the darkest color representing counties with the highest rates (Q4) of mammography. While retaining the same mammography rate labels, counties were then shaded by socioeconomic deprivation and

[2] The population density classification scheme developed by the Kansas Department of Health and Environment was also considered for use in this study. Although this classification was developed to more precisely characterize the unique density nuances of Kansas counties, the methodology only focused on population density and did not account for proximity to metro areas (Institute for Policy and Social Research, 2014). Since county geographic boundaries may not reflect the underlying travel and healthcare use patterns of the population, the Rural-Urban Continuum Codes (RUCC) from the U.S. Department of Agriculture were selected as final the urbanicity classification scheme for this study because it accounts for both population density and proximity to metro areas (U.S. Department of Agriculture, 2013b). Additional analyses were performed to explore the applicability of the RUCC grouping choices, specifically the individual categories included in the non-metro and rural groups. When categories 6 and 7 were shifted from non-metro to rural groups, analysis results confirmed that the overall study findings remained consistent, even though significance levels decreased slightly.

uninsurance quartiles using the same color methodology in order to explore the relationship between the socioeconomic standing and insurance level of a county and mammography use. All maps were created using the GMAP Procedure of SAS version 9.4 (SAS Institute Inc., 2013).

Next, descriptive analyses were performed to examine differences in county characteristics by levels of socioeconomic deprivation and uninsurance. Then, county-level rates of recent, four-year repeat, and six-year repeat mammograms were characterized by socioeconomic deprivation and uninsurance quartiles. One-way ANOVAs were used to test for statistical differences in the means of county characteristics and mammogram rates by socioeconomic deprivation and uninsurance quartiles. Chi-square statistics were conducted to test for statistical differences in the distribution of counties by urbanicity across socioeconomic deprivation and uninsurance quartiles. Finally, unadjusted and adjusted linear regression analyses using the least squares estimation method were performed to assess relationships between county characteristics and mammography rates. Unadjusted regressions were first conducted for each variable as a single predictor of recent, four-year repeat, and six-year repeat mammography.

Finally, all predictors were entered simultaneously into multiple linear regressions for each outcome (recent, four-year repeat, and six-year repeat EDW mammography rates) using the following equation:

$$\begin{aligned} EDW_{RATE} = {} & b_0 + b_1*METRO + b_2*NMETRO + b_3*PBLACK + b_4*PHISP + b_5*MFRATE \\ & + b_6*PCPRATE + b_7*SEP + b_8*UNIS + \varepsilon_i \end{aligned}$$

where EDW_{RATE} was the rate of EDW mammograms for each of the three outcomes across all Kansas counties and b_0 was the average rate of EDW mammograms across all Kansas counties when all predictors had a value of zero. METRO and NMETRO were dummy variables for county urbanicity, PBLACK and PHISP were the county proportion of Black and Hispanic

residents, MFRATE was the number of mammography facilities per 10,000 adult female residents, PCPRATE was the number of PCPs per 10,000 county residents, SEP was the county socioeconomic deprivation index score (mean centered), UNIS was the proportion of uninsured county residents, and ε_i represented the residual variance. All analyses were performed using SPSS version 23 (IBM Corp, 2014) and a *p*-value of <0.05 was used to determine statistical significance.

Results

Mammography Maps. The average county-level recent EDW mammography rate was 14.1 (95% CI=11.9-16.4) per 1,000 women ages 40-64, but ranged from 0.0 to 58.6. Rates of recent mammograms tended to be highest in the southwest corner of Kansas (darkest shading), in addition to a few counties throughout the middle of the state (Figure 1A). Conversely, the counties with the highest socioeconomic deprivation were concentrated in the southeast corner of Kansas (Figure 1B, with darker shading indicating higher deprivation). However, when counties were shaded by uninsurance quartile, those with the highest uninsurance tended to be located in the western third of the state, which also encompassed the areas of highest recent mammogram rates (Figure 1C). Overall, the uninsurance quartiles appeared to more closely align with recent EDW mammography use than the socioeconomic deprivation quartiles.

Figure 1A: Recent Mammogram Rates in EDW Program (per 1,000 Women Ages 40-64) across Kansas by Mammography Rate Quartile, 2013-2014

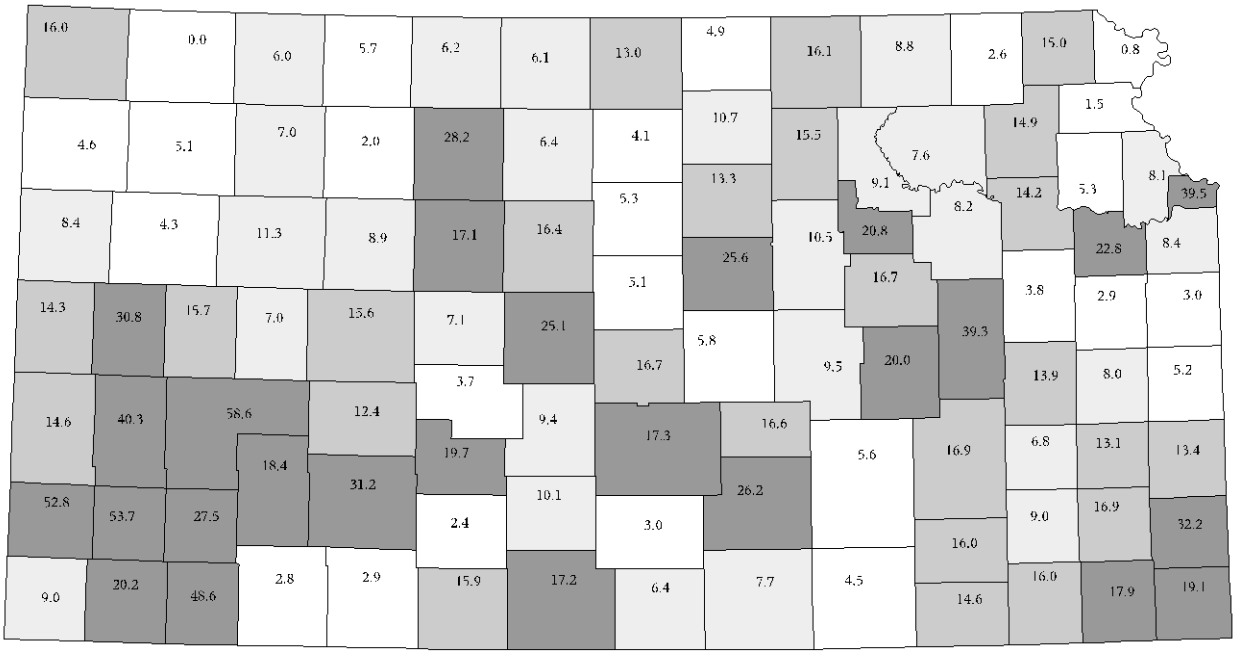


Figure 1A Legend: Recent Mammogram Rate Quartiles

- Quartile 1: 0.0-5.8 (lowest)
- Quartile 2: 6.0-11.3
- Quartile 3: 12.4-16.9
- Quartile 4: 17.1-58.6 (highest)

Figure 1B: Recent Mammogram Rates in EDW Program (per 1,000 Women Ages 40-64) across Kansas by Socioeconomic Deprivation Quartile, 2013-2014

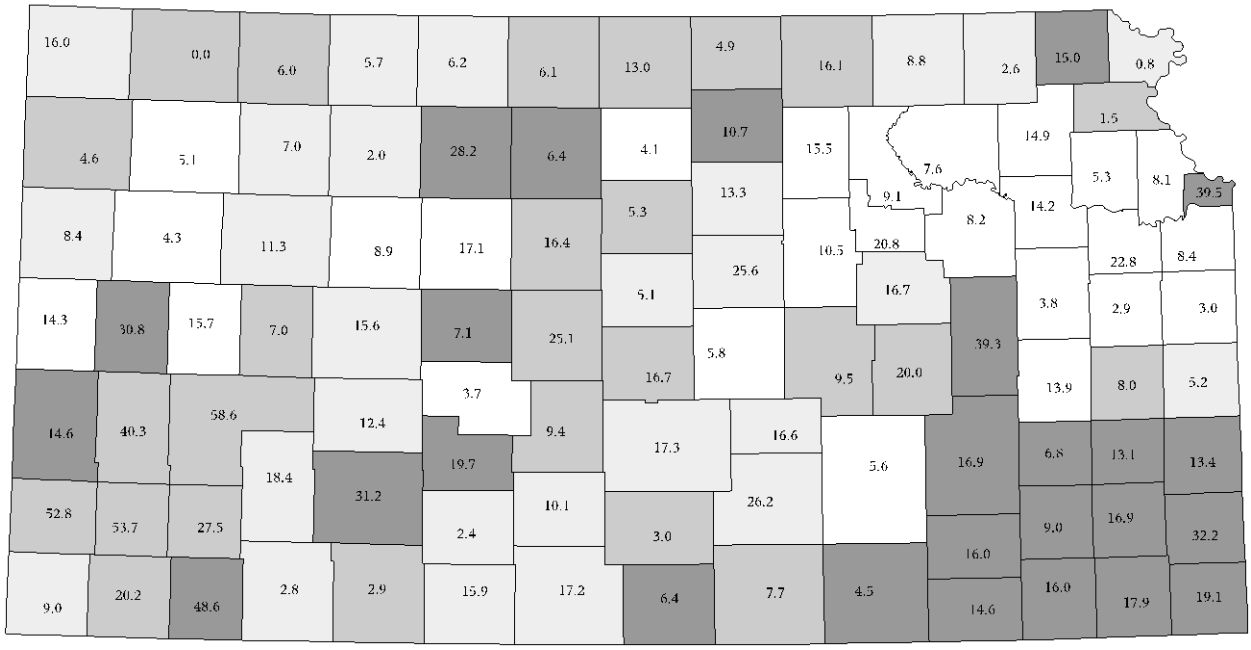


Figure 1B Legend: Socioeconomic Deprivation Index Score Quartiles

- Quartile 1: 0.0-12.1 (lowest)
- Quartile 2: 12.3-13.8
- Quartile 3: 13.9-15.6
- Quartile 4: 15.7-22.6 (highest)

Figure 1C: Recent Mammogram Rates in EDW Program (per 1,000 Women Ages 40-64) across Kansas by Uninsurance Quartile, 2013-2014

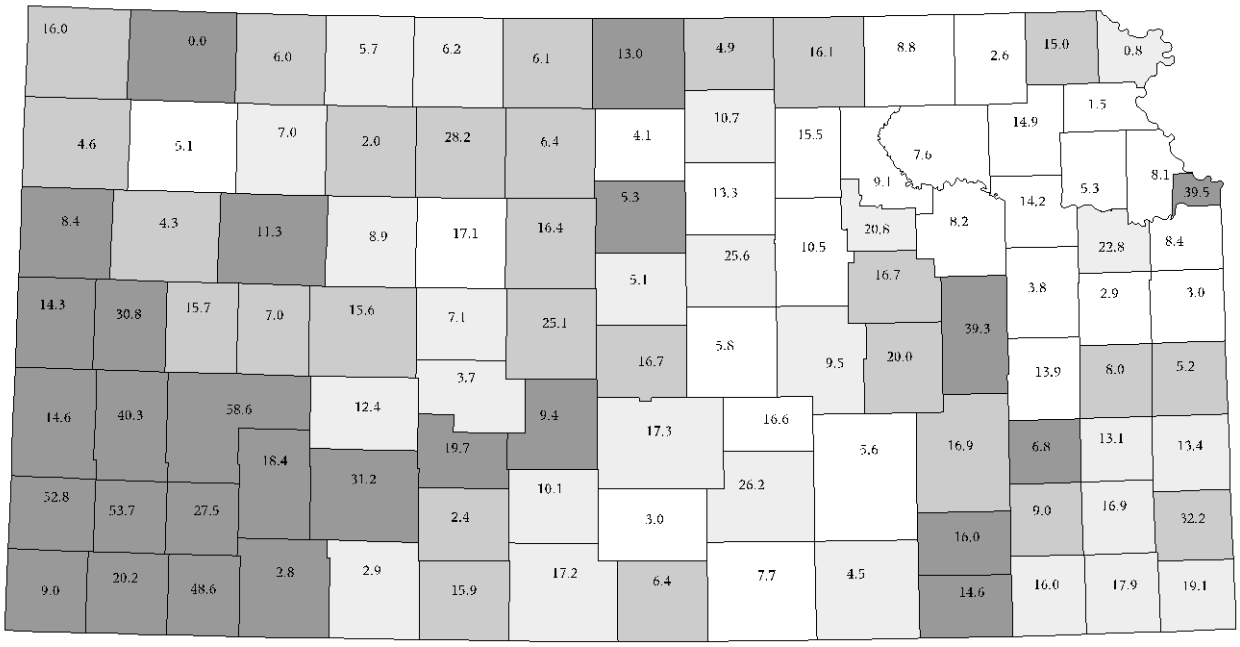


Figure 1C Legend: Percent of Uninsured Resident Quartiles

- Quartile 1: 9.6%-14.4% (lowest)
- Quartile 2: 14.5%-16.0%
- Quartile 3: 16.2%-18.1%
- Quartile 4: 18.2%-25.8% (highest)

Figure Captions: The maps are interpreted using the same approach for all three figures, such that the lightest shade corresponds with the lowest values (Q1) and the darkest shade corresponds with the highest values (Q4). All figures depict recent EDW mammogram rates (numbers in each county) and are shaded by mammogram rates split into quartiles (Figure 1A), socioeconomic deprivation quartiles (Figure 1B), or uninsurance quartiles (Figure 1C).

County Characteristics. Kansas counties (*n*=105) were categorized into three urbanicity groups based on RUCC classifications (Table 1). Metro counties (*n*=19) had an average population density of 204.6 people per square mile (PPSM), while non-metro counties (*n*=44) had 25.2 PPSM, and rural counties (*n*=42) had 4.3 PPSM ($p<0.001$). There were 116 mammography facilities in Kansas with an average of 1.2 facilities per 10,000 adult female county residents (95% CI=0.9-1.5) and 2,026 PCPs with an average of 5.8 PCPs per 10,000 county residents (95% CI=5.1-6.4). It is important to note, however, that 42 counties had no registered mammography facilities and six counties had no PCPs according to the American Medical Association's Physician Master File (Health Resources and Services Administration, 2013).

On average, Kansas county populations were 9% Hispanic and 2% Black, although these proportions varied widely across counties from 1% to 57% for Hispanic populations and 1% to 25% for Black populations. The six variables characterizing various socioeconomic aspects of counties (information shown in Table 1 for descriptive purposes only) were combined to create a composite measure of deprivation, known as the SEP index, with an average score of 13.7 (95% CI=13.1-14.4). Finally, on average, 16.5% (95% CI=15.9%-17.0%) of Kansas county residents were uninsured, although this ranged from 9.6% to 25.0% across the state.

Table 1: Characteristics of Kansas Counties (*n*=105), 2008-2012	
Demographic, 2010	
Urbanicity Group[1]	
Metro County, n (%)	19 (18.1%)
Non-Metro County, n (%)	44 (41.9%)
Rural County, n (%)	42 (40.0%)
Mammogram Facilities (per 10,000 adult women),[2] mean (95% CI)	1.2 (0.9, 1.5)
Primary Care Physicians (PCPs per 10,000 residents), mean (95% CI)	5.8 (5.1, 6.4)
% Black, mean (95% CI)	1.8 (1.2, 2.5)

% Hispanic, mean (95% CI)	8.5 (6.3, 10.7)
Socioeconomic, 2008-2012	
Socioeconomic Position (SEP) Index Score, mean (95% CI)	13.7 (13.1, 14.4)
Median Household Income, mean (95% CI)	$45,812 ($44,519, $47,105)
Median Housing Value, mean (95% CI)	$85,251 ($79,373, $91,129)
% Below Federal Poverty Level (FPL), mean (95% CI)	12.6 (11.8, 13.4)
% No HS Education, mean (95% CI)	11.8 (10.7, 12.9)
% Unemployed, mean (95% CI)	4.9 (4.5, 5.4)
% Working Class, mean (95% CI)	29.8 (28.5, 31.0)
% Uninsured, mean (95% CI)	16.5 (15.9, 17.0)

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-Metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Mammogram facilities data is based on the most recent available information from 2013.

Mammography Rates by Socioeconomic Deprivation and Uninsurance. On average, 14.1 per 1,000 women ages 40-64 received at least one EDW mammogram in 2013-2014, although recent EDW mammogram rates varied widely across counties from 0.0 to 58.6 (Table 2). Less than half of the recent users (5.7/1,000 women ages 40-64) received at least one EDW mammogram every two years from 2011-2014, although four-year repeat EDW mammogram rates varied from 0.0 to 31.2. Finally, nearly half of the four-year repeat users (3.2/1,000 women ages 40-64) received at least one EDW mammogram every two years from 2009-2014, with six-year repeat EDW mammogram rates varying the least from 0.0 to 23.4 across counties.

When examining EDW mammography use by socioeconomic deprivation quartiles, one-way ANOVA analyses uncovered a notable median split, such that counties with lower-than-average deprivation (Q1 and Q2) had lower rates of recent and four-year repeat mammography use (p=0.01 and p=0.04, respectively) than counties with higher-than-average socioeconomic deprivation (Q3 and Q4), although this split was only approaching significance for six-year

repeat mammograms (p=0.08). When examining mammography use by uninsurance quartiles, one-way ANOVA analyses indicated that counties with the lowest uninsurance levels (Q1) had significantly lower recent and repeat mammography rates than other quartiles, while mammography rates in counties with the most uninsurance (Q4) were significantly higher, and mammogram rates were similar for the middle two quartiles (all p-values <0.001).

Table 2: Mammography Rates per 1,000 Women Ages 40-64 across Kansas by Socioeconomic Deprivation and Uninsurance Quartiles, 2009-2014

Characteristic	**Recent Mammogram Rate** (2013-2014, *n*=105) mean (95% CI)	**Four-Year Repeat Mammogram Rate** (2011-2014, *n*=105) mean (95% CI)	**Six-Year Repeat Mammogram Rate** (2009-2014, *n*=105) mean (95% CI)
All Counties	14.1 (11.9, 16.4)	5.7 (4.5, 6.9)	3.2 (2.4, 3.9)
County Socioeconomic Deprivation			
Q1 (least)	9.7 (7.4, 12.0)	3.4 (2.2, 4.5)	1.7 (1.1, 2.4)
Q2	11.1 (8.3, 13.8)	4.8 (3.2, 6.4)	2.8 (1.8, 3.7)
Q3	16.8 (10.0, 23.6)	7.2 (3.5, 11.0)	4.0 (1.7, 6.4)
Q4 (most)	19.0 (14.3, 23.7)	7.4 (5.0, 9.7)	4.1 (2.6, 5.7)
F (*df*)	4.16 (3)*	2.81 (3)*	2.34 (3)$^{+}$
County Uninsurance			
Q1 (least)	8.3 6.4, 10.3)	3.1 (2.1, 4.1)	1.6 (1.0, 2.3)
Q2	12.3 (9.4, 15.2)	4.9 (3.6, 6.2)	2.6 (1.7, 3.4)
Q3	12.5 (9.4, 15.7)	4.5 (2.9, 6.2)	10.2 (6.4, 14.0)
Q4 (most)	23.3 (16.4, 30.3)	2.4 (1.5, 3.3)	6.0 (3.6, 8.5)
F (*df*)	9.94 (3)**	8.23 (3)**	8.26 (3)**

**p<0.001, *p<0.05, +p<0.10 (approaching significance)

County Characteristics by Socioeconomic Deprivation and Uninsurance. Results of one-way ANOVA and chi-square analyses examining whether county characteristics significantly differed by level of socioeconomic deprivation are presented in Table 3. Similarly, Table 4 presents results of one-way ANOVA and chi-square analyses for counties with differing levels of uninsurance. According to RUCC classification, nearly 20% of Kansas counties were considered metro (n=19) with an average population density of 204.6 people per square mile (PPSM). Forty percent of Kansas counties were classified as non-metro (n=44) with 25.2 PPSM and 40% were classified as rural (n=42) with 4.3 PPSM (p<0.001). Results of chi-square analyses showed that the majority of metro counties had the lowest levels of socioeconomic deprivation and uninsurance (Q1). Non-metro counties tended to have the highest levels of socioeconomic deprivation (Q3 and Q4), but only moderate levels of uninsurance (Q2 and Q3). Conversely, rural counties had moderate levels of socioeconomic deprivation (Q2 and Q3), but the highest levels of uninsurance (Q3 and Q4; all p-values <0.001).

Results from one-way ANOVA analyses indicated that counties with higher levels of socioeconomic deprivation (p=0.06) and uninsurance (p<0.001) had higher proportions of Hispanic populations, although there were no significant differences in the proportion of Black populations across counties. In terms of healthcare supply, there were an average of 5.8 PCPs per 10,000 residents (95% CI=5.1-6.4) and 1.2 mammography facilities per 10,000 adult female residents (95% CI=0.9-1.5) across all Kansas counties. Counties with lower levels of socioeconomic deprivation tended to have higher PCP rates (p=0.05), while there were no significant differences in PCP rates across uninsurance quartiles. Although there were no differences in mammography facility rates across socioeconomic deprivation quartiles, there

were significant differences across uninsurance quartiles with the highest levels of uninsurance having the lowest rates of mammography facilities (p=0.02).

As expected, one-way ANOVA analyses confirmed that county-level socioeconomic characteristics significantly differed across deprivation groups (all p-values <0.001), while only median household income, median housing value, percentage without high school education (age 25+), and percentage working class significantly differed across uninsurance quartiles (all p-values <0.001). In general, socioeconomic values tended to decrease as deprivation quartiles increased. However, across uninsurance quartiles, this gradient was not as evident. When these six socioeconomic characteristics were examined as a composite measure (e.g., SEP index score), county deprivation scores increased across uninsurance quartiles (p<0.001) and uninsurance levels increased across socioeconomic deprivation quartiles (p<0.001), ranging from 13.0% (95% CI=12.6%-13.5%) to 20.6% (95% CI=19.8%-21.5%). In particular, counties with the lowest levels of socioeconomic deprivation and uninsurance (Q1), had significantly lower socioeconomic deprivation scores and levels of uninsured residents when compared to counties in the other three quartiles.

Table 3: Kansas County Characteristics by Socioeconomic Deprivation Quartiles (Five Year Average, 2008-2012)

Characteristic	**All (n=105),** mean/n (95% CI/%)	**Q1 – least (n=26),** mean/n (95% CI/%)	**Q2 (n=27),** mean/n (95% CI/%)	**Q3 (n=26),** mean/n (95% CI/%)	**Q4 – most (n=26),** mean/n (95% CI/%)	***F* (*df*) or χ^2 (*df*)**
Demographic Characteristics (2010)						
Population Density (per square mile)	49.3 (18.3, 80.2)	96.4 (4.1, 188.8)	31.5 (-6.3, 69.3)	10.2 (6.3, 14.1)	59.7 (-21.3, 140.7)	1.44 (3)
Metro[1] Counties	19 (18.1%)	12 (63.2%)	4 (21.1%)	2 (10.5%)	1 (5.3%)	26.70 (6)**[2]
Non-Metro[1]	44	11	8	10	15	

Counties	(41.9%)	(25.0%)	(18.2%)	(22.7%)	(34.1%)	
Rural[1] Counties	42 (40.0%)	3 (7.1%)	15 (35.7%)	14 (33.3%)	10 (23.8%)	
% Black	1.8 (1.2, 2.5)	2.7 (1.0, 4.3)	1.5 (0.7, 2.3)	0.8 (0.4, 1.2)	2.4 (0.4, 4.3)	1.61 (3)
% Hispanic	8.5 (6.3, 10.7)	5.2 (3.6, 6.7)	6.0 (4.1, 7.9)	11.7 (5.9, 17.6)	11.2 (5.0, 17.3)	2.58 (3)[+]
Mammography Facilities per 10,000 Adult Women[3]	1.2 (0.9, 1.5)	1.4 (0.8, 2.0)	0.9 (0.3, 1.4)	1.7 (0.9, 2.4)	1.0 (0.5, 1.5)	1.46 (3)
Primary Care Physicians per (PCPs) 10,000 Residents	5.8 (5.1, 6.4)	7.1 (5.6, 8.5)	6.2 (4.7, 7.7)	4.9 (3.8, 6.0)	5.0 (3.8, 6.1)	2.74 (3)*
Socioeconomic Characteristics (Five Year Average, 2008-2012)						
SEP Index Score[4]	13.7 (13.1, 14.4)	9.4 (8.4, 10.4)	12.9 (12.7, 13.2)	14.7 (14.5, 15.0)	17.8 (17.1, 18.6)	127.31 (3)**
Median Household Income	$45,812 ($44,519, $47,105)	$52,026 ($49,070, $54,983)	$45,687 ($44,204, $47,170)	$45,150 ($43,078, $47,221)	$40,390 ($38,584, $42,195)	20.94 (3)**
Median Housing Value	$85,251 ($79,374, $91,129)	$118,808 ($103,772, $133,844)	$80,181 ($72,650, $87,713)	$73,035 ($66,477, $79,592)	$69,177 ($63,636, $74,717)	24.67 (3)**
% Below Federal Poverty Level (FPL)	12.6 (11.8, 13.4)	10.3 (8.7, 12.0)	10.3 (9.3, 11.2)	12.8 (11.7, 13.9)	17.1 (15.8, 18.4)	26.69 (3)**
% No High School Education (Age 25+)	11.8 (10.7, 12.9)	8.2 (7.2, 9.1)	10.8 (9.5, 12.0)	13.3 (10.7, 16.0)	14.9 (12.2, 17.5)	9.00 (3)**
% Unemployed	4.9 (4.5, 5.4)	4.7 (3.8, 5.7)	3.9 (3.1, 4.6)	4.4 (3.7, 5.1)	6.9 (5.9, 7.9)	10.87 (3)**
% Working Class	29.8 (28.5, 31.0)	23.2 (20.7, 25.8)	31.4 (29.4, 33.3)	32.7 (30.9, 34.4)	31.7 (29.4, 34.1)	17.16 (3)**
% Uninsured (Age <65)	16.5 (15.9, 17.0)	13.6 (12.9, 14.4)	16.2 (15.4, 17.0)	18.1 (16.9, 19.2)	17.9 (16.7, 19.2)	17.51 (3)**

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-Metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Chi-square values for cell sizes less than 5 are not reliable. Counts provided in this table are for descriptive purposes only.
3. Mammogram facilities data is based on the most recent available information from 2013.
4. The SEP index score is a composite variable comprised of the six socioeconomic variables that are presented below it in this table, which are provided for descriptive purposes only.

***p*<0.001, **p*<0.05, +*p*<0.10 (approaching significance)

Table 4: Kansas County Characteristics by Uninsurance Quartiles (Five Year Average, 2008-2012)

Characteristic	**Counties (*n*=105),** mean/n (95% CI/%)	**Q1 – least (*n*=26),** mean/n (95% CI/%)	**Q2 (*n*=26),** mean/n (95% CI/%)	**Q3 (*n*=27),** mean/n (95% CI/%)	**Q4 – most (*n*=26),** mean/n (95% CI/%)	***F* (*df*) or χ^2 (*df*)**
Demographic Characteristics (2010)						
Population Density (per square mile)	49.3 (18.3, 80.2)	89.2 (-2.3, 180.7)	50.3 (8.4, 92.3)	10.1 (4.9, 15.2)	49.1 (-32.6, 130.7)	1.08 (3)
Metro[1] Counties	19 (18.1%)	14 (73.7%)	3 (15.8%)	1 (5.3%)	1 (5.3%)	50.74 (6)**[2]
Non-Metro[1] Counties	44 (41.9%)	11 (25.0%)	17 (38.6%)	10 (22.7%)	6 (13.6%)	
Rural[1] Counties	42 (40.0%)	1 (2.4%)	6 (14.3%)	16 (38.1%)	19 (45.2%)	
% Black	1.8 (1.2, 2.5)	1.9 (0.9, 3.0)	3.0 (1.5, 4.5)	0.8 (0.5, 1.1)	1.7 (-0.3, 3.7)	1.98 (3)
% Hispanic	8.5 (6.3, 10.7)	3.9 (2.9, 4.9)	5.1 (3.8, 6.4)	4.4 (2.9, 5.9)	20.8 (14.1, 27.5)	23.03 (3)**
Mammography Facilities per 10,000 Adult Women[3]	1.2 (0.9, 1.5)	1.3 (0.9, 1.7)	1.1 (0.5, 1.7)	1.9 (1.0, 2.7)	0.6 (0.1, 1.1)	3.37 (3)*
Primary Care Physicians per (PCPs) 10,000 Residents	5.8 (5.1, 6.4)	5.9 (4.9, 6.9)	6.2 (4.9, 7.5)	6.0 (4.9, 7.0)	5.0 (3.2, 6.8)	0.67 (3)
Socioeconomic Characteristics (Five Year Average, 2008-2012)						
SEP Index	13.7	10.2	15.2	14.7	15.8	20.35

Score[4]	(13.1, 14.4)	(8.9, 11.5)	(15.0, 15.3)	(13.9, 15.5)	(14.6, 17.0)	(3)**
Median Household Income	$45,812 ($44,519, $47,105)	$51,707 ($48,776, $54,638)	$43,513 ($42,157, 44,869)	$42,609 ($40,759, $44,460)	$45,542 ($42,796, $48,288)	13.37 (3)**
Median Housing Value	$85,251 ($79,374, $91,129)	$115,931 ($102,204, $129,568)	$80,869 ($69,561, $92,178)	$69,252 ($63,282, $75,222)	$75,569 ($68,528, $82,611)	18.75 (3)**
% Below Federal Poverty Level (FPL)	12.6 (11.8, 13.4)	11.0 (9.5, 12.4)	13.4 (11.8, 15.0)	13.1 (11.4, 14.7)	12.9 (11.0, 14.8)	1.78 (3)
% No High School Education (Age 25+)	11.8 (10.7, 12.9)	8.3 (7.4, 9.1)	10.5 (9.8, 11.3)	10.7 (9.6, 11.8)	17.7 (14.5, 20.8)	22.52 (3)**
% Unemployed	4.9 (4.5, 5.4)	5.0 (4.2, 5.8)	5.6 (4.5, 6.6)	4.4 (3.7, 5.1)	4.8 (3.6, 5.9)	1.04 (3)
% Working Class	29.8 (28.5, 31.0)	25.7 (22.9, 28.5)	27.9 (25.3, 30.4)	31.4 (30.0, 33.2)	34.0 (32.1, 36.0)	10.66 (3)**
% Uninsured (Age <65)	16.5 (15.9, 17.0)	13.0 (12.6, 13.5)	14.1 (13.1, 15.2)	17.0 (16.7, 17.2)	20.6 (19.8, 21.5)	173.06 (3)**

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Chi-square values for cell sizes less than 5 are not reliable. Counts provided in this table are for descriptive purposes only.
3. Mammogram facilities data is based on the most recent available information from 2013.
4. The SEP index score is a composite variable comprised of the six socioeconomic variables that are presented below it in this table, which are provided for descriptive purposes only.

**$p<0.001$, *$p<0.05$, +$p<0.10$ (approaching significance)

Bivariate Associations. To explore the bivariate relationships between each county predictor and mammography outcome, unadjusted linear regression analyses were conducted predicting recent, four-year repeat, and six-year repeat EDW mammography use from individual county demographic and socioeconomic characteristics (Table 5). The proportion of Hispanic individuals residing in the county had a significant positive association with recent mammogram use ($p<0.001$). In terms of socioeconomic characteristics, significant positive associations were found between the proportion of residents without high school diplomas ($p<0.001$),

socioeconomic deprivation score (p<0.05), proportion of uninsured residents (p<0.001), and all three mammography outcomes. In other words, as the county proportion of Hispanic population, residents without high school education, socioeconomic deprivation, and uninsurance increased, so did rates of EDW mammography use from 2009-2014. No other predictors showed significant associations with mammography use.

Table 5: Bivariate Associations of Mammography Use and Kansas County Characteristics, 2009-2014

Characteristic	Recent Mammogram Rate (2013-2014, *n*=105)		Four-Year Repeat Mammogram Rate (2011-2014, *n*=105)		Six-Year Repeat Mammogram Rate (2009-2014, *n*=105)	
	b (95% CI)	*β*	*b* (95% CI)	*β*	*b* (95% CI)	*β*
Demographic Characteristics (2010)						
Metro[1] Counties (ref: Rural)	-2.22 (-8.58, 4.14)	-0.08	-1.15 (-4.48, 2.18)	-0.07	-0.77 (-2.87, 1.33)	-0.08
Non-Metro[1] Counties (ref: Rural)	2.97 (-1.99, 7.93)	0.13	1.19 (-1.41, 3.79)	0.10	0.68 (-0.96, 2.32)	0.09
% Black	0.73 (0.08, 1.38)	0.21*	0.28 (-0.06, 0.63)	0.16	0.14 (-0.08, 0.35)	0.12
% Hispanic	0.80 (0.67, 0.93)	0.76**	0.40 (0.32, 0.47)	0.73**	0.26 (0.21, 0.30)	0.75**
Mammography Facilities per 10,000 Adult Women[2]	-0.56 (-2.04, 0.91)	-0.07	-0.16 (-0.93, 0.61)	-0.04	-0.05 (-0.54, 0.43)	-0.02
Primary Care Physicians (PCPs) per 10,000 Residents	0.00 (-0.69, 0.69)	0.00	-0.02 (-0.38, 0.34)	-0.01	-0.03 (-0.25, 0.20)	-0.02
Socioeconomic Characteristics (Five Year Average, 2008-2012)						
SEP Index Score[3]	1.13 (0.51, 1.76)	0.33*	0.51 (0.18, 0.84)	0.29*	0.30 (0.09, 0.51)	0.27*
Median Household Income	0.00 (0.00, 0.00)	0.04	0.00 (0.00, 0.00)	0.06	0.00 (0.00, 0.00)	0.11
Median	0.00	0.06	0.00	0.03	0.00	0.03

Housing Value	(0.00, 0.00)		(0.00, 0.00)		(0.00, 0.00)	
% Below Federal Poverty Level (FPL)	0.52 (-0.02, 1.05)	0.19^{+}	0.11 (-0.17, 0.39)	0.08	0.06 (-0.12, 0.23)	0.06
% No High School Education (Ages 25+)	1.41 (1.10, 1.71)	0.67**	0.70 (0.53, 0.86)	0.64**	0.44 (0.33, 0.54)	0.64**
% Unemployed	1.24 (0.30, 2.18)	0.25*	0.45 (-0.05, 0.95)	0.17	0.23 (-0.09, 0.54)	0.14
% Working Class	0.24 (-0.10, 0.59)	0.14	0.17 (-0.01, 0.35)	0.18^{+}	0.14 (0.02, 0.25)	0.23*
% Uninsured (Age <65)	2.17 (1.56, 2.79)	0.57**	1.07 (0.74, 1.40)	0.54**	0.65 (0.44, 0.86)	0.52**

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-Metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Mammogram facilities data is based on the most recent available information from 2013.
3. The SEP index score is a composite variable comprised of the six socioeconomic variables that are presented below it in this table, which are provided for descriptive purposes only.

**p<0.001, *p<0.05, +p<0.10 (approaching significance)

Adjusted Associations. Multiple linear regression models were conducted for Kansas counties with all independent variables entered as simultaneous predictors of mammography use. Three separate multiple regression analyses were conducted, one for each of the three outcomes: recent, four-year repeat, and six-year repeat EDW mammogram rates (Table 6). When accounting for measures of county urbanicity, healthcare supply, and socioeconomic deprivation, residence in counties with higher levels of uninsurance was significantly associated with increased EDW mammography use. For every 1% increase in the proportion of uninsured county residents, rates of mammography use increased by 3.57 (95% CI=2.80, 4.34; p<0.001), 1.79 (95% CI=1.35, 2.22; p<0.001), and 1.08 (95% CI=0.80, 1.37; p<0.001) mammograms per 1,000

women ages 40-64 for recent, four-year repeat, and six-year repeat mammography outcomes, respectively.

Residence in metro counties (compared to rural counties) was associated with a 13.83 increase (95% CI=8.27, 19.38; $p<0.001$) in the rate of recent mammogram use per 1,000 women ages 40-64, 6.55 increase 95% CI=3.41, 9.68; $p<0.001$) in the rate of four-year repeat mammograms, and 3.84 increase 95% CI=1.80, 5.89; $p<0.001$) in the rate of six-year repeat mammograms. Similar results were found for residence in non-metro compared to rural counties, with 12.80 (95% CI=8.68, 16.92; $p<0.001$), 5.96 (95% CI=3.64, 8.29; $p<0.001$), and 3.53 (95% CI=2.01, 5.04; $p<0.001$) increases in mammograms per 1,000 women ages 40-64 for recent, four-year repeat, and six-year repeat mammography outcomes, respectively. Moreover, for every one additional PCP per 10,000 county residents, recent mammogram rates increased by 0.77 (95% CI=0.25, 1.28; $p<0.05$) and four-year repeat mammograms increased by 0.33 (95% CI=0.04, 0.62; $p<0.05$) per 1,000 women ages 40-64. There was no association between PCP rate and six-year repeat mammography rates. Measures of county minority composition were excluded from the final analyses due to multicollinearity found in preliminary analyses between the proportion of Hispanic residents and uninsurance levels.[3]

[3] Preliminary analyses indicated that county Hispanic population composition and percent uninsurance were multicollinear in their prediction of recent mammography use. Separate models of each predictor demonstrated significant associations with each mammography outcome, but when included as simultaneous predictors of mammography use, all associations except percent Hispanic population fell below significance, indicating considerable overlap in their association with the outcome. The bivariate Pearson correlation between county-level percent Hispanic and percent uninsurance was $r=0.66$ ($p<0.001$), indicating a high degree of overlap between the two predictors (Kutner, Nachtsheim, & Neter, 2004). Because this study's primary research question focused on the effect of county-level socioeconomic deprivation and uninsurance on mammography use, the uninsurance predictor was retained in analyses and county race/ethnicity variables were excluded. However, although it is unclear whether these documented associations were solely related to the county-level proportion of uninsurance rather

When taken together, these six variables explained 54% of the variance in recent mammogram rates, 46% of the variance in four-year repeat mammogram rates, and 42% of the variance in six-year repeat mammogram rates. Examination of standardized coefficients for recent and four-year repeat mammography rates revealed that percent uninsured residents was the strongest predictor (β=0.93 and β=0.90, respectively), followed by residing in non-metro (β=0.54 and β=0.49, respectively) or metro counties (β=0.46 and β=0.42, respectively) compared to rural counties, and county PCP rate (β=0.22 and β=0.18, respectively). Similar results were found for six-year repeat mammography rates, although county PCP rate was not significant.

Table 6: Adjusted Associations of Mammography Use and Kansas County Characteristics, 2009-2014

Characteristic	Recent Mammogram Rate (2013-2014, *n*=105)		Four-Year Repeat Mammogram Rate (2011-2014, *n*=105)		Six-Year Repeat Mammogram Rate (2009-2014, *n*=105)	
	b (95% CI)	β	*b* (95% CI)	β	*b* (95% CI)	β
Demographic Characteristics (2010)						
Metro[1] Counties (ref: Rural)	13.83 (8.27, 19.38)	0.46**	6.55 (3.41, 9.68)	0.42**	3.84 (1.80, 5.89)	0.39**
Non-Metro[1] Counties (ref: Rural)	12.80 (8.68, 16.92)	0.54**	5.96 (3.64, 8.29)	0.49**	3.53 (2.01, 5.04)	0.46**
Mammography Facilities per 10,000 Adult Women[2]	-0.65 (-1.74, 0.45)	-0.09	-0.17 (-0.78, 0.45)	-0.04	-0.05 (-0.45, 0.36)	-0.02
Primary Care Physicians (PCPs) per 10,000 Residents	0.77 (0.25, 1.28)	0.22*	0.33 (0.04, 0.62)	0.18*	0.18 (-0.01, 0.37)	0.15
Socioeconomic Characteristics (Five Year Average, 2008-2012)						

than Hispanic population, analysis results would likely have been similar regardless of the county-level variable used. Results from these preliminary models are presented in Appendix A.

SEP Index Score	-0.26 (-0.89, 0.38)	-0.08	-0.20 (-0.56, 0.16)	-0.11	-0.14 (-0.37, 0.10)	-0.12
% Uninsured (Age <65)	3.57 (2.80, 4.34)	0.93**	1.79 (1.35, 2.22)	0.90**	1.08 (0.80, 1.37)	0.86**
Intercept	-52.61 (-66.43, -38.78)		-26.30 (-34.10, -18.50)		-15.96 (-21.06, -10.87)	
R^2	0.54		0.46		0.42	
F (*df*)	19.18 (6)**		14.02 (6)**		11.94 (6)**	

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-Metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Mammogram facilities data is based on the most recent available information from 2013.

**p<0.001, *p<0.05, +p<0.10 (approaching significance)

Discussion

The purpose of this study was to examine to what extent county-level socioeconomic characteristics were associated with mammography use among low-income, uninsured women in Kansas who participated in a free mammography screening program over multiple screening intervals. This study uncovered a positive relationship between county-level uninsurance and EDW mammography use, such that counties with more uninsured residents had higher rates of recent, four-year repeat, and six-year repeat mammogram use in the EDW program from 2009-2014, even when accounting for county socioeconomic deprivation. Results also indicated that metro and non-metro counties (compared to rural counties) and counties with more PCPs had higher rates of recent and repeat EDW mammograms. Although county socioeconomic deprivation was associated with all three outcomes by itself, when analyzed as a simultaneous predictor with county uninsurance, the relationship between county socioeconomic deprivation and EDW mammography use was no longer significant. Together, these characteristics explained

approximately half of the county-level variation in EDW mammography use for all three outcomes, with county uninsurance being the strongest predictor. Therefore, these findings partially support the study hypothesis that county-level socioeconomic characteristics, specifically deprivation and uninsurance, would be positively associated with mammogram use in the EDW program.

To put these findings in context with broader mammography screening use, nearly 74% of U.S. women ages 40 and older have reported receiving a mammogram within the past two years (Kaiser Family Foundation, 2015b). Although overall mammography screening rates are high, substantial unmet need remains nationally, as researchers have estimated that nearly 60% of low-income (<250% FPL), uninsured women did not receive a mammogram in the past year (Howard et al., 2015). Similarly, in Kansas, women have reported comparably high overall use of mammography, with documented decreases by nearly half for those with low incomes or no insurance coverage (American Cancer Society, 2014). Although the EDW program has provided 3,500-4,000 mammograms annually since 2011 (including the 2012 enrollment cap), it is estimated that the program only serves 10-15% of potentially eligible women (Howard et al., 2015; Snyder, October 15, 2014). As such, this study highlights that although EDW is serving thousands of women annually, many more Kansas women may also be in need of the program's mammography services. When taken together, this information suggests that advanced resource targeting strategies may be needed if resources remain at current levels.

As one of the first studies to explore the impact of county-level characteristics on mammography use among low-income women, these results broadly contribute to prior research demonstrating the importance of area-level socioeconomic characteristics, particularly uninsurance and deprivation levels, on mammography screening (Dailey et al., 2011; Pagan et

al., 2008). More specifically, this study adds to a small, but growing literature in the U.S. investigating the impact of insurance rates on the community as a whole (Gresenz & Escarce, 2011; Pagan & Pauly, 2006; Pauly & Pagan, 2008). Only one study has examined the influence of uninsurance on mammography use, finding that as community uninsurance rates increased among the general U.S. population, the likelihood of female residents obtaining recent mammograms decreased (Pagan et al., 2008). Conversely, the present study found that as the proportion of county residents without health insurance increased, so did rates of recent and repeat EDW mammograms.

Although the current study appears to be contradictory at face value, a closer examination reveals that these two studies may have similar conceptual findings. One plausible explanation for these contrasting results is that the EDW program may have acted as a 'pseudo insurer' for low-income, uninsured women in Kansas. As a third-party, the EDW program provided payments on behalf of enrolled participants to healthcare providers, essentially transforming uninsured residents with minimal financial resources into 'insured' patients for breast and cervical cancer screening services. Conceptually, this process is similar to how health insurance companies provide payments on behalf of their subscribers. However, an important distinction between the two payers is that EDW participants only have coverage for breast and cervical cancer-related services and remain uninsured for all other medical needs (Kansas Department of Health & Environment, 2014a), whereas individuals with health insurance have coverage for many other healthcare services. Yet, without the EDW program providing continued financial backing for mammography services for low-income, uninsured women in Kansas, it is possible that counties with higher levels of uninsured residents may have had lower mammography use

overall. As such, these results suggest that the EDW program may have improved access and payment processes in the local screening marketplaces where it operated during these six years.

Moreover, this study also expands another niche area of research examining the association of area-level socioeconomic deprivation and mammography use. Among the general U.S. population, only two studies have examined this relationship and documented that women living in communities with higher socioeconomic deprivation (as measured by the SEP index) had a lower likelihood of obtaining six-year repeat mammograms compared to women living in communities with lower socioeconomic deprivation (Dailey et al., 2011; Dailey et al., 2007). Conversely, the present study failed to find a significant association between county-level socioeconomic deprivation and recent or repeat EDW mammography use. Together, these results suggest that county uninsurance levels may better estimate recent and repeat mammography use in the EDW program than other county characteristics, including measures of socioeconomic deprivation.

There are several possible explanations for the contrasting results between this study and previous research. The current study builds on prior work in four key ways: 1) by studying a narrower population (low-income, uninsured women), 2) in a new location (predominantly rural Midwest state), 3) exploring multiple mammography outcomes (recent and repeat measures), and 4) testing new combinations of area-level socioeconomic predictor variables with mammography use (deprivation and uninsurance). First, although prior studies have examined mammography use among the general U.S. population, the current study focused only on low-income, uninsured women. Because they may have poorer health exposures and reduced resources to address health needs (Lynch & Kaplan, 2000), low-income, uninsured women's use of mammography may significantly differ from those with more financial resources or insurance coverage.

Second, prior studies have examined narrow geographic areas, such as census tracts (Dailey et al., 2011) and metropolitan areas (Pagan et al., 2008), but the present study expanded the geographic unit of analysis to counties. By doing so, the findings suggest that the association of area-level socioeconomic characteristics and mammography use may extend beyond proximal areas to broader geographies. Using counties in resource allocation models may also be one potential method to target future EDW resources. Moreover, this study also focused on mammography use in the predominantly rural state of Kansas, with findings suggesting that these county-level relationships with mammography use can apply to various urbanicities and geographic regions across the U.S.

Third, because there is no consensus about a standardized method to measure mammography use, previous researchers have used multiple outcomes with varying definitions (e.g., never, recent, repeat mammography) (Clark et al., 2003). To explore differences in the relationship of county-level characteristics and mammography screening over multiple screening intervals, this study expanded upon prior research by examining three distinct outcome measures of recent, four-year repeat, and six-year repeat mammogram rates the same population. One significant difference between prior studies and this one, however, is that the current study only analyzed women who received mammograms in the EDW program from 2009-2014 and did not include information about women who did not have EDW mammograms. Even though this study was not a formal evaluation of the EDW program, by focusing only on mammography users, the results indicate that counties with higher levels of uninsurance had higher odds of using mammography services when they were available over a six-year period. Moreover, these results also provide important information about the county-level conditions under which prior participants have engaged in mammography screening in the EDW program, such as counties

with higher levels of urbanicity and rates of PCPs, that may be important for future service targeting to locate women who may also be inclined to using the services.

Finally, and perhaps most importantly, is that the current study expanded prior work by combining two noteworthy area-level socioeconomic measures into the same analysis – deprivation *and* uninsurance. Previous research has independently demonstrated that these two predictors were associated with mammography use among the general U.S. population. However, the two prior area-level socioeconomic deprivation studies did not include any area-level measures of health insurance in their models (Dailey et al., 2011; Dailey et al., 2007), which emerging research has demonstrated can significantly impact healthcare service utilization for both residents with and without insurance (Institute of Medicine, 2009). By analyzing these predictors simultaneously, these findings suggest that levels of community uninsurance may be a more reliable predictor of mammography utilization for women participating in free screening programs over multiple screening intervals than socioeconomic deprivation.

Limitations. This study has several limitations. First, as a retrospective analysis, it relied on administrative and clinical service data that were not originally collected for research purposes, which reduced control over the availability of information (Shi, 2008). Most notably, due to fiscal limitations, the EDW program capped enrollment in Program Year 2012 (7/1/2011-6/31/2012), which resulted in decreased participation during study analysis years 2011 and 2012 by nearly 20% over previous years (Snyder, October 15, 2014). Although these caps may have reduced mammogram use data for the two repeat outcomes, study results were consistent across all three outcomes. Moreover, the use of service claims in research can be a more reliable measure of true mammography utilization than frequently used self-reported screening metrics because of the association with payment for the services provided (Virnig & Madeira, 2012).

Second, because this study only focused on low-income mammography users who participated in the Kansas EDW program, the results may not be generalizable to mammography non-users, women with higher incomes or insurance, or users residing in different geographic locations.

Third, counties were chosen as the geographic unit of analysis for this study because they best balanced availability of area-level socioeconomic data and sample size limitations for the three mammography outcomes. However, counties may have concealed or underestimated important differences that smaller geographic areas, such as census tracts or more other socially meaningful geographic divisions (Krieger et al., 2002). However, because programmatic resources may often be distributed by counties, the results of this analysis may be particularly useful to program administrators. Fourth, because no individual-level data were included in the analyses, these findings are limited to county-level inferences about EDW mammography use and cannot be disaggregated to estimate behaviors of individual women (Robinson, 1950). Chapters four and five address this limitation by using hierarchical modeling techniques, which disaggregate county-level from individual-level predictors of mammography use.

Fifth, temporal or spatial misclassification may have occurred due to the use of multiple years in study analyses. Information on EDW mammography use was evaluated from 2009-2014, while county demographic characteristics were derived from 2010 data, mammography facility counts were based on 2013 data, and county economic characteristics were based on five-year estimates from the 2010 U.S. Census spanning 2008-2012. However, regardless of the chosen reference year, the five-year estimates of county characteristics would have been similar (Health Resources and Services Administration, 2014). Moreover, due to limitations of the EDW data system, all women were assigned to live in the same county for the six study years based on the most recent address on file with the program, which may have resulted in differences in

county-level characteristics between the time of geographic classification and time of mammogram use (Dailey et al., 2011). Countering this concern, research has found that although low-income populations have exhibited frequent residential mobility, their moves often occur within short distances rather than across county boundaries (Coulton, Theodos, & Turner, 2009).

Sixth, although the SEP index represents a more comprehensive definition of deprivation because it takes multiple socioeconomic characteristics into account (O'Campo & Burke, 2004; Oakes & Rossi, 2003), exploratory bivariate analyses revealed that some measures incorporated within the SEP index were significantly related to mammography use on their own. For instance, the proportion of residents (age 25+) without high school diplomas was positively associated with all three mammography outcomes, such that as the proportion of poorly educated residents increased, so did the use of recent and repeat mammograms. However, several other single-dimension measures of county-level SEP, such as proportion of residents below FPL, unemployed adults, and working class, produced mixed associations with the three mammography outcomes in this study. To better understand the interplay of these SEP characteristics with mammography use among low-income women, future research should explore additional comparisons of the relationship between single-dimension area-level characteristics, such as education and employment, to socioeconomic deprivation indices.

Finally, in preliminary analyses, it was discovered that county-level measures of the proportion of Hispanic population and uninsurance were multicollinear in their prediction of EDW mammography use. In other words, counties with high levels of Hispanic populations also tended to have high levels of uninsurance. The significant overlap between these two variables suggests the Hispanic composition variable was likely a proxy measure for county-level uninsurance, although it is possible that both variables could have produced similar analysis

results. Because the primary focus of this study was to assess the effect of county-level socioeconomic deprivation and uninsurance on mammography use, the county-level minority population composition measures were excluded from the final models. Yet, by removing these measures, important community facets of minority populations not adequately captured by a measure of uninsurance may have been omitted from the final analyses.

Implications. The findings of this study have several implications. First, these results indicate that communities with characteristics often associated with being 'in need' of breast and cervical cancer screening services, such as high levels of uninsured residents, are in fact using these healthcare services when made accessible. This study and others like it collectively suggest that higher levels of 'insured' residents (whether formally or by a targeted screening program) could benefit the health of all members in the community. Moreover, this is one of the first studies to-date to examine the role that broader community characteristics may play in the use of mammography by low-income women. Notably, these women may be at risk for lower use of preventive screening services, since their reduced personal resources may increase the need to rely on the resources of the surrounding community (Lynch & Kaplan, 2000). Additionally, the consistency of results from this study for all three outcomes at two-, four-, and six-year intervals implies that these community characteristics may create lasting effects that can influence mammography use over multiple screening intervals.

Second, although narrow in scope, the results of this study may have particular relevance to policymakers of Kansas (and similar states) regarding the effect of the EDW program on the use of mammography and other preventive health screenings. Without the EDW program's financial backing for mammography, it is likely that Kansas communities with higher levels of uninsured residents would have had lower rates of cancer screenings, as the current results

suggest successful program targeting and service deliver in higher uninsured counties. It is important to acknowledge, however, that EDW participants only have coverage for breast and cervical cancer-related services. Since participants continue to lack insurance and financial resources for other healthcare needs, these women ultimately remain predisposed to a higher likelihood of poor health outcomes. Because health insurance status can change rapidly, a practical extension of these findings could be to invest in activities that promote the expansion of insurance across the state, including lobbying for Medicaid expansion and affordable health insurance options. These efforts could help more Kansas women attain insurance, which would provide coverage for mammograms, in addition to other important preventive and primary care services. Furthermore, this extended insurance coverage could then enable the EDW program to judiciously target limited resources to more women who may need breast and cervical cancer screening services, including women who do not qualify for government assistance due to income and immigration limitations (Garfield et al., 2016).

Future research can build on these findings by determining whether or not they hold true: 1) when accounting for person-level characteristics, 2) within smaller geographic areas, such as zip codes or census tracts, 3) when using counts of all EDW-eligible women as the denominator in county-level mammography rate calculations, and 4) for non-poor and insured women in Kansas. Moreover, the fluidity of health insurance status also allows researchers to evaluate changes in mammography use, among both poor and non-poor women, if health insurance coverage changes occur in Kansas. Additional studies should also incorporate person-level characteristics to more fully understand how community resources influence mammography use among individual women at various levels of the socioeconomic spectrum. Since this is one of the first studies to examine the relationship of mammography use among low-income, uninsured

women and the county-level characteristics of communities in which they reside, additional research should evaluate methods to best target limited programmatic resources to communities who may be most in need of and receptive to these screening services.

Conclusion

In summary, this study found that Kansas counties with higher levels of uninsurance had higher rates of recent and repeat mammograms in the EDW program. Building on prior research, this study applied both the concepts of community uninsurance and socioeconomic deprivation to mammography use in a new population (low-income women) and geographic area (Kansas counties) over multiple screening intervals (three mammography outcomes). These findings indicate that regardless of the socioeconomic deprivation level of a county, the highest rates of mammography use in the EDW program are in counties with the most uninsured residents. These results suggest that the EDW program may have expanded the local mammography marketplace by effectively converting uninsured participants into 'insured' patients for breast and cervical cancer screening services. As such, this study reiterates the important role that health insurance plays in the facilitation of healthcare service utilization. Ultimately, these findings may indicate that changes to the health insurance composition of communities may be doubly beneficial, in that they extend health insurance coverage to previously uninsured individuals and free up limited resources from the EDW program to help target other women in need of mammography.

Chapter 4: County-Level Socioeconomic Deprivation and Mammography Utilization Among Low-Income Women in Kansas, 2011-2014 (Paper 2)

Introduction

Numerous studies have examined the relationship of area-level characteristics and the cancer screening behaviors of those who live there. Over the past decade, however, researchers have focused their attention on the role area-level socioeconomic position (SEP) has played in the use of mammography screening among the general U.S. population (Calo et al., 2016; Dailey et al., 2011; Pruitt et al., 2009). Yet, there is reason to believe that the SEP of an community may significantly impact the use of mammography screening in vulnerable populations, such as low-income, uninsured women, as their reduced personal resources may increase the need to rely on community resources (Lynch & Kaplan, 2000; Pruitt et al., 2009). To date, however, no studies have examined how area-level SEP might influence mammography use among the vulnerable population of low-income, uninsured women.

Many cancer screening investigations have found significant relationships between area-level disadvantage and poor mammography use, such that as area-level SEP declined, so did mammography screening (Pruitt et al., 2009). However, several null findings (Lian et al., 2008; Rosenberg et al., 2005), as well as differences in study design, statistical modeling (e.g., inconsistent use of multi-level analysis techniques), and outcome measurement (e.g., never, recent, repeat) make definitive conclusions about the relationship between area-level SEP and mammography use difficult (Pruitt et al., 2009). Moreover, studies documenting significant relationships have tended to only examine the association of single-dimension measures of area-level SEP with mammography use, such as poverty level (Calo et al., 2016; Schootman et al.,

2006), household income (Jackson et al., 2009; Rahman et al., 2003), or educational attainment (Engelman et al., 2002; Parker et al., 1998; Wells & Horm, 1998).

Although each of these studies has identified important associations, the majority only found one measure of SEP to be significant, even if they analyzed multiple single-dimension measures. These findings indicate that the complexity of the SEP concept may be difficult to adequately capture by only analyzing single-dimension variables (O'Campo & Burke, 2004). Collectively, these findings appear to suggest that a more comprehensive method of quantifying SEP, such as using a combination of multiple domains in a single measure (e.g., an index), may more accurately capture the economic position of an area (Oakes & Rossi, 2003). As such, a small but growing literature has emerged in the U.S. using indices to measure area-level SEP and the corresponding association with mammography screening. Among the general U.S. population, only two studies have examined this relationship using an SEP index, concluding that higher area-level socioeconomic deprivation was independently associated with non-adherence to mammography screening, regardless of person-level characteristics (Dailey et al., 2011; Dailey et al., 2007).

While these two studies are beginning to advance the investigation of mammography screening in new directions, they are limited in several ways. First, these studies only examined mammography use among the general U.S. screening population. Because preventive cancer screenings require individuals to interact with the environment in which those services exist (Pruitt et al., 2009), there is reason to believe that those with reduced personal resources, such as low-income, uninsured women, may need to rely more on the socioeconomic resources in their surrounding community to obtain mammography screenings. Second, these studies focused on narrow geographic areas, such as census tracts and urban neighborhoods. However, in order to

further understanding about the relationship of area-level socioeconomic deprivation and mammography screening, it is important to examine if these findings can also be replicated in larger geographic and more rural areas of the country, such as Kansas, as these locations may have access issues that were not adequately explored in prior studies. Finally, these studies examined mammography non-adherence and six-year repeat screening outcomes. However, because there is no consensus in the literature about how to measure mammography use (Clark et al., 2009), it is important to understand if these findings also hold true when investigating other outcomes, such as recent or never use of mammography.

One opportunity to examine mammography screening among low-income women is the National Breast and Cervical Cancer Early Detection Program (NBCCEDP). Sponsored by the Centers for Disease Control and Prevention (CDC) since 1991, this program has provided free breast and cervical cancer screenings, diagnostic services, and direct links to treatment via state Medicaid programs for low-income, uninsured women in all fifty states (Centers for Disease Control and Prevention, 2002). Although breast and cervical cancer-related services are free to participants, the program does not offer coverage for other health needs. Additionally, women are required to qualify and enroll annually to receive mammography services, since each state has separate eligibility criteria based on local need, preferences, and funding levels (Centers for Disease Control and Prevention, 2015). For example, the Kansas program, known as Early Detection Works (EDW), has provided mammography services to enrolled women ages 40-64 with incomes under 225% FPL and no functional insurance (i.e., have no insurance or an unmet deductible over $2,500) since 1997 (Kansas Department of Health & Environment, 2014b).

Overall, research has suggested that NBCCEDP may be improving access to breast cancer screening and treatment for women across the U.S. (Hoerger et al., 2011; Howard et al.,

2010). However, recent evidence has indicated that state programs, such as EDW, are only screening 10-15% of eligible women each year (Howard et al., 2015; Snyder, October 15, 2014). This data indicates that substantial need and prolonged discrepancies in breast cancer screening still exist among low-income, uninsured women. When coupled with findings from prior mammography screening research, there is reason to believe that area-level characteristics may significantly influence low-income women's use of mammography, even when the screening services are offered free of charge (Pruitt et al., 2009). However, no research to-date has examined the relationship of area-level characteristics and mammography use by NBCCEDP participants nationally or at the state level.

As such, there is growing interest among researchers and policymakers to better understand how specific community characteristics might influence access to and use of mammography services for vulnerable populations (Pruitt et al., 2009). Expanding engagement with NBCCEDP services, however, requires a more detailed understanding of the community characteristics that may extend beyond the influence of reduced personal resources to facilitate use of screening mammography. In particular, exploring characteristics related to recent mammography use may provide insight to target specific environmental opportunities where eligible women may be most open to engaging with the program. Thus, improving understanding of the relationship between area-level SEP and mammography use among low-income, uninsured women is an important step toward improving screening, and ultimately, reducing breast cancer disparities. Therefore, the purpose of this study was to determine to what extent county-level SEP was associated with mammography use among low-income women in Kansas who participated in a free mammography screening program.

Hypothesis

Because indicators of poor area-level SEP have demonstrated prior associations with reduced mammography use among the general U.S. population, this study hypothesized that counties with greater socioeconomic deprivation (as measured by an SEP index) would have lower recent mammography use in the EDW program than counties with lower socioeconomic deprivation, when controlling for person-level characteristics.

Methods

Study Design and Data Sources. A cross-sectional retrospective design was used to assess the relationship of county- and person-level characteristics and mammography use among low-income women in Kansas. To do this, data were gathered for both county-level and person-level characteristics. County-level demographic and socioeconomic data were obtained from the 2014 release of Area Health Resource Files (AHRF) for all 105 Kansas counties, which is based on estimates from the 2010 U.S. Census, using the Federal Information Processing Standards (FIPS) code of 20 for Kansas (Health Resources and Services Administration, 2013). Counts of all mammography facilities (permanent and mobile units) in Kansas were obtained from the U.S. Food and Drug Administration's (FDA) Mammography Facilities Database using each facility's zip code to classify it into the proper county. The database provides information only for current facilities containing radiation-emitting machines, so no information was available for mammography facilities prior to 2013 (U.S. Food and Drug Administration, 2014).

Person-level data, including mammography use, were obtained from administrative and clinical service records from the Kansas EDW program. As a state division of the NBCCEDP, the EDW program provides breast and cervical cancer screening services to low-income (<225%

FPL), uninsured and underinsured (no insurance or only hospitalization insurance with deductible over $2,500) women ages 40-64 living in Kansas (Kansas Department of Health & Environment, 2014a). Demographic and service claims data for clinical breast exams (CBEs), mammograms, and pap tests were provided at the encounter-level for all participants since program initiation in 1996. Due to the implementation of a new integrated data system in 2013, however, self-reported socioeconomic information was only reliably available for participants who had enrolled in the EDW program in 2013 or 2014 (Snyder, July 1, 2014).

IRB Approval. This study was approved by the University of Kansas School of Medicine's Institutional Review Board (IRB) with a Health Insurance Portability and Accountability Act (HIPAA) privacy waiver (IRB #00002605). Access to the EDW program administrative and clinical service data was obtained through an approved data use agreement with the Kansas Department of Health and Environment (KDHE).

Dependent Variable. To explore characteristics associated with recent EDW program engagement, clinical data on EDW mammogram use from 2011-2014 were used to construct a dichotomous dependent variable for recent versus non-recent mammogram use. Only these four years were chosen for study analyses because they most closely aligned with available area-level data characterizing the environment in which mammography screening occurred. First, counts of mammograms per participant per year were calculated by aggregating encounter-level claims data at the person-level for all EDW mammograms performed from 1996-2014, which resulted in 16,563 participants who received at least one mammogram in the EDW program.

Next, in accordance with current literature, participants were classified as 'recent users' (coded as '1') if they had at least one program mammogram in the past 24 months (2013-2014) (Breen et al., 2011; Howard & Adams, 2012). Participants who had at least one program

mammogram in the past 24-48 months (2011-2012) were classified as 'non-recent users' (coded as '0'). EDW participants without a mammogram during the study years (*n*=2,959) were excluded from analyses, leaving 13,604 participants (82.1%) in the final study population. As a result, this study only focused on EDW mammography users and did not include any information about non-users.

Independent Variables. Independent variables in this study were measured at both the county- and person-level. County-level characteristics included socioeconomic deprivation, urbanicity, healthcare supply, and minority population composition measures, while person-level characteristics included data on demographics and screening behaviors. One county was excluded from analyses due to lack of person-level mammography outcomes, resulting in 104 counties and 13,604 EDW participants included in the final study analyses. County-level characteristics were the main focus of analyses, while person-level characteristics were used as control variables. Each measure is described in detail below.

County-Level Socioeconomic Deprivation. The primary independent variable of interest was county socioeconomic deprivation as a predictor of mammography use among EDW participants. To quantify socioeconomic deprivation, a composite measure of six socioeconomic variables, known as the Socioeconomic Position (SEP) index, was created for each county following the methodology of Krieger et al. (2002) and Dailey et al. (2011). Variables included in the index were: 1) median household income, 2) median housing value, 3) percentage below FPL, 4) percentage without high school education (age 25+), 5) percentage unemployed, and 6) percentage working class. The first four variables were obtained directly from AHRF data, while the fifth and sixth variables were computed using only AHRF data.

The percentage of unemployed workers for 2008-2012 was calculated by dividing the number of unemployed workers by the total civilian labor force during the same years. Similar to the methodology of other studies, the percentage of working class individuals was calculated by summing workers in agriculture/forestry/mining, construction, and manufacturing occupations and dividing by the number of workers in all occupations during 2008-2012 (Becker, 2006). Next, scales for median household income and median home value were reversed, so that higher index scores indicated higher levels of socioeconomic deprivation. Standardized z-scores were calculated for each variable and summed to create a total composite SEP index score for each county. For ease of interpretation, the SEP index scores were centered and divided into quartiles with higher quartiles (Q4) indicating higher degrees of socioeconomic deprivation. Only Quartile 1 was included in the final models because preliminary analyses indicated there were no significant differences between Quartiles 2-4, but there was a significant difference between Quartile 1 and Quartiles 2-4.

County-Level Urbancity, Healthcare Supply, and Minority Composition. To account for county characteristics that may have represented shared exposures for EDW participants (Benjamins et al., 2004; Litaker & Tomolo, 2007; Mobley et al., 2008), measures of county urbanicity, healthcare supply, and minority population composition were included as control variables. Counties were classified by urbanicity using the 2013 version of the Rural-Urban Continuum Code (RUCC) methodology, which is based on the most recent version of the U.S. Census (U.S. Department of Agriculture, 2013b). Counties were first classified into one of nine categories from metro (1) to rural (9) based on a combination of population density and proximity to metro areas. For study analyses, counties were grouped into metro (classifications 1-3), non-metro (classifications 4-7), and rural (classifications 8-9) categories using grouping

definitions provided by the U.S. Department of Agriculture (2013b). Rural counties were selected as the reference group for the models because they were a large urbanicity group.

Measures of healthcare supply focused on availability of mammography facilities and primary care physicians (PCPs) in each county. Rates were calculated by dividing counts of mammography facilities and primary care physicians by the total number of adult women and total population per county, respectively, and multiplying by 10,000 to enable valid cross-county comparisons (Friis, 2010). Measures of minority population composition were obtained directly from 2010 AHRF data for the percentage of Black and Hispanic population in each county and divided by 10 so that each one-unit change in the models corresponded to a meaningful 10% change in minority population composition.

Person-Level Demographics. To account for individual characteristics that may have predisposed participants to having a recent mammogram (Schueler et al., 2008), information on EDW program participants' age and self-reported race/ethnicity were obtained from administrative data based on participants' most recent enrollment date with the program. To account for early initiation of mammography screening, age was calculated as the age participants obtained their first EDW program mammogram using date of birth and mammogram service dates. Race variables were created from self-reported race and ethnicity of Hispanic or Non-Hispanic records. For analysis purposes, these variables were then used to create a combined race/ethnicity variable of Non-Hispanic White, Non-Hispanic Black, Hispanic, and Other/Unknown Race, with any report of Hispanic ethnicity resulting in Hispanic classification. In the final models, the Non-Hispanic White category was chosen as the reference group because it was the largest and the Other/Unknown Race category was omitted from analyses (n=765

participants) due to questions of measurement accuracy. Exploratory analyses indicated that model results did not differ substantially based on this exclusion.

Person-Level Screening Characteristics. Because previous research has shown that prior screening behaviors and history of breast cancer were reliable indicators of future screening use (Schueler et al., 2008), data on each participant's breast and cervical cancer screening services in the EDW program and breast cancer history were included. Information on EDW program participants' breast and cervical cancer screening history was obtained from program clinical data. First, all EDW mammograms since the initiation of the program in 1996 were totaled for each participant to provide information about the frequency of interaction with the program. Next, historical claims data were used to create dichotomous variables indicating whether or not each participant had received a pap test or clinical breast exam (CBE) in the EDW program prior to each mammogram. Finally, self-reported information on participants' personal and family history of breast cancer was used to create a single dichotomous variable to indicate if the participant or her mother, grandmother, or sister had ever been diagnosed with breast cancer.

Person-Level Socioeconomic Characteristics. To account for personal characteristics that may have enabled women to obtain a recent mammogram, socioeconomic data for all EDW participants were collected and coded as similarly to the Dailey et al. (2011) study as possible. Self-reported information on EDW program participants' socioeconomic characteristics was obtained from program administrative data based on participants' most recent date of contact with the program. The July 2013 implementation of a new EDW administrative data system enabled the systematic collection of socioeconomic information on participants that was not previously possible (Snyder, July 1, 2014). As a result, much of these data were missing, particularly for 'non-recent users' because of the timing of implementation. Nevertheless, when

available, the following data were obtained for EDW program participants and examined in exploratory analyses: household income, number of income dependents, FPL, insurance status, employment status, English language primacy, educational attainment, and relationship status.

Household income was measured in $1,000 increments of change, FPL was measured in 10% increments of change, and number of income dependents was measured continuously. Insurance and employment status were coded dichotomously to indicate whether or not the participant had insurance or was working for pay. A dichotomous variable for English language primacy was created by recoding the EDW 'primary language' variable as '1' for English and '0' for all other languages. The EDW 'education level' variable was recoded into three levels to indicate educational attainment of non-high school graduate, high school graduate, and some college or higher. The 'marital status' variable was recoded into three relationship status levels of single, separated/widowed, and married. In the models, non-high school graduate and married categories were selected as reference groups.

Study Analyses. Participants were geographically classified based on their most recent county of residence on file with the EDW program and county-level data were assigned to each participant based on unique county FIPS codes (U.S. Census Bureau, 2010). First, descriptive analyses were performed to explore person-level characteristics, while county-level characteristics were described in Table 1 of Paper 1. Independent samples t-tests and chi-square tests were used to explore differences in person-level characteristics between recent and non-recent users. Next, logistic regression techniques were used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for the unadjusted relationships between recent mammography use and county- and person-level characteristics. Descriptive and logistic regression analyses

were performed using SPSS version 23 (IBM Corp, 2014) and a *p*-value of <0.05 was used to determine statistical significance.

Finally, a series of three hierarchical generalized linear models (HGLMs) were conducted to disaggregate the variance in mammography use due to person- versus county-level characteristics. When data have multiple levels of analysis, such as women nested within counties, hierarchical models are appropriate to account for clustering (Subramanian, Jones, & Duncan, 2003). For this study, multilevel logistic models (Bernoulli distribution) were conducted using EM Laplace and full maximum likelihood estimation to calculate the likelihood of recent compared to non-recent mammography use. A random effect was included on the intercept to allow the model to estimate county-level variation around the average likelihood of mammography use. EM Laplace estimation was selected over the default penalized quasi likelihood (PQL) estimation because PQL estimation has been shown to underestimate random effects, in this case county-level variance (Raudenbush & Bryk, 2002), which was the primary area of interest for this study.

HGLM simultaneously models outcomes at two different analysis levels – a Level 1 model to estimate the effects of person-level characteristics on the person-level outcome of mammography use, and a Level 2 model to estimate the effects of county-level characteristics on the coefficients from the Level 1 analysis (Raudenbush & Bryk, 2002). Random intercepts were estimated in all models, but slopes of the person-level variables were fixed to limit model complexity associated with the estimation of multiple variances and covariances at Level 1 (Raudenbush & Bryk, 2002). All HGLM analyses were performed using HLM 7 Hierarchical Linear and Nonlinear Modeling software (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011) and a *p*-value of <0.05 was used to determine statistical significance.

To estimate the likelihood of having a recent mammogram due to county-level characteristics, Model 1 examined the effect of the primary predictor, county socioeconomic deprivation, with the other county-level characteristics. Next, all person-level predictors were entered into Model 2 to estimate only the effect of person-level characteristics on the likelihood of recent mammography to establish a baseline for comparison with the final model. Finally, all county- and person-level predictors were entered together into Model 3, as shown in the following equations:

Level 1: $\text{prob}(RECENTMAM_{ij}=1|\beta_j) = \phi_{ij}$

$$\log[\phi_{ij}/(1 - \phi_{ij})] = \eta_{ij}$$

$$\eta_{ij} = \beta_{0j} + \beta_{1j}*AGE_{ij} + \beta_{2j}*BLACK_{ij} + \beta_{3j}*HISP_{ij} + \beta_{4j}*MAMCT_{ij} + \beta_{5j}*PAP + \beta_{6j}*CBE_{ij} + \beta_{7j}*BCHIST_{ij}$$

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}*SEPQ1_j + \gamma_{02}*MFRATE_j + \gamma_{03}*PCPRATE_j + \gamma_{04}*METRO_j + \gamma_{05}*NMETRO_j + \gamma_{06}*PBLACK_j + \gamma_{07}*PHISP_j + u_{0j}$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

$$\beta_{6j} = \gamma_{60}$$

$$\beta_{7j} = \gamma_{70}$$

where ϕ_{ij} was the probability of having a recent versus non-recent mammogram (RECENTMAM). The link function, $\log[\phi_{ij}/(1 - \phi_{ij})]$, transformed the original probability into a binomial distribution of log odds (η_{ij}) for modeling as a continuous outcome. β_{0j} was the likelihood of women living in county *j* having a recent mammogram and γ_{00} was the average likelihood of having a recent mammogram across all Kansas counties. The betas ($\beta_{1j} - \beta_{7j}$) represented the coefficients for each corresponding person-level characteristic per county. The average value of each person-level characteristic across all counties was represented by the

gammas ($\gamma_{01} - \gamma_{08}$). Each β represented the distribution of j counties and each γ was the average of each person-level characteristic (indicated by the subscript i) across all counties. For instance, the equation $\beta_{1j} = \gamma_{10}$ indicated that each participant's age at first mammogram (β_{1j}) was averaged across all counties to produce a single estimate of the effect of age on likelihood of recent mammogram use (γ_{10}).

At the person-level, AGE was age at first EDW program mammogram, BLACK and HISP ware dummy variables for race/ethnicity, MAMCT was the count of EDW mammograms received, and PAP, CBE, and BCHIST were dummy variables for prior pap test, prior CBE, and history of personal or family breast cancer. At the county-level, SEPQ1 was a dummy variable for the least deprived counties, MFRATE was the number of mammography facilities per 10,000 adult women, PCPRATE was the number of PCPs per 10,000 county residents, METRO and NMETRO were dummy variables for county urbanicity, PBLACK and PHISP were the proportion of black and Hispanic county residents, and u_{0j} represented the remaining unexplained variation in mammography use due to county-level differences (i.e., the random effect). In order to estimate an intercept with an interpretable value, the person-level predictors of AGE and MAMCT were grand-mean centered, as well as the county-level predictors of MFRATE, PCPRATE, PBLACK, and PHISP. Person-level BLACK and HISP predictors were group-mean (county-mean) centered to estimate the effect of race/ethnicity within the average county (Hofmann & Gavin, 1998).

Results

Descriptive Analyses. On average, there were 131 EDW participants per county (range=1-3,459) who received one or more program mammograms from 2011-2014. Kansas

counties averaged 75 recent users (range=1-2,074) and 56 non-recent users (range=1-1,385). On average, participants had their first EDW mammogram at age 47, with recent users engaging in the program at slightly younger ages than non-recent users (p<0.001; Table 1). Recent users were comprised of more Hispanic women (42% v. 30%, respectively) and fewer Non-Hispanic White women (43% v. 53%, respectively) than non-recent users. Users averaged 2.6 mammograms each, with recent users having slightly more than non-recent users (p<0.001). Nearly all users had a prior CBE, while slightly over half reported a prior pap test and roughly 10% reported a personal or family history of breast cancer.

Table 1: Characteristics of Low-Income Mammography Users in Kansas, 2011-2014

Characteristic	**All Users, 2011-2014** (n=13,604) mean/n (CI/%)	**Recent Users, 2013-2014** (n=7,837) mean/n (CI/%)	**Non-Recent Users, 2011-2012** (n=5,767) mean/n (CI/%)	***t* (*df*) or χ^2 (*df*)**
Demographic				
Age at First EDW Mammogram				
Age (years)	46.5 (46.4, 46.7)	46.9 (46.8, 47.1)	48.2 (48.0, 48.3)	10.75 (13,602)**
< 40	277 (2.0%)	189 (2.4%)	88 (1.5%)	80.30 (2)**
40-49	8,559 (62.9%)	5,136 (65.5%)	3,423 (59.4%)	
50+	4,768 (35.1%)	2,512 (32.1%)	2,256 (39.1%)	
Race/Ethnicity				
Non-Hispanic White	6,451 (47.4%)	3,367 (43.0%)	3,084 (53.5%)	244.69 (4)**
Non-Hispanic Black	1,374 (10.1%)	732 (9.3%)	642 (11.1%)	
Hispanic	5,014 (36.9%)	3,272 (41.8%)	1,742 (30.2%)	
Other/Unknown	765 (5.6%)	466 (5.9%)	299 (5.2%)	
Screening Behavior				
EDW Mammogram Count				
Total Mammograms	2.6 (2.5, 2.6)	2.8 (2.8, 2.9)	2.2 (2.2, 2.3)	-15.72 (13,602)**
1	6,176 (45.5%)	3,171 (40.5%)	3,005 (52.1%)	273.35 (4)**
2	2,753 (20.2%)	1,576 (20.1%)	1,177 (20.4%)	

3	1,600 (11.8%)	974 (12.4%)	626 (10.9%)	
4	1,012 (7.4%)	658 (8.4%)	354 (6.1%)	
5+	2,063 (15.2%)	1,458 (18.6%)	605 (10.5%)	
Prior Clinical Breast Exam				
No	1,060 (7.8%)	445 (5.7%)	615 (10.7%)	114.95 (1)**
Yes	12,544 (92.2%)	7,392 (94.3%)	5,152 (89.3%)	
Prior Pap Test				
No	5,688 (41.8%)	3,548 (45.3%)	2,140 (37.1%)	91.03 (1)**
Yes	7,916 (58.2%)	4,289 (54.7%)	3,627 (62.9%)	
Breast Cancer History[1]				
No	11,672 (85.8%)	6,651 (84.9%)	5,021 (87.1%)	112.62 (2)**
Yes	1,443 (10.6%)	980 (12.5%)	463 (8.0%)	
Unknown	489 (3.6%)	206 (2.6%)	283 (4.9%)	

1. Breast cancer history was defined as personal experience or a female family member (mother, grandmother, or sister) having breast cancer.

**p<0.001, *p<0.05, +p<0.10 (approaching significance)

Unadjusted Associations. Results of unadjusted associations between EDW mammography use and county- and person-level characteristics, performed to first explore how each independent variable related to the likelihood of recent mammography use before combining the variables into a single model, are presented in Table 2. Residence in a non-metro county (compared to a rural county) was associated with a 1.09 times (95% CI=1.01-1.17) increase in the likelihood of having a recent mammogram. Compared to the least disadvantaged counties (Quartile 1), residents of counties in Quartiles 2 and 3 were 1.15 times (95% CI=1.06-1.25) and 1.44 times (95% CI=1.26-1.65) more likely, respectively, to have a recent compared to a non-recent mammogram. Residents of Quartile 4 counties did not significantly differ from Quartile 1 counties in the likelihood of having a recent mammogram (OR=1.07, 95% CI=0.98-1.17).

When examining person-level characteristics, women who began screening in the EDW program at younger ages were less likely to have a recent compared to a non-recent mammogram (OR=0.97, 95% CI=0.97-0.98). Hispanic women were 1.72 times (95% CI=1.60-1.86) more likely to have a recent mammogram than White women. Users with more EDW program mammograms or who had a prior clinical breast exam were 1.14 times (95% CI=1.12-1.16) and 1.98 times (95% CI=1.75-2.25) more likely to have a recent mammogram, while those who had a prior pap test were 29% less likely (OR=0.71, 95% CI=0.67-0.77) to have a recent mammogram. Finally, users who had a personal or family history of breast cancer were 1.60 times (95% CI=1.42-1.80) more likely to have a recent than non-recent mammogram.

Table 2: Unadjusted Associations between Mammography Use and County- and Person-Level Characteristics of Low-Income Mammography Users in Kansas, 2011-2014

Characteristic		**Recent Users, 2013-2014** (*n*=7,837) mean/n (CI/%)	**Non-Recent Users, 2011-2012** (*n*=5,767) mean/n (CI/%)	**OR (95% CI)**
County-Level	**Demographic**			
	Urbanicity Group[1]			
	Metro	5,108 (65.2%)	3,848 (66.7%)	1.00 (referent)
	Non-Metro	2,412 (30.8%)	1,668 (28.9%)	1.09* (1.01, 1.17)
	Rural	317 (4.0%)	251 (4.4%)	0.95 (0.80, 1.13)
	% Black Population	7.8 (7.6, 7.9)	7.7 (7.5, 7.9)	1.00 (1.00, 1.01)
	% Hispanic Population	15.0 (14.7, 15.3)	13.4 (13.2, 13.7)	1.01* (1.01, 1.01)
	Mammogram Facilities (per 10,000 Adult Women)[2]	0.8 (0.8, 0.8)	0.8 (0.8, 0.8)	1.02 (0.97, 1.07)
	Primary Care Physicians (per 10,000 Residents)	7.0 (7.0, 7.1)	7.0 (7.0, 7.1)	1.01 (0.99, 1.03)
	Socioeconomic			
	Deprivation Score	13.1 (12.0, 13.2)	13.1 (13.0, 13.2)	1.00 (1.00, 1.00)
	Quartile 1 (least deprived)	2,236 (28.5%)	1,810 (31.4%)	1.00 (referent)

	Quartile 2	2,741 (35.0%)	1,932 (33.5%)	1.15* (1.06, 1.25)
	Quartile 3	730 (9.3%)	411 (7.1%)	1.44* (1.26, 1.65)
	Quartile 4 (most deprived)	2,130 (27.2%)	1,614 (28.0%)	1.07 (0.98, 1.17)
Person-Level	**Demographic**			
	Age at First EDW Mammogram			
	Age (years)	46.9 (46.8, 47.1)	48.2 (48.0, 48.3)	0.97** (0.97, 0.98)
	Race/Ethnicity			
	Non-Hispanic White	3,367 (43.0%)	3,084 (53.5%)	1.00 (referent)
	Non-Hispanic Black	732 (9.3%)	642 (11.1%)	1.04 (9.30, 1.17)
	Hispanic	3,272 (41.8%)	1,742 (30.2%)	1.72** (1.60, 1.86)
	Other/Unknown	466 (5.9%)	299 (5.2%)	1.43** (1.23, 1.66)
	Screening Behavior			
	EDW Mammogram Count			
	Total Mammograms	2.8 (2.8, 2.9)	2.2 (2.2, 2.3)	1.14** (1.12, 1.16)
	Prior Clinical Breast Exam			
	No	445 (5.7%)	615 (10.7%)	1.00 (referent)
	Yes	7,392 (94.3%)	5,152 (89.3%)	1.98** (1.75, 2.25)
	Prior Pap Test			
	No	3,548 (45.3%)	2,140 (37.1%)	1.00 (referent)
	Yes	4,289 (54.7%)	3,627 (62.9%)	0.71** (0.67, 0.77)
	Breast Cancer History[3]			
	No	6,651 (84.9%)	5,021 (87.1%)	1.00 (referent)
	Yes	980 (12.5%)	463 (8.0%)	1.60** (1.42, 1.80)
	Unknown	206 (2.6%)	283 (4.9%)	0.55** (0.46, 0.66)

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-Metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Mammogram facilities data is based on the most recent available information from 2013.
3. Breast cancer history was defined as personal experience or a female family member (mother, grandmother, or sister) having breast cancer.

**p<0.001, *p<0.05, +p<0.10 (approaching significance)

Multilevel Adjusted Associations. Table 3 presents results from a series of three HGLMs that were conducted to examine the association of both person- and county-level characteristics with the likelihood of recent mammography use. The null, or unconditional model, first estimated the average likelihood of having a recent compared to non-recent mammogram across all Kansas counties was 1.29 (95% CI=1.16-1.42), meaning that, on average, women in this study were more likely to have had a recent compared to a non-recent mammogram. Although not shown here, these results indicated significant variation in mammography use by county ($\tau_{00} = 0.120$, $p<0.001$). Based on this model, county-level variation in mammography use was estimated to account for approximately 3.5% of the total variance in recent mammography use in the EDW program (Intraclass Correlation Coefficient = $\sigma^2/(\sigma^2+\pi^2/3)$ = 0.11980/(0.11980+3.29) = 0.035) (Rodriguez & Elo, 2003). Even though a small proportion of the variation in mammography use was due to county-level characteristics, the significance test indicated this variation was not due to chance, which justified the addition of county-level predictors to attempt to explain the county-level variance.

Next, Model 1 tested the effects of county-level socioeconomic deprivation on the likelihood of recent mammography use. When accounting for all other county-level characteristics, including urbanicity, rates of mammography facilities and PCPs, and minority population composition, residence in counties with the lowest levels of socioeconomic deprivation (Quartile 1) was significantly associated with a higher likelihood of having a recent mammogram (OR=1.33, 95% CI=1.05-1.68). For comparison purposes, Model 2 determined the baseline likelihood of mammography use was significantly associated with nearly all person-level predictors prior to examining the effect of county-level uninsurance in the full model. Finally, when accounting for all person- and county-level characteristics in Model 3, residence in

counties with the lowest levels of socioeconomic deprivation (Quartile 1 compared to Quartiles 2-4) was significantly associated with a 1.35 times higher likelihood of having a recent compared to a non-recent mammogram (95% CI=1.00-1.82; $p<0.05$). When accounting for person-level characteristics in Model 3, the likelihood of recent mammography use associated with county-level socioeconomic deprivation slightly increased from Model 1 to 1.33 from 1.35, respectively.

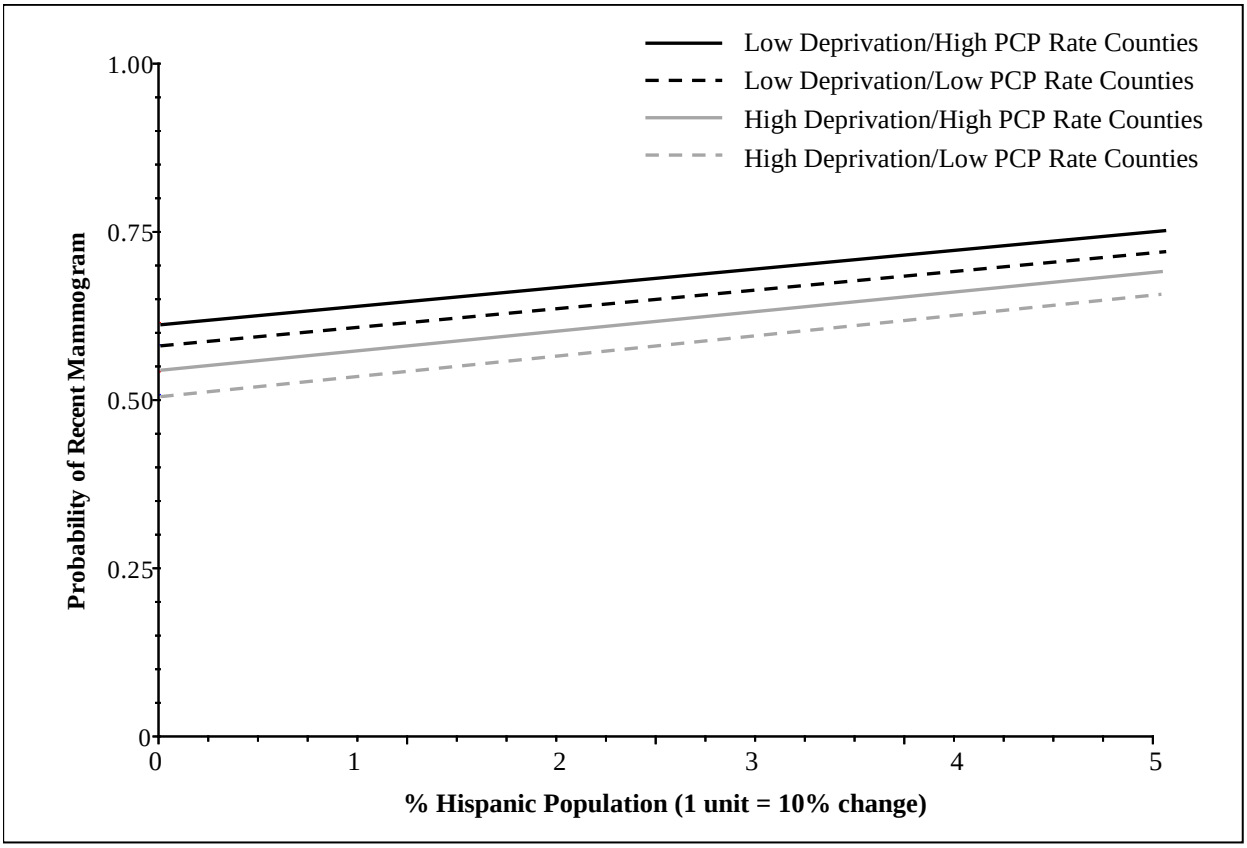
Moreover, for every one additional PCP per 10,000 county residents, the likelihood of recent mammography increased by 1.04 times (95% CI=1.00-1.08; $p=0.06$). For every 10% increase in the Hispanic population of a county, the likelihood of recent mammography increased by 1.12 times (95% CI=1.00-1.25; $p<0.001$). Residence in counties with the lowest socioeconomic deprivation explained 11.7%, county PCP rate explained 11.4%, and proportion of county Hispanic population explained 26.2% of the county-level variation in mammography. Taken together, these three county-level characteristics explained 35.3% of the variance in the likelihood of person-level recent mammography use. The relationship of these county-level characteristics to the likelihood of recent mammography is graphically presented in Figure 1.

Additional exploratory analyses were performed for person-level socioeconomic characteristics, including household income, income dependents, education levels, employment status, English language primacy, and relationship status. However, high levels of missing data (ranging from 1,425 (10.9%) to 7,037 (53.8%) available women) due to the implementation of a new EDW data collection system in 2013 limited the ability to perform analyses on the full study population. Only the association between number of income dependents and the likelihood of recent mammography use neared significance (OR=1.12, 95% CI=1.00-1.25; $p=0.06$; Model 6). No other person-level socioeconomic characteristics were associated with the likelihood of recent mammography. Results from these exploratory models are located in Appendix B and C.

Table 3: Adjusted Associations Between Likelihood of Recent Mammography Use and County- and Person-Level Characteristics in Kansas, 2011-2014			
Fixed Components	**Model 1**	**Model 2**	**Model 3**
County-Level Predictors			
Deprivation Quartile 1 (ref: Quartiles 2-4)	1.33* (1.05, 1.68)		1.35* (1.00, 1.82)
Metro (ref: Rural)	0.78 (0.56, 1.08)		0.82 (0.57, 1.19)
Non-Metro (ref: Rural)	0.96 (0.74, 1.25)		1.06 (0.81, 1.40)
Mammography Facilities (per 10,000 Adult Women)	0.99 (0.91, 1.08)		0.99 (0.91, 1.07)
Primary Care Providers (per 10,000 Residents)	1.04+ (1.00, 1.07)		1.04+ (1.00, 1.08)
% Black Population (10% Change)	0.96 (0.71, 1.31)		1.01 (0.53, 1.91)
% Hispanic Population (10% Change)	1.17** (1.08, 1.27)		1.12** (1.00, 1.25)
Person-Level Predictors			
Age at First EDW Mammogram		0.98** (0.97, 0.99)	0.98** (0.97, 0.99)
Non-Hispanic Black (ref: Non-Hispanic White)		1.02 (0.87, 1.20)	1.02 (0.82, 1.27)
Hispanic (ref: Non-Hispanic White)		1.55** (1.36, 1.75)	1.55** (1.34, 1.79)
EDW Mammogram Count		1.20** (1.19, 1.22)	1.20** (1.18, 1.22)
Prior Pap Test		0.44** (0.42, 0.47)	0.44** (0.41, 0.47)
Prior Clinical Breast Exam		2.08** (1.93, 2.25)	2.05** (1.89, 2.22)
Breast Cancer History		1.62** (1.37, 1.92)	1.63** (1.37, 1.93)
Intercept	1.26* (1.04, 1.51)	1.03 (0.92, 1.16)	0.96 (0.78, 1.18)
Tau_{00}	0.064**	0.123**	0.072**
% County-Level Variance Explained	47.5%	n/a	41.4%
Change in Deviance (DF)	n/a (9)	2604.50 (9)**	19.72 (16)**
Comparison	n/a	2v1	3v2

**p<0.001, *p<0.05, +p<0.10 (approaching significance)

Figure 1: County-Level Predictors of Recent vs. Non-Recent Mammography Use in the EDW Program



Lower socioeconomic deprivation counties (Quartile 1) were associated with higher probability of recent mammography (black lines) compared to higher socioeconomic deprivation counties (Quartiles 2-4; gray lines). Counties with more PCPs had higher probability of recent mammography compared to counties with fewer PCPs (solid lines represent 75th percentile and dotted lines represent 25th percentile). Counties with higher proportions of Hispanic residents (x-axis) also had higher probability of recent mammography compared to counties with lower proportions of Hispanic residents.

Discussion

The purpose of this study was to determine to what extent county-level SEP was associated with recent mammography use among low-income women in Kansas who participated in a free mammogram screening program. This study found a significant relationship between county-level SEP and recent mammography use, such that residents of counties with the lowest levels of socioeconomic deprivation (Quartile 1) had a higher likelihood of having a recent compared to a non-recent EDW mammogram than women living in counties with higher levels of socioeconomic deprivation (Quartiles 2-4). Put another way, poor women living in counties with greater socioeconomic affluence were more likely to have a recent EDW mammogram than women from less affluent counties, even when accounting for personal characteristics. Results also indicated that living in counties with more PCPs and larger Hispanic populations were associated with greater likelihood of having a recent EDW mammogram. Together, these three characteristics explained more than one-third of the variation in mammography use due to county-level characteristics. Therefore, these findings support the study hypothesis that county-level socioeconomic deprivation would be negatively associated with recent mammogram use in the EDW program.

As one of the first studies to explore the impact of county-level SEP on mammography use among low-income women, these findings broadly contribute to prior research demonstrating the significant role that the socioeconomic environment can play in facilitating use of screening mammography in the U.S. Overall, the results of this study align with most prior research examining single-dimension SEP measures, demonstrating that as indicators of area-level SEP improved so did mammography use (Pruitt et al., 2009). Additionally, this study also contributes to a smaller group of studies that utilized multilevel research techniques to account for both

person- and area-level characteristics in their analyses. These researchers found that independent of person-level factors, residence in areas with greater poverty levels (Calo et al., 2016; Schootman et al., 2006) or fewer high school graduates (Kothari & Birch, 2004) was associated with decreased use of mammography.

More importantly, this study also expands a small, but growing literature in the U.S., using a composite measure of SEP that combines multiple single-dimension characteristics to more comprehensively assess the socioeconomic deprivation of a community. Only two prior studies have used an SEP index to explore the relationship between area-level socioeconomic deprivation and mammography use, while also controlling for person-level characteristics. In Connecticut, Dailey et al. (2007) found that black and white women were 3.55 and 2.13 times, respectively, more likely to be nonadherent to mammography screening recommendations when they lived in the most disadvantaged urban neighborhoods (Quartile 4) compared to the least disadvantaged (Quartile 1). Similarly, when examining area-level SEP across the U.S., Dailey et al. (2011) found that residents of more disadvantaged areas (Quartiles 2-4) had a 23%-37% lower likelihood of repeat mammography compared to those from the most advantaged areas (Quartile 1). Likewise, the results of the present study found that poor women living in the least disadvantaged Kansas counties (Quartile 1) had a 1.35 times higher likelihood of recent mammography compared to poor women living in more disadvantaged counties (Quartiles 2-4).

Building on the research framework of the two prior Dailey studies, the present study applied the same composite measure of area-level socioeconomic deprivation (SEP index) as the primary predictor variable to a different: 1) study population, 2) geographic area, and 3) mammography outcome. Although conclusions were similar for all three studies, differences in these three study features may have contributed any observed differences in the strength of

outcomes between them. First, the two prior studies examined mammography use among the general U.S. population, while the present study focused only on mammography use among low-income, uninsured women who participated in a free mammography screening program. The consistency of results across studies suggests that the socioeconomic environment in which women live may play an important role in facilitating the use of mammography screening. These findings may be of particular importance to the EDW program because they suggest that although the mammograms are free, their use may still be influenced by the socioeconomic environment in which low-income, uninsured women live.

Second, although the two prior studies examined mammography use in narrow geographic areas of urban neighborhoods and census tracts, the present study expanded the geographic region of analysis to the county-level in a predominantly rural state. The consistency of area-level socioeconomic deprivation and mammography use relationships across these studies suggests that the influence of the environment on mammography screening may be more extensive than first investigated and apply to multiple geographic areas of the U.S., regardless of urbanicity. Finally, while Dailey et al. (2007) examined nonadherence to age-specific mammography screening recommendations, Dailey et al. (2011) measured six-year repeat mammography use across the general U.S. mammography-eligible population. In contrast, this study focused on recent mammography use to investigate county-level characteristics that may be associated with greater timely engagement among women who participated in a free mammography program. Collectively, these studies indicate that living in communities with lower levels of socioeconomic deprivation may increase the likelihood of mammography use, regardless of the specific population or geographic area.

Limitations. This study has several limitations. First, it is a retrospective analysis focused only on low-income mammography users in the Kansas EDW program. Therefore, these findings only apply to a narrowly defined population and cannot be extrapolated to describe the relationship of county-level SEP and mammography use among non-program participants or the broader U.S. population. Second, the administrative and clinical program data analyzed in this study were not originally collected for research purposes, which may have created challenges in the measurement and reliability of some information (Shi, 2008). As a result, the large volume of missing socioeconomic data for EDW program participants limited the ability to control for and explore the effect of person-level socioeconomic characteristics in county-level SEP analyses. Even though this information was unavailable, however, there was moderate homogeneity among the study population with regard to socioeconomic resources, as all women in this study participated in the EDW program, which required participants to be under 225% FPL and have no insurance to qualify for mammogram services (Kansas Department of Health & Environment, 2014b).

Third, the choice of county as geographic unit of analysis may have been too large to detect some meaningful differences or not representative of the most socially, culturally, or economically meaningful geographic divisions (Krieger et al., 2002). For instance, SEP measures, such as household income, residents without high school education, and unemployed residents could vary significantly within counties, particularly those with large geographic areas. Using measurements at the county-level rather than smaller geographic areas, such as zip codes or census tracts, may have obscured important differences between socioeconomic indicators across smaller geographic areas. However, counties were chosen for use in this study because they best balanced the availability of area-level data with sample size limitations imposed by

counties with smaller participating EDW populations, as well as aligned with resource allocation methods.

Fourth, assigning women to live in the same county for four years may have increased the likelihood of temporal or spatial misclassification of socioeconomic resources (Dailey et al., 2011). In particular, multiyear estimates of county-level SEP measurements may have concealed the impact of changes in county socioeconomic conditions over time. Countering this concern, research has found that although low-income populations have exhibited mobility within zip codes and cities, they often do not move outside county boundaries (Coulton et al., 2009). Additionally, county-level socioeconomic data were five-year estimates based on the 2010 U.S. Census and would have provided similar data for the study regardless of the chosen reference year (Health Resources and Services Administration, 2014). Therefore, although this study's ability to detect meaningful differences in mammography use may have been limited by geographic and temporal issues, this would have likely resulted in an underestimation of the true association of county-level characteristics with mammography use among individual women.

Implications. Although narrow in scope, the results of this study may have particular relevance to policymakers of Kansas and similar states. Kansas is a predominantly rural state with large farming, manufacturing, and construction workforces that may not provide steady income or health insurance benefits to employees (Kansas Labor Information Center, 2016). As a result, these residents may be left in need of socioeconomic resources to obtain healthcare services, including screening mammograms (Kaiser Family Foundation, 2015a). Although this study suggests that the socioeconomic affluence of counties is associated with mammography use among women participating in a free mammography program, improving counties'

socioeconomic conditions requires complex and coordinated efforts that could take many years before garnering results.

However, a more practical application of these findings might be in health program planning and strategic partnership development. State policymakers and program administrators could consider using county-level SEP measures as a means of targeting limited cancer screening resources and interventions, as well as building partnerships to deliver more screening resources. For instance, this study suggests that poor women in counties with higher socioeconomic deprivation are at a greater risk of not receiving timely breast cancer screenings, even when they are free. Additional outreach, education, and partnerships with local providers may be necessary to ensure these women engage in timely breast cancer screening.

Future research can build on these findings by determining whether or not they hold true: 1) over time, 2) within smaller geographic areas, such as zip codes or census tracts, in Kansas and 3) for poor women who are eligible for EDW services but have not used them or among non-poor women in rural areas. Doing so would further extend this line of inquiry and provide additional information about the extent of the relationship between area-level characteristics and mammography use among all women. Moreover, expanding this study could enable more precise longitudinal analyses that may be better suited to tease out specific effects of county-level environments on person-level mammography use over time. Future studies also should incorporate additional person-level socioeconomic characteristics to more fully understand how community resources influence mammography use among women at various levels of the socioeconomic spectrum.

Conclusion

In summary, this study found that low-income women living in the least deprived Kansas counties were more likely to receive a recent mammogram compared to low-income women living in more deprived counties in a free mammography screening program. Building on prior research, this study applied a validated composite measure of area-level socioeconomic deprivation to a new geographic area (Kansas counties) and study population (low-income women), while garnering similar results to prior studies (Dailey et al., 2011; Dailey et al., 2007). As such, this study indicates that even when mammography screenings are offered free of charge, the characteristics of the broader environment may play an important role in their actual use. Ultimately, however, these findings suggest that a comprehensive public health strategy may be warranted to adequately address cancer health disparities by focusing on the most socioeconomically vulnerable populations.

Chapter 5: County-Level Uninsurance and Mammography Utilization Among Low-Income Women in Kansas, 2011-2014 (Paper 3)

Introduction

In Kansas, low-income adults have limited health insurance options. Since electing not to expand Medicaid under the Patient Protection and Affordable Care Act (ACA), very few Kansas adults qualify for Medicaid coverage and many other poor adults have difficulty purchasing insurance via exchange marketplaces (Kaiser Family Foundation, 2014). This coverage gap between government and private insurance is doubly problematic for low-income, uninsured individuals. Not only because they often experience negative health consequences from the distribution of health resources and exposures in their communities (Lynch & Kaplan, 2000), but because they also do not have health insurance to combat these exposures (Institute of Medicine, 2004). To access healthcare services, low-income, uninsured individuals often rely on community resources, such as charity care or free screening programs. Thus, there is reason to believe that an increased number of uninsured residents in a community may particularly affect access to healthcare services, such as mammography screenings, for low-income, uninsured individuals, as community resources may become more limited (Lynch & Kaplan, 2000; Pagan & Pauly, 2006). However, very little research to-date has examined how area-level uninsurance might influence mammography use among low-income, uninsured women.

Beyond having direct negative person-level effects on those who are uninsured (Hadley, 2003), research has shown that a lack of health insurance – a critical mechanism for attaining medical services such as mammograms (Institute of Medicine, 2009) – also can have further adverse implications for the community as a whole. For instance, several emerging studies have demonstrated that area-level uninsurance rates can impact individuals *with* insurance, such that

the higher the uninsurance rate of the community, the less likely insured adults living there were able to access services and felt satisfied with their care (Gresenz & Escarce, 2011; Pagan & Pauly, 2006; Pauly & Pagan, 2008). To date, only one study has applied this concept to cancer screening, finding that among the general U.S. population, as community uninsurance rates increased, the likelihood of female residents obtaining recent mammograms decreased, regardless of their own insurance status, personal characteristics, or area-level income (Pagan et al., 2008). Although the dynamics of community uninsurance are still poorly understood, these studies indicate that local healthcare systems may be stressed by the financial pressures associated with increasing numbers of residents without insurance coverage. In turn, this financial vulnerability becomes a community problem when access to care for even seemingly protected populations, such as the insured, is negatively affected (Institute of Medicine, 2009).

As an acknowledgement of the importance of insurance for individuals and communities, the ACA was a recent effort to increase comprehensive health insurance coverage nationally by using a three-prong approach of 1) expanding Medicaid (up to 138% of the federal poverty level [FPL]), 2) creating health insurance exchanges (100-400% FPL), and 3) building on the current employer-based insurance structure (U.S. Department of Health & Human Services, 2015). Although nearly nine million nonelderly adults have become insured since 2013, declines in uninsurance rates have varied widely across the U.S., primarily due to state Medicaid expansion decisions (Kaiser Family Foundation, 2015a). Uninsurance rates have dropped significantly for poor adults residing in states expanding Medicaid programs, while they have remained nearly unchanged in non-expansion states (Collins et al., 2014; Majerol et al., 2015).

In Kansas, a non-expansion state, adults without children are ineligible for Medicaid coverage regardless of their income, while parents must have incomes below 38% FPL (under

$10,000 annual income for a family of four) to apply for Medicaid (Kaiser Family Foundation, 2014). Although exchanges have been established for adults with incomes 100-400% FPL to purchase subsidized insurance, over 80,000 uninsured Kansas adults with incomes under 100% FPL (under $24,300 annual income for a family of four) have fallen into a coverage gap between government programs and private insurance (Kaiser Family Foundation, 2014). Moreover, other Kansas women are also unable to obtain health insurance due to their immigrant status or relatively low incomes (100-250% FPL) that do not enable them to purchase subsidized insurance (Garfield et al., 2016).

Additionally, recent research has extended the problem of insufficient Medicaid coverage beyond the individual. Sabik et al. (2015) found that all women living in Medicaid non-expansion states had significantly lower odds of receiving mammograms than women living in expansion states, regardless of their own insurance status. Moreover, uninsured women in non-expansion states demonstrated the worst mammography screening outcomes of all, leading authors to conclude that without financial access to preventive screening services, such as Medicaid coverage, health disparities for low-income, uninsured women may only be prolonged.

Although not true insurance coverage, one option for low-income, uninsured women to access breast and cervical cancer screening services in the U.S. is the National Breast and Cervical Cancer Early Detection Program (NBCCEDP). Instituted in 1991, the program provides free cancer screenings, diagnostic services, and links to treatment via state Medicaid programs for low-income, uninsured women in all fifty states (Centers for Disease Control and Prevention, 2002). To accommodate local needs, preferences, and funding, each state program has separate eligibility criteria (Centers for Disease Control and Prevention, 2015). The Kansas program, titled Early Detection Works (EDW), provides annual mammography services to enrolled

women ages 40-64 with incomes under 225% FPL and no functional insurance (i.e., no insurance or unmet deductible over $2,500) (Kansas Department of Health & Environment, 2014b). While some research has shown that NBCCEDP is improving access to cancer screening and treatment across the U.S. (Hoerger et al., 2011; Howard et al., 2010), other estimates have indicated that only 10-15% of eligible women are receiving services annually (Howard et al., 2015; Snyder, October 15, 2014). Additionally, even though NBCCEDP has served over 4.6 million women nationally, it does not offer comprehensive health insurance, leaving participants without coverage for all other health concerns (Agency for Healthcare Research and Quality, 2011; Centers for Disease Control and Prevention, 2014).

When taken together, this information suggests that low-income, uninsured women are a particularly vulnerable population in Kansas. Because low-income, uninsured individuals often rely on broader community resources, such as charity care or the EDW program, to access to healthcare services, an increased number of uninsured residents in a community may particularly affect their ability to access healthcare services (Lynch & Kaplan, 2000). To date, however, little research has examined the impact of area-level uninsurance on low-income women's use of preventive screening services. Moreover, since low-income, uninsured women are at greater risk for lower mammography use and poorer breast cancer prognosis than women with more financial resources or insurance (American Cancer Society, 2014), improving understanding of the relationship between the uninsurance levels of communities and mammography use among women who live there is an important step toward increasing breast cancer screening, and ultimately, reducing cancer disparities. Therefore, the purpose of this study was to determine to what extent county-level uninsurance was associated with mammography use among low-

income, uninsured women in Kansas who participated in a free mammography screening program.

Hypothesis

Because prior research has found that high levels of area-level uninsurance were associated with reduced mammography use among the general U.S. population, this study first hypothesized (H_1) that counties with higher levels of uninsurance would have lower recent mammography use in the EDW program than counties with lower levels of uninsurance, when controlling for person-level characteristics. However, it was possible the opposite may have been true, given that when analyzing only county-level characteristics, Paper 1 found that county-level uninsurance was associated with higher rates of recent and repeat EDW mammography use. Additionally, because this study focused on women with few personal socioeconomic resources, it was plausible they may have been more inclined to obtain free mammograms through the EDW program than uninsured women in the broader population. Therefore, this study also hypothesized (H_2) that counties with higher levels of uninsurance would have correspondingly higher recent mammography use in the EDW program than counties with lower levels of uninsurance, when controlling for person-level characteristics.

Methods

Study Design and Data Sources. A cross-sectional retrospective design was used to assess the relationship of county- and person-level characteristics and mammography use among low-income, uninsured women in Kansas. Data were obtained for both county-level and person-level characteristics from three sources. The 2014 release of Area Health Resource Files

(AHRF), which is based on estimates from the 2010 U.S. Census, provided county-level demographic and socioeconomic data for all 105 Kansas counties using the Federal Information Processing Standards (FIPS) code of 20 for Kansas (Health Resources and Services Administration, 2013). Additional county-level data on counts of all Kansas mammography facilities (permanent and mobile units) were obtained from the U.S. Food and Drug Administration's (FDA) Mammography Facilities Database using the zip code for each facility to classify it into the proper county. Since the database only provides information for current facilities, all counts were based on data from 2013 (U.S. Food and Drug Administration, 2014).

Administrative and clinical service records from the Kansas EDW program provided person-level demographic, socioeconomic, and mammography use data. The EDW program is the Kansas division of the NBCCEDP and provides breast and cervical cancer screening services to low-income (<225% FPL), uninsured and underinsured (no insurance or only hospitalization insurance with deductible over $2,500) women ages 40-64 living in Kansas (Kansas Department of Health & Environment, 2014a). Encounter-level demographic and clinical service claims data for all clinical breast exams (CBEs), pap tests, and mammograms were provided for all participants since program initiation in 1996. Due to the implementation of a new integrated data system in 2013, however, self-reported socioeconomic information was only reliably available for participants who had enrolled in the EDW program in 2013 or 2014 (Snyder, July 1, 2014).

IRB Approval. This study was approved by the University of Kansas School of Medicine's Institutional Review Board (IRB) with a Health Insurance Portability and Accountability Act (HIPAA) privacy waiver (IRB #00002605). Access to the EDW program administrative and clinical service data was obtained through an approved data use agreement with the Kansas Department of Health and Environment (KDHE).

Dependent Variable. To explore characteristics associated with recent EDW program engagement, clinical data on mammogram use by EDW program participants from 2011-2014 were used to construct a dichotomous dependent variable for recent mammogram use (coded as '1') versus non-recent use (coded as '0'). These four years were chosen for study analyses because they most closely aligned with available area-level data characterizing the environment in which mammography screening occurred. First, encounter-level claims data for all EDW mammograms performed from 1996-2014 were aggregated at the person-level to create counts of mammograms per participant per year. This resulted in 16,563 participants who had received at least one mammogram in the EDW program.

Next, in accordance with current literature, participants were classified as 'recent users' if they had at least one program mammogram in the past 24 months (2013-2014) (Breen et al., 2011; Howard & Adams, 2012). Participants who had at least one program mammogram in the past 24-48 months (2011-2012) were classified as 'non-recent users.' EDW participants without a mammogram during the study years (n=2,959) were excluded from analyses, leaving 13,604 participants (82.1%) in the final study population. As a result, this study only focused on EDW mammography users and did not include any information about non-users.

Independent Variables. Independent variables in this study were measured at both the county- and person-level. County-level characteristics included uninsurance level, socioeconomic deprivation, urbanicity, healthcare supply, and minority composition measures, while individual (or person-level) characteristics included demographics information and screening behaviors. One county was excluded from analyses due to lack of person-level mammography outcomes, resulting in 104 counties and 13,604 EDW participants included in the

final study analyses. County-level characteristics were the main focus of analyses, while person-level characteristics were used as control variables. Each measure is described in detail below.

County-Level Uninsurance. Similar to the Pagan et al. (2008) study, the primary independent variable of interest was percentage of uninsured county residents as a predictor of mammography use among EDW participants. Proportions of uninsured residents were obtained directly from AHRF data for each county for individual years from 2008 to 2012. To align with the other county-level socioeconomic variables, five-year average estimates of the proportion of uninsured residents were calculated for each county by summing uninsurance measures for all years and dividing by five.

County-Level Socioeconomic Deprivation. To control for county-level socioeconomic deprivation, a composite measure of six socioeconomic variables, known as the Socioeconomic Position (SEP) index, was created for each county following the methodology of Krieger et al. (2002) and Dailey et al. (2011). Variables included in the index were: 1) median household income, 2) median housing value, 3) percentage below FPL, 4) percentage without high school education (age 25+), 5) percentage unemployed, and 6) percentage working class. The first four variables were obtained directly from AHRF data, while fifth and sixth variables were computed using only AHRF data.

The percentage of unemployed workers in 2008-2012 was calculated by dividing the number of unemployed workers by the total civilian labor force during the same years. Similar to the methodology of other studies, the percentage of working class individuals was calculated by summing workers in agriculture/forestry/mining, construction, and manufacturing occupations and dividing by the number of workers in all occupations during 2008-2012 (Becker, 2006). Next, scales for median household income and median home value were reversed, so that higher

index scores indicated a higher level of socioeconomic deprivation. Standardized z-scores were calculated for each variable and summed to create a total composite SEP index score for each county.

County-Level Population Urbanicity, Healthcare Supply, and Minority Composition. To account for county characteristics that may have represented shared exposures for EDW participants (Benjamins et al., 2004; Litaker & Tomolo, 2007; Mobley et al., 2008), measures of county urbanicity, healthcare supply, and minority population composition were included as control variables. Counties were classified by urbanicity using the 2013 version of the Rural-Urban Continuum Code (RUCC) methodology, which is based on the most recent version of the U.S. Census (U.S. Department of Agriculture, 2013b). Counties were first classified into one of nine categories from metro (1) to rural (9) based on a combination of population density and proximity to metro areas. For study analyses, counties were further grouped into metro (classifications 1-3), non-metro (classifications 4-7), and rural (classifications 8-9) categories using grouping definitions provided by the U.S. Department of Agriculture (2013b). Rural counties were selected as the reference group for the models because they were a large urbanicity group.

Measures of healthcare supply focused on availability of mammography facilities and primary care physicians (PCPs) in each county. Rates were calculated by dividing counts of mammography facilities and primary care physicians by the total number of adult women and total population per county, respectively, and multiplying by 10,000 to enable valid cross-county comparisons (Friis, 2010). Measures of minority population composition were obtained directly from 2010 AHRF data for the percentage of Black and Hispanic population in each county and

divided by 10 so that each one-unit change in the models corresponded to a meaningful 10% change in minority population composition.

Person-Level Demographics. To account for individual characteristics that may have predisposed participants to having a recent mammogram (Schueler et al., 2008), information on EDW program participants' age and self-reported race/ethnicity were obtained from administrative data based on the participants' most recent date of contact with the program. To account for early initiation of mammography screening, age was calculated as the age participants obtained their first EDW program mammogram using date of birth and mammogram service dates. Race variables were constructed from self-reported race and ethnicity of Hispanic or Non-Hispanic records. For analysis purposes, these variables were then used to create a combined race/ethnicity variable of Non-Hispanic White, Non-Hispanic Black, Hispanic, and Other/Unknown Race, with any report of Hispanic ethnicity resulting in Hispanic classification. In the final models, the Non-Hispanic White category was chosen as the reference group because it was the largest and the Other/Unknown Race category was omitted from analyses (n=765 participants) due to questions of measurement accuracy. Exploratory analyses indicated that model results did not differ substantially based on this exclusion.

Person-Level Screening Characteristics. Because previous research has shown that prior screening behaviors and history of breast cancer were reliable indicators of future screening use (Schueler et al., 2008), data on each participant's breast and cervical cancer screening services in the EDW program and breast cancer history were included. EDW program clinical data provided information on participants' breast and cervical cancer preventive screening history. First, all EDW mammograms since the initiation of the program in 1996 were totaled for each participant to provide information about the frequency of interaction with the program. Next, historical

claims data was used to create dichotomous variables for whether or not each participant had received a pap test or clinical breast exam (CBE) in the EDW program prior to each mammogram. Finally, self-reported information on participants' personal and family history of breast cancer was used to create a single dichotomous variable to indicate if the participant or her mother, grandmother, or sister had ever been diagnosed with breast cancer.

Person-Level Socioeconomic Characteristics. To account for personal characteristics that may have enabled women to obtain a recent mammogram, socioeconomic data for all EDW participants were collected and coded as similarly to the Dailey et al. (2011) study as possible. Self-reported information on EDW program participants' socioeconomic characteristics was obtained from program administrative data based on the participants' most recent date of contact with the program. The July 2013 implementation of a new EDW administrative data system enabled the systematic collection of socioeconomic information on participants that was not previously possible (Snyder, July 1, 2014). As a result, much of this data was missing, particularly for 'non-recent users' because of the timing of implementation. Nevertheless, when available, the following data were obtained for EDW program participants and examined in exploratory analyses: household income, number of income dependents, FPL, insurance status, employment status, English language primacy, educational attainment, and relationship status.

Household income was measured in $1,000 increments of change, FPL was measured in 10% increments of change, and number of income dependents was measured continuously. Insurance and employment status were coded dichotomously to indicate whether or not the participant had insurance or was working for pay. A dichotomous variable for English language primacy was created by recoding the EDW 'primary language' variable as '1' for English and '0' for all other languages. The EDW 'education level' variable was recoded into three levels to

indicate educational attainment of non-high school graduate, high school graduate, and some college or higher. The 'marital status' variable was recoded into three relationship status levels of single, separated/widowed, and married. In the models, non-high school graduate and married categories were selected as reference groups.

Study Analyses. Participants were geographically classified based on their most recent county of residence on file with the EDW program and county-level data were assigned to each participant based on unique county FIPS codes (U.S. Census Bureau, 2010). First, descriptive analyses were performed to explore person-level characteristics, while county-level characteristics were described in Table 1 of Paper 1. Independent samples t-tests and chi-square tests were used to explore differences in person-level characteristics between recent and non-recent users. Next, logistic regression techniques were used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for the unadjusted relationships between recent mammography use and county- and person-level characteristics. Descriptive and logistic regression analyses were performed using SPSS version 23 (IBM Corp, 2014) and a *p*-value of <0.05 was used to determine statistical significance.

Finally, a series of three hierarchical generalized linear models (HGLM) were conducted to disaggregate the variance in mammography use due to person- versus county-level characteristics. When data have multiple levels of analysis, such as women nested within counties, hierarchical models are appropriate to account for clustering (Subramanian et al., 2003). For this study, multilevel logistic models (Bernoulli distribution) were conducted using EM Laplace and full maximum likelihood estimation to calculate the likelihood of recent compared to non-recent mammography use. A random effect was included on the intercept to allow the model to estimate county-level variation around the average likelihood of

mammography. EM Laplace estimation was chosen over the default penalized quasi likelihood (PQL) estimation because PQL estimation has been shown to underestimate random effects, in this case county-level variance, which was the major area of interest for this study (Raudenbush & Bryk, 2002).

HGLM simultaneously models outcomes at two different analysis levels – a Level 1 model to estimate the effects of person-level characteristics on the person-level outcome of mammography use, and a Level 2 model to estimate the effects of county-level characteristics on the coefficients from the Level 1 analysis (Raudenbush & Bryk, 2002). Random intercepts were estimated in all models, but slopes of the person-level variables were fixed because they were used as control variables in the analyses. All HGLM analyses were performed using HLM 7 Hierarchical Linear and Nonlinear Modeling software (Raudenbush et al., 2011) and a *p*-value of <0.05 was used to determine statistical significance.

Model 1, examined the effect of the primary predictor, county uninsurance, with the other county-level characteristics to estimate the likelihood of having a recent mammogram only due to county-level characteristics. Next, to estimate only the effect of person-level characteristics on the likelihood of recent mammography as a baseline for comparison with the final model, all person-level predictors were entered into Model 2. Finally, all county- and person-level predictors were entered simultaneously into Model 3, according to the following equations:

Level 1: $\text{prob}(RECENTMAM_{ij}=1|\beta_j) = \phi_{ij}$

$$\log[\phi_{ij}/(1 - \phi_{ij})] = \eta_{ij}$$

$$\eta_{ij} = \beta_{0j} + \beta_{1j}*AGE_{ij} + \beta_{2j}*BLACK_{ij} + \beta_{3j}*HISP_{ij} + \beta_{4j}*MAMCT_{ij} + \beta_{5j}*PAP + \beta_{6j}*CBE_{ij} + \beta_{7j}*BCHIST_{ij}$$

Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01}*UNIS_j + \gamma_{02}*SEP_j + \gamma_{03}*MFRATE_j + \gamma_{04}*PCPRATE_j + \gamma_{05}*METRO_j + \gamma_{06}*NMETRO_j + \gamma_{07}*PBLACK_j + \gamma_{08}*PHISP_j + u_{0j}$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

where ϕ_{ij} was the probability of having a recent versus non-recent mammogram (RECENTMAM). The link function, $\log[\phi_{ij}/(1 - \phi_{ij})]$, transformed the original probability into a binomial distribution of log odds (η_{ij}) for modeling as a continuous outcome. β_{0j} was the likelihood of women living in county *j* having a recent mammogram and γ_{00} was the average likelihood of having a recent mammogram across all Kansas counties. The betas ($\beta_{1j} - \beta_{7j}$) represented the coefficients for each corresponding person-level characteristic per county. The average value of each person-level characteristic across all counties was represented by the gammas ($\gamma_{01} - \gamma_{08}$). Each β represented the distribution of *j* counties and each γ was the average of each person-level characteristic (indicated by the subscript i) across all counties. For instance, the equation $\beta_{1j} = \gamma_{10}$ indicated that each participant's age at first mammogram (β_{1j}) was averaged across all counties to produce a single estimate of the effect of age on likelihood of recent mammogram use (γ_{10}).

At the person-level, AGE was age at first EDW program mammogram, BLACK and HISP ware dummy variables for race/ethnicity, MAMCT was the count of EDW mammograms received, and PAP, CBE, and BCHIST were dummy variables for prior pap test, prior CBE, and history of personal or family breast cancer. At the county-level, UNIS was the proportion of uninsured county residents, SEP was the county socioeconomic deprivation score, MFRATE was the number of mammography facilities per 10,000 adult women, PCPRATE was the number of PCPs per 10,000 county residents, METRO and NMETRO were dummy variables for county

urbanicity, PBLACK and PHISP were the proportion of black and Hispanic county residents, and u_{0j} represented the remaining unexplained variation in mammography use due to county-level differences (i.e., the random effect). In order to have an intercept with an interpretable value, the person-level predictors of AGE and MAMCT were grand-mean centered, as well as the county-level predictors of UNIS, SEP, MFRATE, PCPRATE, PBLACK, and PHISP. Person-level BLACK and HISP predictors were group-mean (county-mean) centered to estimate the effect of ethnicity within the average county (Hofmann & Gavin, 1998).

Results

Descriptive Analyses. On average, there were 131 EDW participants per county (range=1-3,459) who received one or more program mammograms from 2011-2014. Kansas counties averaged 75 recent users (range=1-2,074) and 56 non-recent users (range=1-1,385). On average, participants had their first EDW mammogram at age 47, with recent users engaging in the program at slightly younger ages than non-recent users (p<0.001; Table 1). Recent users were comprised of more Hispanic women (42% v. 30%, respectively) and fewer Non-Hispanic White women (43% v. 53%, respectively) than non-recent users. Users averaged 2.6 program mammograms each, with recent users having slightly more than non-recent users (p<0.001). Additionally, more recent users had multiple program mammograms than non-recent users, indicating greater engagement with program screening. Nearly all users had a prior CBE, while slightly over half reported a prior pap test and 10% reported a personal or family history of breast cancer.

Table 1: Characteristics of Low-Income Mammography Users in Kansas, 2011-2014				
Characteristic	**All Users, 2011-2014** (*n*=13,604) mean/n (CI/%)	**Recent Users, 2013-2014** (*n*=7,837) mean/n (CI/%)	**Non-Recent Users, 2011-2012** (*n*=5,767) mean/n (CI/%)	***t* (*df*) or χ^2 (*df*)**
Demographic				
Age at First EDW Mammogram				
Age (years)	46.5 (46.4, 46.7)	46.9 (46.8, 47.1)	48.2 (48.0, 48.3)	10.75 (13,602)**
< 40	277 (2.0%)	189 (2.4%)	88 (1.5%)	80.30 (2)**
40-49	8,559 (62.9%)	5,136 (65.5%)	3,423 (59.4%)	
50+	4,768 (35.1%)	2,512 (32.1%)	2,256 (39.1%)	
Race/Ethnicity				
Non-Hispanic White	6,451 (47.4%)	3,367 (43.0%)	3,084 (53.5%)	244.69 (4)**
Non-Hispanic Black	1,374 (10.1%)	732 (9.3%)	642 (11.1%)	
Hispanic	5,014 (36.9%)	3,272 (41.8%)	1,742 (30.2%)	
Other/Unknown	765 (5.6%)	466 (5.9%)	299 (5.2%)	
Screening Behavior				
EDW Mammogram Count				
Total Mammograms	2.6 (2.5, 2.6)	2.8 (2.8, 2.9)	2.2 (2.2, 2.3)	-15.72 (13,602)**
1	6,176 (45.5%)	3,171 (40.5%)	3,005 (52.1%)	273.35 (4)**
2	2,753 (20.2%)	1,576 (20.1%)	1,177 (20.4%)	
3	1,600 (11.8%)	974 (12.4%)	626 (10.9%)	
4	1,012 (7.4%)	658 (8.4%)	354 (6.1%)	
5+	2,063 (15.2%)	1,458 (18.6%)	605 (10.5%)	
Prior Clinical Breast Exam				
No	1,060 (7.8%)	445 (5.7%)	615 (10.7%)	114.95 (1)**
Yes	12,544 (92.2%)	7,392 (94.3%)	5,152 (89.3%)	
Prior Pap Test				
No	5,688 (41.8%)	3,548 (45.3%)	2,140 (37.1%)	91.03 (1)**
Yes	7,916 (58.2%)	4,289 (54.7%)	3,627 (62.9%)	
Breast Cancer History[1]				
No	11,672 (85.8%)	6,651 (84.9%)	5,021 (87.1%)	112.62 (2)**
Yes	1,443 (10.6%)	980 (12.5%)	463 (8.0%)	
Unknown	489 (3.6%)	206 (2.6%)	283 (4.9%)	

1. Breast cancer history was defined as personal experience or a female family member (mother, grandmother, or sister) having breast cancer.

**$p<0.001$, *$p<0.05$, +p approaching significance

Unadjusted Associations. Unadjusted associations between EDW mammography use and county- and person-level characteristics were performed to first explore how each independent variable related to the likelihood of recent mammography use before combining the variables into a single model (Table 2). Residence in a non-metro county (compared to a rural county) or a county with a larger Hispanic population was associated with a 1.09 times (95% CI=1.01-1.17) increase in the likelihood of having a recent mammogram. Similarly, residence in counties with higher proportions of uninsured residents was associated with a 1.02 times (95% CI=1.01-1.03) increase in the likelihood of having a recent mammogram. There was no significant difference in county mammography facility rates, PCP rates, or socioeconomic deprivation scores for users and non-users.

When examining person-level characteristics, women who began screening in the EDW program at younger ages were less likely to have a recent compared to a non-recent mammogram (OR=0.97, 95% CI=0.97-0.98). Hispanic women were 1.72 times (95% CI=1.60-1.86) more likely to have a recent mammogram than White women. Users with more EDW program mammograms or who had a prior clinical breast exam were 1.14 times (95% CI=1.12-1.16) and 1.98 times (95% CI=1.75-2.25) more likely to have a recent mammogram, while those who had a prior pap test were 29% less likely (OR=0.71, 95% CI=0.46-0.66) to have a recent mammogram. Finally, users who had a personal or family history of breast cancer were 1.60 times (95% CI=1.42-1.80) more likely to have a recent than non-recent mammogram.

Table 2: Unadjusted Associations between Mammography Use and County- and Person-Level Characteristics of Low-Income Mammography Users in Kansas, 2011-2014				
Characteristic		**Recent Users, 2013-2014** (*n*=7,837) mean/n (CI/%)	**Non-Recent Users, 2011-2012** (*n*=5,767) mean/n (CI/%)	**OR (95% CI)**
County -Level	**Demographic**			
	Urbanicity Group[1]			
	Metro	5,108 (65.2%)	3,848 (66.7%)	1.00 (referent)
	Non-Metro	2,412 (30.8%)	1,668 (28.9%)	1.09* (1.01, 1.17)
	Rural	317 (4.0%)	251 (4.4%)	0.95 (0.80, 1.13)
	% Black Population	7.8 (7.6, 7.9)	7.7 (7.5, 7.9)	1.00 (1.00, 1.01)
	% Hispanic Population	15.0 (14.7, 15.3)	13.4 (13.2, 13.7)	1.01* (1.01, 1.01)
	Mammogram Facilities (per 10,000 Adult Women)[2]	0.8 (0.8, 0.8)	0.8 (0.8, 0.8)	1.02 (0.97, 1.07)
	Primary Care Physicians (per 10,000 Residents)	7.0 (7.0, 7.1)	7.0 (7.0, 7.1)	1.01 (0.99, 1.03)
	Socioeconomic			
	Deprivation Score	13.1 (12.0, 13.2)	13.1 (13.0, 13.2)	1.00 (1.00, 1.00)
	% Uninsured	16.0 (15.9, 16.1)	15.7 (15.6, 15.8)	1.02** (1.01, 1.03)
Person -Level	**Demographic**			
	Age at First EDW Mammogram			
	Age (years)	46.9 (46.8, 47.1)	48.2 (48.0, 48.3)	0.97** (0.97, 0.98)
	Race/Ethnicity			
	Non-Hispanic White	3,367 (43.0%)	3,084 (53.5%)	1.00 (referent)
	Non-Hispanic Black	732 (9.3%)	642 (11.1%)	1.04 (9.30, 1.17)
	Hispanic	3,272 (41.8%)	1,742 (30.2%)	1.72** (1.60, 1.86)
	Other/Unknown	466 (5.9%)	299 (5.2%)	1.43** (1.23, 1.66)
	Screening Behavior			
	EDW Mammogram Count			
	Total Mammograms	2.8 (2.8, 2.9)	2.2 (2.2, 2.3)	1.14** (1.12, 1.16)
	Prior Clinical Breast Exam			

	No	445 (5.7%)	615 (10.7%)	1.00 (referent)
	Yes	7,392 (94.3%)	5,152 (89.3%)	1.98** (1.75, 2.25)
	Prior Pap Test			
	No	3,548 (45.3%)	2,140 (37.1%)	1.00 (referent)
	Yes	4,289 (54.7%)	3,627 (62.9%)	0.71** (0.67, 0.77)
	Breast Cancer History[3]			
	No	6,651 (84.9%)	5,021 (87.1%)	1.00 (referent)
	Yes	980 (12.5%)	463 (8.0%)	1.60** (1.42, 1.80)
	Unknown	206 (2.6%)	283 (4.9%)	0.55** (0.46, 0.66)

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-Metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Mammogram facilities data is based on the most recent available information from 2013.
3. Breast cancer history was defined as personal experience or a female family member (mother, grandmother, or sister) having breast cancer.

**p<0.001, *p<0.05, +p approaching significance

Multilevel Adjusted Associations. A series of three HGLMs were conducted to examine the association of both person- and county-level characteristics with the likelihood of recent mammography use (Table 3). The null, or unconditional model, first estimated the average likelihood of having a recent compared to non-recent mammogram across all Kansas counties was 1.29 (95% CI=1.16-1.42), meaning that, in general, women in this study were more likely to have had a recent versus less recent mammogram. Although not shown here, these results indicated there was significant variation in mammography use by county ($\tau_{00} = 0.120$, p<0.001). Based on this model, county-level variation in mammography use was estimated to account for approximately 3.5% of the total variance in recent mammography use in the EDW program (Intraclass Correlation Coefficient = $\sigma^2/(\sigma^2+\pi^2/3) = 0.11980/(0.11980+3.29) = 0.035$) (Rodriguez & Elo, 2003). Even though a small proportion of the variation in mammography use was due to

county-level characteristics, the significance test indicated this variation was not due to chance, which justified the addition of county-level predictors to attempt to explain the county-level variance.

Next, Model 1 tested the effects of county-level uninsurance on the likelihood of recent mammography use. When accounting for all other county-level characteristics, including urbanicity and rates of mammography facilities and PCPs, residence in counties with higher levels of uninsurance was significantly associated with a higher likelihood of having a recent mammogram (OR=1.10, 95% CI=1.06-1.14).[4] For comparison purposes, Model 2 determined the baseline likelihood of recent mammography use was significantly associated with nearly all person-level characteristics prior to examining the effect of county-level uninsurance in the full model. Finally, Model 3 revealed that when accounting for all person- and county-level characteristics, residence in counties with higher levels of uninsured residents was significantly associated with a higher likelihood of having a recent mammogram. For every 1% increase in the proportion of uninsured county residents, the likelihood of recent mammography use increased by 1.07 times (95% CI=1.03-1.12; $p<0.05$). When accounting for person-level characteristics in

[4] Preliminary analyses indicated that county-level minority population composition and percent uninsurance were multicollinear in their prediction of recent mammography use. Separate models of each predictor demonstrated significant associations with recent mammography use, but when included as simultaneous predictors of mammography use, *both* associations fell below significance, indicating considerable overlap in their relationship with the outcome. The bivariate Pearson correlation between county-level percent Hispanic and percent uninsurance was $r=0.67$ ($p<0.001$), indicating a high degree of overlap between the two predictors (Kutner et al., 2004). The interaction term for these two variables was non-significantly associated with recent mammography use and did not improve model fit. Because this study's primary research question focused on the effect of county-level uninsurance on mammography use, the uninsurance predictor was retained in analyses and race/ethnicity variables were excluded. However, although it is unclear whether these documented associations were solely related to the county-level proportion of uninsurance rather than Hispanic population, analysis results would likely have been similar regardless of the county-level variable used. Results from these preliminary models are presented in Appendix D.

Model 3, the likelihood of recent mammography use associated with county-level uninsurance slightly decreased from Model 1 from 1.10 to 1.07, respectively.

Moreover, residence in non-metro counties (compared to rural counties) was associated with a 1.43 times (95% CI=1.10-1.86; $p<0.05$) increase in the likelihood of recent mammography. For every one additional PCP per 10,000 county residents, the likelihood of recent mammography also increased by 1.04 times (95% CI=0.99-1.08; $p=0.05$). For every one-unit increase in county socioeconomic deprivation, the likelihood of having a recent mammogram decreased by 5% (95% CI=0.90-1.00; $p<0.05$). Residence in counties with higher levels of uninsurance explained 39.9%, higher levels of socioeconomic deprivation explained 35.2%, residence in non-metro versus rural counties explained 27.4%, and county PCP rate explained 10.8% of the county-level variation in mammography. Taken together, these four county-level characteristics explained 49.2% of the variance in the likelihood of person-level recent mammography use.

Additional exploratory analyses were performed for person-level socioeconomic characteristics, including household income, income dependents, education levels, employment status, English language primacy, and relationship status. Findings from these models should be considered with caution because there were high levels of missing data (ranging from 1,425 (10.9%) to 7,037 (53.8%) available women) due to the implementation of a new EDW data collection system in 2013. Only the number of income dependents was significantly associated with the likelihood of recent mammography use (OR=1.12, 95% CI=1.02-1.22; Model 10). No other person-level socioeconomic characteristics were associated with likelihood of recent mammography. Results from these exploratory models are located in Appendix E and F.

Table 3: Adjusted Associations Between Likelihood of Recent Mammography Use and County- and Person-Level Characteristics in Kansas, 2011-2014			
Fixed Components	**Model 1**	**Model 2**	**Model 3**
County-Level Predictors			
% Uninsured	1.10** (1.06, 1.14)		1.07* (1.03, 1.12)
Socioeconomic Deprivation Score	0.94** (0.91, 0.97)		0.95* (0.90, 1.00)
Metro (ref: Rural)	1.08 (0.81, 1.44)		1.10 (0.78, 1.57)
Non-Metro (ref: Rural)	1.38* (1.08, 1.77)		1.43* (1.10, 1.86)
Mammography Facilities (per 10,000 Adult Women)	0.98 (0.91, 1.06)		0.99 (0.91, 1.05)
Primary Care Providers (per 10,000 Residents)	1.04* (1.00, 1.08)		1.04+ (0.99, 1.08)
Person-Level Predictors			
Age at First EDW Mammogram		0.98** (0.97, 0.99)	0.98** (0.97, 0.99)
Non-Hispanic Black (ref: Non-Hispanic White)		1.02 (0.87, 1.20)	1.02 (0.82, 1.27)
Hispanic (ref: Non-Hispanic White)		1.55** (1.36, 1.75)	1.55** (1.34, 1.79)
EDW Mammogram Count		1.20** (1.19, 1.22)	1.20** (1.18, 1.22)
Prior Pap Test		0.44** (0.42, 0.47)	0.44** (0.41, 0.47)
Prior Clinical Breast Exam		2.08** (1.93, 2.25)	2.05** (1.89, 2.22)
Breast Cancer History		1.62** (1.37, 1.92)	1.63** (1.37, 1.93)
Intercept	1.09 (0.91, 1.31)	1.03 (0.92, 1.16)	0.87 (0.71, 1.05)
Tau_{00}	0.052**	0.123**	0.060**
% County-Level Variance Explained	35.0%	n/a	39.5%
Change in Deviance (DF)	n/a (4)**	2605.57 (7)**	19.13 (4)**

Comparison	n/a	2 v 1	3 v 2

**$p<0.001$, *$p<0.05$, +$p<0.10$ (approaching significance)

Discussion

The purpose of this study was to determine to what extent county-level uninsurance was associated with recent mammography use among low-income, uninsured women in Kansas who participated in a free mammography screening program. This study found a significant relationship between county-level uninsurance and recent EDW mammography use, such that residents of counties with higher proportions of uninsured residents had a higher likelihood of having a recent compared to a non-recent EDW mammogram. Put another way, poor women living in counties with more uninsured residents were more likely to have a recent mammogram than poor women from counties with fewer uninsured residents, even when accounting for personal characteristics. Results also indicated that living in non-metro compared to rural counties and counties with more PCPs were associated with higher likelihoods of having a recent EDW mammogram. Living in counties with higher levels of socioeconomic deprivation, however, was associated with a lower likelihood of having a recent EDW mammogram. Together, these four characteristics explained half of the county-level variation in mammography use. Therefore, these findings failed to support study hypothesis H_1, but did support hypothesis H_2 that county-level uninsurance would be positively associated with recent mammogram use among women who participated in a free mammography screening program.

As one of the first studies to explore the impact of county-level uninsurance on mammography use among low-income, uninsured women, these findings broadly contribute to prior research demonstrating the vital role health insurance plays in facilitating healthcare service

utilization, particularly the use of preventive screenings such as mammography (Majerol et al., 2015; Schueler et al., 2008). Moreover, this study also advances a small, but growing literature in the U.S. examining how area-level uninsurance rates affect all residents. Several emerging studies have found that community uninsurance rates can impact individuals *with* health insurance, such that the higher the uninsurance rate of the community, the less likely insured adults living there were able to access medical services and be satisfied with their care (Gresenz & Escarce, 2011; Pagan & Pauly, 2006; Pauly & Pagan, 2008).

However, when applying the area-level uninsurance concept to mammography screening, Pagan et al. (2008) found that as community uninsurance rates increased, the likelihood of women who lived there obtaining recent mammograms decreased, regardless of their own insurance status, personal characteristics, or area-level income. That is, even if a woman had health insurance, she was significantly less likely to receive a recent mammogram if she lived in a community with more uninsured residents. However, the present study found that increased levels of community uninsurance were associated with a *higher* likelihood of mammography use among low-income women without insurance, regardless of their personal characteristics. Not only does this finding appear to conflict with prior research, but it is also the first study to document that higher levels of area-level uninsurance were associated with *increased* use of healthcare services, specifically mammography screening.

Moreover, the present study contributed to prior literature by extending the Pagan et al. (2008) findings in three ways, which may have also contributed to the difference in results. First, although Pagan et al. (2008) focused on all women in the U.S., the present study examined community uninsurance among only low-income, uninsured women who participated in a free mammography program in order to improve understanding of how the distribution of community

resources may affect access to breast cancer screening for vulnerable populations. Second, Pagan et al. (2008) focused on 60 metropolitan statistical areas across the U.S., while the present study broadened the geographic unit of analysis to the county level in a predominantly rural state. As such, detecting a significant relationship between area-level uninsurance and mammography use at a broader geographic level suggests this relationship may be more extensive and entrenched across geographies than documented by prior researchers. Finally, the Pagan et al. (2008) study measured recent mammography use within the past one year, whereas the present study defined recent mammography use as at least one mammogram in the past two years. Although seemingly minor, this change in measurement may have contributed to differences in study findings since the Pagan et al. (2008) outcome was more conservative. Moreover, this distinction is also conceptually important because most researchers advocate that the two-year recent outcome is the best measure of timely mammography use because it covers conflicting screening recommendations by professional organizations (Clark et al., 2003).

One plausible explanation for the present study's contradictory finding to the Pagan et al. (2008) study is that although participants lacked formal health insurance, the EDW program may have been acting as a 'pseudo insurer' in the healthcare markets in which it operated. Similar to how payments are made by third-party health insurance companies on behalf of subscribers, the EDW program paid contracting providers for mammograms and other breast cancer-related services delivered to enrolled participants (Kansas Department of Health & Environment, 2014a; Sergeant & Snyder, July 16, 2014). As such, the program essentially transformed uninsured participants with potential financial risks into a population of 'insured' women with contracted service payments for breast and cervical cancer screenings. In these communities, the EDW program both increased access to mammography for participants and reduced the risk of

uncompensated care for providers. These results suggest that counties characterized by higher levels of uninsurance may offer greater opportunities for the EDW program to garner participants and provide mammography services.

Researchers have hypothesized that area-level uninsurance can 'spillover' from uninsured residents to also impact insured individuals' ability of to access care in several ways. First, more uninsured residents in a community can result in a redistribution of costs, such that the uninsured may rely on charity care and taxpayers or those with insurance may pay more to cover uncompensated care. Second, higher levels of uninsured residents can alter the quality and availability of services offered, as providers may modify hours or curtail unprofitable services (Institute of Medicine, 2009). Notably, the degree to which these spillover effects influence local healthcare markets depends on their size, with smaller markets such as the rural areas in Kansas, often being the most vulnerable (Pauly & Pagan, 2007).

Although spillover effects from high area-level uninsurance generally negatively affect the entire community, in the case of EDW mammography use, a unique positive spillover effect may have occurred. Although nuanced, this logic aligns with the positive spillover effects suggested by Glazer and McGuire (2002) and McMorrow (2013), such that shifts in the payer market may actually improve access for some patients as providers seek to balance payment and minimize uncompensated care. Providers who contract with the EDW program are reimbursed at the Medicare allowable rate for delivering mammography services to participants (Kansas Department of Health & Environment, 2015). Because the EDW program reduces providers' financial risk to care for patients with fewer financial resources, physicians practicing in geographic areas with higher levels of uninsured residents may be more inclined to participate in the program than those in areas with more insured residents. Although more research is needed

on the precise mechanisms that produce spillover effects from community uninsurance, these results could suggest that as the EDW program entered communities with high uninsurance, it may have improved the local mammography screening market.

Limitations. This study has several limitations. First, since it is a retrospective analysis of low-income mammography users in the Kansas EDW program, the findings cannot be extrapolated to describe mammography use among low-income women in the broader U.S. population who did not participate in a free screening program. Because of these population differences, direct comparison of findings with prior research was not possible. Ideally, this study should have incorporated mammography claims data for all low-income women in Kansas over the age of 40, regardless of their insurance status or participation in the EDW program. Doing so would have enabled more comprehensive analyses to further tease out how county-level characteristics may have been related to insurance coverage, participation in the EDW program, and mammography use among all low-income women. Additionally, this data would have facilitated testing of the notion that EDW may have been acting as a 'pseudo insurer' for low-income, uninsured women in Kansas.

Second, because the administrative and clinical data analyzed in this study were not originally collected for research purposes (Shi, 2008), there were limitations in the availability of information that resulted in a large volume of missing socioeconomic data for EDW program participants. However, because the program required all participants to have incomes under 225% FPL and no insurance to qualify for mammogram services, there was moderate homogeneity among the study population with regard to socioeconomic resources (Kansas Department of Health & Environment, 2014b). Thus, while this study was unable to explicitly control for individual socioeconomic differences for all low-income women, the results do

represent important relationships for a vulnerable, policy-relevant subpopulation of uninsured, low-income women in Kansas. Third, while this study speculated about potential positive spillover effects, it was unable to actually measure the effects of the EDW program on the healthcare delivery systems of communities in which it operated. To estimate these effects, payments providers received from low-income, uninsured women who did not participate in the EDW program (e.g., tax credits, charity care, reduced payments) should be compared to the reimbursement they received for providing mammography services to EDW participants. Moreover, these analyses should be performed for multiple years in order to examine the interplay of the EDW program and the insurance composition of communities over time.

Finally, in preliminary analyses, it was discovered that county-level measures of uninsurance and the proportion of Hispanic population were multicollinear in their prediction of EDW mammography use. In other words, counties with high levels of uninsurance also tended to have high levels of Hispanic populations. The significant overlap between these two variables suggests that the Hispanic population composition variable was likely a proxy measure tapping into underlying measure of county-level uninsurance, although it is possible that both variables could have produced similar analysis results. Because the primary focus of this study was to assess the effect of county-level uninsurance on mammography use, the county-level minority population composition measures were excluded from the final models. Yet, by omitting these measures, important facets of minority populations in these communities may not have been adequately captured by a measure of uninsurance.

Implications. The findings of this study have several implications. First, this study suggests that the EDW program has targeted geographic areas with large uninsured communities that are in need of mammography screening services. At face value, the area-level uninsurance

findings of the present study appear to contrast with prior literature (Gresenz & Escarce, 2011; Pagan et al., 2008; Pauly & Pagan, 2008). However, if the EDW program may actually have been functioning as a proxy insurance mechanism for participants receiving cancer screening services, the results might be conceptually similar. By simultaneously reducing financial barriers for low-income, uninsured women and reimbursing contracting physicians who provided mammography services, the EDW program essentially increased the number of 'insured' women in the community for breast cancer screening services.

It is important to acknowledge, however, that EDW participants only had coverage for breast and cervical cancer-related services. Because they continue to lack insurance and financial resources to obtain other important preventive and primary care services, EDW participants (and other low-income Kansas women) remain predisposed to a higher likelihood of poor health outcomes than women with more income or insurance coverage (Lynch & Kaplan, 2000). Moreover, of all the county-level characteristics examined in this study, uninsurance status is the one characteristic amenable to rapid change, indicating that policies promoting or expanding insurance coverage may be an important lever to consider as part of the broader portfolio of initiatives to improve the health status of communities.

Second, although narrow in scope, the results of this study may have particular relevance to policymakers of Kansas (and similar states) regarding the collective influence of health insurance coverage. Further complicating the wide variation in uninsurance across Kansas (from 9.6% to 25.8%) is the gap between Medicaid coverage and subsidized insurance from health insurance exchanges that nearly 80,000 of the poorest Kansas residents (with incomes under 100% FPL) must contend with (Kaiser Family Foundation, 2014). However, the results of this study suggest that expanding Medicaid coverage in Kansas may be dually beneficial for the

EDW program, as well as all low-income adults. Although Medicaid would only likely cover a portion of the women eligible for EDW services (as women under 225% FPL and with pending or illegal immigration statuses can participate in EDW), the extended insurance coverage would provide more comprehensive access for other necessary preventive and primary care services for low-income women (Garfield et al., 2016), as well as enable the EDW program to use limited resources to make cancer screenings available to additional women.

Future research can build on these findings by determining whether or not the results hold true: 1) over time, 2) for non-poor and insured women in Kansas, 3) within smaller geographic areas, such as zip codes or census tracts, and 4) when examining other area-level socioeconomic characteristics, such as the insurance composition of the healthcare market. Moreover, the fluidity of health insurance status also enables researchers to investigate changes in mammography use, among both poor and non-poor women, as health insurance coverage changes occur (whether actual or theoretical) in Kansas. Doing so would enable more precise longitudinal analyses that may be better suited to tease out specific effects of environments on person-level mammography use over time. Additional studies should also incorporate area-level minority population measures and person-level socioeconomic characteristics to more fully understand how community resources influence mammography use among women at various levels of the socioeconomic spectrum.

Conclusion

In summary, this study found that low-income women, who participated in a free mammography screening program, living in Kansas counties with higher levels of uninsurance were more likely to receive a recent compared to non-recent EDW mammogram. Building on

prior research, this study applied the concepts of community uninsurance and mammography use to a new, narrower population (low-income women) and geographic area (Kansas counties). These findings appear to indicate that the EDW program may have improved the local mammography screening marketplace by effectively converting uninsured participants into insured patients with contracted payments for breast and cervical cancer screening services. As such, this study reiterates the important role health insurance plays in the facilitation of healthcare service utilization. Ultimately, these findings may indicate that changes to the health insurance composition of communities may be doubly beneficial, in that they extend health insurance coverage to previously uninsured individuals and free up limited resources from the EDW program to help target other women in need of mammography.

Chapter 6: Conclusions

Summary of Findings

The purpose of this dissertation was to explore county-level characteristics associated with mammography use by low-income, uninsured women in Kansas who participated in a free mammography screening program. To accomplish this goal, three related studies were conducted to explore use of EDW mammography services utilizing several analytic techniques to predict different mammography outcomes. County-level socioeconomic characteristics, such as uninsurance and deprivation, were the focus of analyses, while county-level measures of urbanicity, healthcare supply, and minority populations, as well as person-level characteristics were used as control variables. The first study used multiple linear regression analyses to identify county-level characteristics associated with rates of recent and repeat mammography use. The second and third studies used hierarchical generalized linear models (HGLM) to explore county-level characteristics associated with the likelihood of recent compared to non-recent mammography use, while controlling for person-level characteristics of EDW program participants.

Collectively, these three studies found that county-level uninsurance, socioeconomic deprivation, urbanicity, primary care provider (PCP) rate, and Hispanic population composition were significantly associated with EDW mammography use among program participants. County-level uninsurance, urbanicity (non-metro counties compared to rural counties), PCP rates, and Hispanic population composition were positively associated with mammography use. However, county-level socioeconomic deprivation was negatively associated with mammography use. In addition to the descriptions of the findings for the primary independent variables of interest (i.e., uninsurance and socioeconomic deprivation), the other three significant

control variables are also discussed in the following paragraphs. When analyzed in combination with one another, these county-level characteristics explained one-third to one-half of the variation in person-level mammography use among EDW program participants.

Uninsurance. County-level uninsurance was positively associated with EDW mammography use among program participants in the two studies in which it was included. As the proportion of uninsured residents in a county increased, so did rates of recent and repeat mammograms in Chapter 3, as well as the likelihood of having a recent mammogram in Chapter 5. This positive relationship remained consistent across analytic models, regardless of the outcome measured or if analyses controlled for person-level characteristics. This positive finding appears to run counter to most research on area-level uninsurance, which has documented that as the uninsurance level of a community increased, use of healthcare services, including mammography, typically decreased for all residents, regardless of their own insurance status (Gresenz & Escarce, 2011; Pagan et al., 2008; Pagan & Pauly, 2006; Pauly & Pagan, 2008).

Although there may be a few explanations for these findings, Chapters 3 and 5 of this dissertation suggest that the EDW program may have been acting as a 'pseudo insurer' for participating low-income, uninsured women. By making payments to providers for mammography services delivered to enrolled participants, the EDW program appeared to operate in a similar fashion to how third-party insurers pay for their subscribers. However, a critical difference between the free screening program and third-party payers is that EDW participants only have coverage for breast and cervical-cancer related services, whereas health insurers provide more comprehensive medical coverage for their subscribers (Kansas Department of Health & Environment, 2014a). As such, this finding suggests that even when controlling for measures of socioeconomic deprivation, urbanicity, healthcare supply, minority population

composition, and person-level characteristics, county-level uninsurance remained an important predictor of EDW mammogram use over multiple screening intervals among program participants.

Socioeconomic Deprivation. County-level socioeconomic deprivation was negatively related to EDW mammography use among program participants, such that the higher the socioeconomic deprivation score of the county (as measured by an SEP index), the lower the likelihood of recent EDW mammography use by residents. In Chapter 4, poor women living in counties with the lowest socioeconomic deprivation scores (Quartile 1) had a higher likelihood of recent mammography use than poor women living in counties with higher socioeconomic deprivation scores (Quartiles 2-4). Similarly, when analyzed as a continuous control variable with county uninsurance in Chapter 5, as the county socioeconomic deprivation score increased, the likelihood of poor female residents having a recent EDW mammogram decreased. By detecting similar results using different categorical and continuous variations of the SEP index to examine county-level socioeconomic deprivation, these findings suggest that even when mammograms were offered free of charge, area-level socioeconomic resources may have been an important predictor of the likelihood of EDW participants having timely mammograms.

Moreover, these results align with previous studies in a small but growing literature examining the association of area-level socioeconomic deprivation (as measured by an SEP index) and mammography use. Among the general U.S. population, prior research has found that higher area-level socioeconomic deprivation was associated with non-adherence to mammography use, even when accounting for person-level characteristics (Dailey et al., 2011; Dailey et al., 2007). These dissertation findings have expanded on the two prior studies by applying the same composite area-level SEP measure from the general U.S. population to a

narrower population of low-income, uninsured women who participated in a free screening program in a largely rural Midwest state. By garnering similar results in different populations and geographic locations, these studies collectively suggest area-level socioeconomic resources may be a meaningful predictor in shaping access to healthcare services for all residents of a community.

Urbanicity. Counties with higher levels of urbanicity (metro and non-metro) were generally positively associated with higher EDW mammography rates and likelihood of recent EDW mammograms among program participants when compared to rural counties. In Chapter 3, a positive relationship was found when only examining county-level characteristics, such that metro and non-metro counties had higher rates of recent and repeat mammograms than rural counties. Similarly, when controlling for person-level characteristics in Chapter 5, a positive relationship was found, with residents of non-metro counties having a higher likelihood of recent mammography use than residents of rural counties. However, there was no significant association between urbanicity and mammography use documented in Chapter 4. Because county uninsurance was analyzed in Chapters 3 and 5, but not in Chapter 4, these findings suggest that urbanicity groups may not clearly distinguish between socioeconomic deprivation levels (as measured by an SEP index), but may differentiate between levels of uninsurance.

In general, these dissertation findings align with mammography research over the past two decades regarding population density. A prominent review of more than 200 studies concluded that women living in rural areas (compared to non-rural areas) were 25% less likely (95% CI: 10%-37% reduction), on average, to obtain mammograms, even when accounting for personal characteristics (Schueler et al., 2008). When expanding the concept of population density to urbanicity, which also accounts for proximity to metro areas (U.S. Department of

Agriculture, 2013b), these findings align with other research documenting that women in rural areas with decreased proximity to metro areas were significantly less likely to receive mammograms than women in metro or suburban areas (Coughlin et al., 2008; Coughlin et al., 2002). Moreover, nearly all associations in this dissertation remained consistent in post-analyses exploring variations of urbanicity classification. Although further investigation is needed, this research may collectively suggest that for low-income, uninsured women who participated in a free mammography screening program and lived in rural areas in Kansas, proximity to resources (such as PCPs) may be an important predictor of mammography use.

PCP Rate. County-level PCP rate was positively associated with EDW mammography use in all three studies, such that counties with more PCPs per 10,000 residents had higher mammography rates in Chapter 3 and a higher likelihood of recent mammograms in Chapters 4 and 5. These findings are partially aligned with previous literature, as prior studies have documented inconsistent associations between measures of area-level PCPs and mammogram use in the general U.S. population. Some researchers have found that the number of PCPs in an area (Benjamins et al., 2004; Litaker & Tomolo, 2007) or a PCP shortage area (Phillips et al., 1998) were significant indicators of mammography use, while other studies have found no association (Baker et al., 2004; Coughlin et al., 2008). Conceptually, a county-level PCP measure may reflect one of two underlying notions. It may be directly measuring an important facet of the healthcare supply of an area. Or, since more PCPs may provide more opportunities for medical visits and mammogram discussions for residents, county PCP rate may be indirectly measuring increased mammogram recommendations – a significant reason women have previously reported for obtaining mammograms (Schueler et al., 2008).

Notably, however, this study found no association between other measures of county-level healthcare supply, namely rates of mammography facilities per county, and mammography use among EDW program participants. This result corresponds to prior research documenting no association between the quantity of mammography facilities and mammography use among the general U.S. population (Breen et al., 2011; Engelman et al., 2002; Jackson et al., 2009). However, in Kansas, Engelman et al. (2002) found that greater distance to (not number of) permanent mammography facilities was associated with a decreased likelihood of receiving mammograms. Although this dissertation did not account for distance to mammography facilities in analyses, its findings collectively suggest that the number of PCPs per county (or opportunities for patient recommendations), not mammography facilities, may be an important factor motivating EDW program participants to obtain mammograms.

Minority Population Composition. County-level Hispanic population measures were positively associated with mammography use in Chapter 4, such that as the proportion of the Hispanic population in a county increased, so did the likelihood of having a recent mammogram among EDW program participants. However, there was no significant relationship between the non-Hispanic black population of a county and mammography use. Although prior research with area-level measures of minority populations has produced conflicting results, no studies to-date have documented *higher* use of mammography screening associated with an increasing Hispanic population. Among mammography research in the general U.S. population, some studies reported higher mammography use as the non-Hispanic black population increased (Benjamins et al., 2004; Coughlin et al., 2008), while others documented lower use as the Hispanic population increased (Calo et al., 2016; Parker et al., 1998; Wells & Horm, 1998), and still others reported no association at all (Baker et al., 2004; Rosenberg et al., 2005; Sabogal et al., 2001).

Several factors may have influenced the magnitude of the association between the county-level Hispanic population and free mammogram use via the EDW program in Chapter 4. First, the type and availability of employment often attracting minority populations, particularly of Hispanic ethnicity, such as seasonal and migrant positions in farming and manufacturing sectors, is more prevalent in rural areas of Kansas (U.S. Department of Agriculture, 2013a; U.S. Department of Labor, 2014). Often, these jobs do not offer steady income or health insurance to enable use of necessary healthcare services or preventive screenings, such as mammograms (Rosenbaum & Shin, 2005). Second, although only 9% of Kansas county populations were Hispanic, on average (U.S. Census Bureau, 2014a), over one-third of the EDW population was Hispanic. Additionally, there was a 10% increase in the EDW Hispanic population from non-recent to recent mammogram users, indicating noteworthy growth in mammography screening among Hispanic women in the EDW program from 2013-2014. These higher-than-average levels of Hispanic participants and population demographic shifts in the EDW population may be due to programmatic targeting of geographic areas of high uninsurance and low-income, which also had high levels of Hispanic women who were eligible for the EDW program. Additionally, the EDW program also provides culturally competent recruitment and enrollment materials and bilingual outreach workers to accommodate local population needs (Sergeant & Snyder, July 16, 2014). As a result, these population variances may have increased the underlying likelihood that EDW program participants living in counties with greater Hispanic populations recently received a mammogram in the EDW program.

Notably, measures of minority population composition were not included in analyses for Chapters 3 or 5 because significant multicollinearity was detected between county-level measures of uninsurance and Hispanic population composition, with bivariate Pearson

correlations of r=0.66 (p<0.001) and r=0.67 (p<0.001) in Chapters 3 and 5, respectively (Kutner et al., 2004). This information suggests that the Hispanic population variable was also likely measuring some amount of county uninsurance. Although there was a strong association detected in Chapter 4 between mammography use and county Hispanic population, when the county uninsurance predictor was included in the models for Chapters 3 and 5, it was thought to be a more precise measure of uninsurance levels. Therefore, minority population composition measures were only included as control variables in analyses for socioeconomic deprivation and omitted from analyses using county uninsurance variables. However, it is possible that either county-level variable (e.g., the proportion of uninsured or Hispanic residents) could have produced similar analysis results.

Limitations

Although there are several limitations that apply to this dissertation, the three most notable ones are described in the following paragraphs. First, and perhaps the most important limitation, was that none of the studies in this dissertation contained information about low-income, uninsured women in Kansas who did not participate in the EDW program. All analyses were cross-sectional and only focused on mammography use among women who received EDW mammograms, which was approximately 15% of the annual EDW eligible population that totaled nearly 40,000 women in 2013 (Snyder, October 15, 2014). Because the EDW program required participants to enroll annually in order to receive services, there may have been selection bias associated with women who enrolled in the program and those who did not. Notably, women who enrolled in the program were likely more inclined to seek mammography services than women who chose not to apply. As a result, the findings of these three studies

primarily apply to low-income, uninsured women who participated in free mammography screening programs.

Although not possible due to deidentified data limitations, it would have been ideal to gather mammography claims data for all low-income women in Kansas over multiple years for use in these studies. These data could then have been stratified according to mammography use by year, income level, insurance status, EDW program participation, and other personal characteristics for analysis purposes. Equipped with this information, study analyses could have more fully evaluated the relative influence of income, insurance status, and the role of the EDW program on low-income women's mammography use over time. As a result of having this information, the findings of these studies would have been more broadly generalizable to most low-income women and potentially identify more actionable levers for policy change.

Second, because these studies were retrospective and relied on administrative and clinical service claims data, there was limited control over the quality and availability of the EDW data. Most notable was the large volume of missing person-level socioeconomic data (48-90% missing depending on the variable) due to the implementation of a new data system in 2013 (Snyder, July 1, 2014). Although some of the information was unavailable because participants had not interacted with the program since implementation of the new system, many of the new data fields were not required during the annual enrollment process, which resulted in inconsistent data collection methods. Having more granular information about the socioeconomic characteristics of each participant per year may have enabled this dissertation to reveal more precise or nuanced estimates of mammography use, as comprehensive person-level data could have been included in the analytic models or enabled novel sub-analyses.

Other important EDW data challenges were enrollment caps due to funding limitations. In general, the EDW program provided mammograms for nearly all low-income, uninsured women who applied, as funding increased annually since 1997 to cover program growth (Sergeant & Snyder, July 16, 2014). However, state budget limitations were imposed on the program at the end of FY2012 year (7/1/2011-6/31/2012). Although the EDW program attempted to mitigate negative consequences by prioritizing services to women with higher clinical need, there were nearly 20% fewer mammograms delivered (totaling approximately 1,000) compared to previous years (Snyder, October 15, 2014). For this dissertation, the 2012 budget change likely reduced the number of mammograms that would have been included in the four-year repeat mammogram rate and the 'non-recent users' group (coded as '0') for the recent mammogram outcome. Despite this enrollment cap, however, the high volume of annual participants remained sufficient to power analyses to evaluate the relationship between county-level characteristics and mammography use among EDW program participants.

Finally, the choice of county as the geographic unit of analysis may have underestimated or concealed some meaningful differences. Although counties were used in this dissertation because they best balanced available area-level data and EDW program participation, they may not have been the most representative of socially meaningful divisions or healthcare utilization patterns (Krieger et al., 2002). For instance, while these three studies controlled for the rate of mammography facilities per county, they did not include measures of distance from each participant's residence to the facility, which may have been an important predictor of mammography utilization. It is important to note, however, that this unit of analysis best aligns with programmatic resource allocation methods. Moreover, these dissertation findings extend previous research, which primarily focused on smaller geographic areas, such as census tracks or

metropolitan statistical areas (Dailey et al., 2011; Dailey et al., 2007; Pagan et al., 2008), because the current studies explored the same primary predictor variables as prior studies but in a broader geographic area. Ultimately, this geographic choice may indicate that the relationship between mammography use and area-level characteristics was more extensive than first studied, as all three studies consistently detected significant relationships across counties.

Research and Policy Implications

The results of the three studies that comprise this dissertation have several implications. First, they confirm that the EDW program has been utilized in communities most 'in need' of free mammography services, such as counties with high levels of uninsurance and socioeconomic deprivation. Many prior studies have identified person- and area-level factors associated with mammography use among the general population, commonly citing high cost and uninsurance as reasons women do not obtain mammograms (Pruitt et al., 2009; Schueler et al., 2008). However, the significance of the studies in this dissertation is they demonstrate that when low-income, uninsured women were presented with 'affordable' (e.g., free) mammography services, they were utilized consistently over multiple screening intervals. This information is important for policymakers and public health administrators because it further confirms the necessity of continuing to make affordable health services available to vulnerable populations.

Moreover, the findings of Chapters 4 and 5 provide additional information about the specific county-level characteristics of where participants who were most likely to engage with the EDW program lived, such as counties with high levels of uninsured residents. Conversely, these studies also identified characteristics of counties in which low-income, uninsured women who were at-risk for not having timely EDW mammograms resided. This information could be

beneficial for program administrators to help direct resources to geographic areas where women may be at the highest risk of not receiving timely mammograms in free screening programs.

Second, although seemingly counter to prior research, this dissertation also highlights the important role insurance plays in facilitating access to healthcare services, including mammography screening. In Chapters 3 and 5, county-level uninsurance was the strongest predictor of low-income, uninsured women engaging in recent and repeat mammogram use in the EDW program. In particular, these findings demonstrate that the number of uninsured residents in the community can impact mammography utilization for everyone. Fortunately, of all the county-level characteristics examined in this dissertation, health insurance is the one that is most amenable to change. As a result, these findings suggest that research and policy efforts should be focused on promoting and expanding comprehensive insurance coverage across Kansas. Doing so would be doubly beneficial for low-income, uninsured women, as many would receive more comprehensive coverage for their healthcare needs, and the limited resources of the EDW program could be allocated to the remaining eligible women, such as those with income and immigration status limitations to obtaining insurance coverage (Garfield et al., 2016).

Finally, this dissertation expands prior research by analyzing the relationship of area-level characteristics and mammography use: 1) in a new population, 2) in a broader geographic area, and 3) by attempting to expand prior concepts measuring socioeconomic deprivation. These studies are the first to specifically focus on the relationship of area-level characteristics and mammography use for low-income, uninsured women who participated in a free screening program, as prior research has primarily examined this relationship among the general U.S. population. In order to mitigate disparities in mammography use, it is important to begin by distinguishing how poorer health exposures and reduced resources to address health needs

(Lynch & Kaplan, 2000) can impact low-income, uninsured women's mammography use compared to those with more financial resources or insurance coverage.

Additionally, previous research has examined the relationship of area-level characteristics and mammography use in narrow geographic areas, such as census tracts or metropolitan statistical areas (Dailey et al., 2011; Dailey et al., 2007; Pagan et al., 2008). However, this dissertation expanded the geographic unit of analysis to counties in a predominantly rural state. By detecting significant findings at a broader level in rural areas, these three studies collectively suggest that the relationship between area-level socioeconomic characteristics and mammography use may be more expansive than first thought and apply to various urbanicities and geographic regions across the U.S.

Moreover, this dissertation has also progressed the study of how to measure the concept of area-level SEP and healthcare service use. Because of the complexity of the SEP concept, several researchers have suggested that measuring it with single-dimension variables, such as poverty level or educational attainment, may not best capture the deprivation level of a community (O'Campo & Burke, 2004; Oakes & Rossi, 2003). As such, several studies have employed indices to more comprehensively measure socioeconomic deprivation, with the SEP index being the most commonly used (Dailey et al., 2011; Dailey et al., 2007; Krieger et al., 2002). Although this index included six variables (median household income, median housing value, percentage below FPL, percentage without high school education (age 25+), percentage unemployed, percentage working class) to quantify various concepts of SEP, there were no variables to measure health insurance coverage.

Because health insurance is a key factor in accessing medical services (Institute of Medicine, 2004; Schueler, Chu, & Smith-Bindman, 2008), the absence of a measure of health

insurance when other researchers applied a measure of socioeconomic deprivation to healthcare service utilization was an important omission in prior studies. As such, this dissertation explored the extent to which insurance coverage predicted mammography use, even when accounting for the effects of area-level socioeconomic deprivation, as measured by the SEP index. By finding that health insurance was a strong predictor of mammography use among EDW participants in both of the analyses in which it was included (Chapters 3 and 5), these findings demonstrate that the omission of a measure of health insurance from the SEP index, when applied to healthcare service utilization, may not fully capture the economic position of a community.

Since these are the first studies to examine the relationship of mammography use among low-income, uninsured women and the socioeconomic characteristics of communities in which they reside, future research should extend this line of inquiry by focusing on several key areas. First, and perhaps most importantly, future studies should analyze data on all low-income, uninsured women, not just EDW mammography users. In particular, these studies should calculate county-level mammogram rates (similar to the results of Chapter 3) to first estimate EDW program use among all eligible women, then at a national level in order to track changes in mammogram trends and associated person- and county-level characteristics over time. These analyses would also enable researchers to further explore the nature of the relationship between area-level characteristics and mammography use and begin to study the relative influence of income level, insurance status, and the role of the EDW program on low-income women's mammography use.

Second, new analyses should focus on examining changes in the relationship of county-level characteristics and mammography use over time, as this may enable more precise longitudinal analyses to tease out specific effects of county-level environments on person-level

mammography use over time. Third, future studies regarding mammography use should test various combinations of methods to quantify area-level SEP that incorporate measures of insurance coverage. This information would enable further exploration of the role health insurance plays in facilitating access to medical care, including mammography screening, in the context of other measures of SEP. Moreover, changes in insurance coverage as a result of the ACA have provided opportunities over the past several years to examine the interplay of measures of socioeconomic deprivation and insurance coverage over time. Finally, new studies should incorporate person-level characteristics in analyses to more fully understand how community resources influence mammography use among individual women at various levels of the socioeconomic spectrum.

Conclusions

In summary, this dissertation found that Kansas counties with higher levels of uninsurance and lower levels of socioeconomic deprivation had increased rates of recent and repeat mammograms and an increased likelihood of recent compared to non-recent mammograms among women who participated in the EDW program. Building on previous research, the studies in this dissertation applied the concepts of area-level uninsurance and a validated composite measure of socioeconomic deprivation to mammography use in a new population (e.g., low-income, uninsured women who participated in a free mammography program) and geographic area (e.g., Kansas counties). The results of these studies were similar to prior research regarding area-level socioeconomic deprivation in that greater area-level deprivation was associated with reduced mammography use (Dailey et al., 2011; Dailey et al., 2007). Moreover, the findings also appeared to run counter to previous studies on area-level

uninsurance that documented lower mammography use as area-level uninsurance increased (Gresenz & Escarce, 2011; Pagan et al., 2008; Pagan & Pauly, 2006).

As such, these findings suggest two key points. First, even when mammography screenings were offered at no charge to the individual woman via a free screening program, the characteristics of the broader environment likely played an important role in their utilization. Second, the EDW program may have been acting as a 'pseudo insurer' by effectively converting uninsured women into insured patients with contracted payments for mammograms, which may have improved the ability of the local healthcare marketplace to deliver breast cancer screening services. Collectively, these findings suggest that to improve the socioeconomic environment in which mammography services are delivered, a comprehensive public health strategy may be warranted. A more practical solution, however, may be to focus research and policy efforts on promoting and expanding health insurance. Doing so would be doubly beneficial in that it would extend more comprehensive coverage to previously uninsured low-income women, as well as free up limited resources from the EDW program to help target other women in need of mammography services, such as those with income and immigrant status limitations for insurance coverage.

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Appendices

Appendix A (Chapter 3): Adjusted Associations of Mammography Use and Kansas County Characteristics, 2009-2014						
Characteristic	**Recent Mammogram Rate** (2013-2014, *n*=105)		**Four-Year Repeat Mammogram Rate** (2011-2014, *n*=105)		**Six-Year Repeat Mammogram Rate** (2009-2014, *n*=105)	
	b (95% CI)	*β*	*b* (95% CI)	*β*	*b* (95% CI)	*β*
Demographic Characteristics (2010)						
Metro[1] Counties (ref: Rural)	4.43 (-2.00, 10.85)	0.15	1.94 (-1.76, 5.64)	0.12	0.40 (-1.89, 2.69)	0.04
Non-Metro[1] Counties (ref: Rural)	4.89 (-0.02, 9.80)	0.21+	1.92 (-0.91, 4.74)	0.16	0.37 (-1.38, 2.12)	0.05
% Black	0.28 (-0.19, 0.76)	0.08	0.07 (-0.21, 0.34)	0.04	0.00 (-0.17, 0.17)	0.00
% Hispanic	0.55 (0.32, 0.79)	0.53**	0.30 (0.16, 0.43)	0.54**	0.24 (0.16, 0.32)	0.70**
Mammography Facilities per 10,000 Adult Women[2]	-0.27 (-1.27, 0.73)	-0.04	0.01 (-0.56, 0.59)	0.00	0.08 (-0.27, 0.44)	0.03
Primary Care Physicians (PCPs) per 10,000 Residents	0.46 (-0.02, 0.94)	0.13+	0.18 (-0.09, 0.46)	0.10	0.07 (-0.11, 0.24)	0.06
Socioeconomic Characteristics (Five Year Average, 2008-2012)						
SEP Index Score	0.19 (-0.43, 0.80)	0.06	0.05 (-0.31, 0.40)	0.03	0.07 (-0.14, 0.29)	0.07
% Uninsured (Age <65)	1.19 (-0.02, 2.40)	0.31+	0.53 (-0.17, 1.22)	0.26	0.07 (-0.36, 0.50)	0.06
Intercept	-18.46 (-37.19, 0.28)		-8.44 (-19.22, 2.34)		-1.80 (-8.47, 4.88)	
R^2	0.63		0.55		0.57	
F (*df*)	20.63 (8)**		14.82 (8)**		15.76 (8)**	

1. Counties were grouped according to the 2013 Rural-Urban Continuum Codes (RUCC) classification method: Metro = RUCC classifications 1-3, Non-Metro = RUCC classifications 4-7, Rural = RUCC classifications 8-9.
2. Mammogram facilities data is based on the most recent available information from 2013.

**$p<0.001$, *$p<0.05$, +$p<0.10$ (approaching significance)

Appendix B (Chapter 4): Unadjusted Associations between Mammography Use and Socioeconomic Characteristics of Low-Income Mammography Users in Kansas, 2011-2014			
Characteristic	**Recent Users, 2013-2014** (*n*=7,837) mean/n (CI/%)	**Non-Recent Users, 2011-2012** (*n*=5,767) mean/n (CI/%)	**OR (95% CI)**
Annual Household Income			
Total Income[1]	$17,904.89 ($17,646.20, $18,163.58)	$17,500,73 ($16,677.41, $18,324.05)	1.00 (1.00, 1.00)
<$20,000	3,664 (46.8%)	395 (6.8%)	1.00 (referent)
$20,000+	2,151 (27.4%)	204 (3.5%)	1.14 (0.95, 1.36)
Unknown	2,022 (25.8%)	5,168 (89.6%)	0.04** (0.04, 0.05)
Income Dependents			
Income Dependents[1]	1.9 (2.8, 2.9)	2.7 (2.6, 2.8)	1.07* (1.01, 1.13)
1	1,348 (17.2%)	160 (2.8%)	1.00 (referent)
2+	4,312 (55.0%)	422 (7.3%)	1.21* (1.00, 1.47)
Unknown	2,177 (27.8%)	5,185 (89.9%)	0.05** (0.04, 0.06)
Federal Poverty Level			
Federal Poverty Level[1]	94.6 (93.4, 95.9)	95.1 (90.8, 99.3)	1.00 (1.00, 1.00)
<100%	3,359 (42.9%)	342 (5.9%)	1.00 (referent)
100%+	2,274 (29.0%)	235 (4.1%)	0.99 (0.83, 1.12)
Unknown	2,204 (28.1%)	5,190 (90.0%)	0.04** (0.04, 0.05)
Insurance Coverage			
No	6,243 (79.7%)	725 (12.6%)	1.00 (referent)
Yes	100 (1.3%)	23 (0.4%)	0.51** (0.32, 0.80)
Unknown	1,494 (19.1%)	5,019 (87.0%)	0.04* (0.03, 0.04)
Employment			
No	1,120 (14.3%)	132 (2.3%)	1.00 (referent)
Yes	3,013 (38.4%)	343 (5.9%)	1.04 (0.84, 1.28)
Unknown	3,704 (47.3%)	5,292 (91.8%)	0.08** (0.07, 0.10)
Educational Attainment			
Non-High School Grad	859 (11.0%)	95 (1.6%)	1.00 (referent)
High School Grad	229 (2.9%)	27 (0.5%)	0.94 (0.60, 1.48)
Some College or Higher	218 (2.8%)	15 (0.3%)	1.61 (0.91, 2.83)
Unknown	6,531 (83.3%)	5,630 (97.6%)	0.13** (0.10, 0.16)
Relationship Status			

Married-Like Relationship	1,763 (22.5%)	139 (2.4%)	1.00 (referent)
Single	1,130 (14.4%)	111 (1.9%)	0.78 (0.52, 1.16)
Separated/Widowed	326 (4.2%)	33 (0.6%)	0.80 (0.62, 1.04)
Unknown	4,618 (58.9%)	5,484 (95.1%)	0.07** (0.06, 0.08)
Primary Language			
English	2,116 (27.0%)	241 (4.2%)	1.00 (referent)
Other Language	2,152 (27.5%)	235 (4.1%)	1.04 (0.86, 1.26)
Unknown	3,569 (45.5%)	5,291 (91.7%)	0.08** (0.07, 0.09)

1. Calculations for these variables are based only on available data. Missing data counts can be ascertained from the "unknown" categories for the corresponding variables.

**$p<0.001$, *$p<0.05$, +$p<0.10$ (approaching significance)

Appendix C (Chapter 4): Adjusted Associations Between Likelihood of Recent Mammography Use and County- and Person-Level Characteristics (with Socioeconomic Characteristic Exploratory Analyses) in Kansas, 2011-2014									
Fixed Comp-onents	**Model 4** *n*= 13,071	**Model 5** *n*= 6,346	**Model 6** *n*= 6,172	**Model 7** *n*= 6,142	**Model 8** *n*= 7,037	**Model 9** *n*= 4,601	**Model 10** *n*= 4,711	**Model 11** *n*= 1,425	**Model 12** *n*= 3,484
County-Level Predictors									
Depri-vation Q1 (ref: Q2-Q4)	1.36* (1.00, 1.82)	1.58 (0.94, 2.58)	1.44 (0.92, 2.26)	1.57 (0.96, 2.59)	1.33 (0.85, 2.08)	0.88 (0.51, 1.53)	0.99 (0.56, 1.76)	1.24 (0.17, 8.91)	0.83 (0.46, 1.52)
Metro (ref: Rural)	0.82 (0.57, 1.19)	0.57 (0.27, 1.18)	0.63 (0.30, 1.34)	0.59 (0.28, 1.23)	0.64 (0.31, 1.32)	1.21 (0.56, 2.59)	0.55 (0.21, 1.44)	0.38 (0.03, 5.46)	0.61 (0.24, 1.56)
Non-Metro (ref: Rural)	1.06 (0.81, 1.40)	0.82 (0.45, 1.48)	0.84 (0.44, 1.70)	0.83 (0.47, 1.50)	0.81 (0.47, 1.41)	1.41 (0.70, 2.84)	0.91 (0.42, 1.94)	0.69 (0.14, 3.50)	0.94 (0.45, 1.97)
Mammo-graphy Facilities (per 10,000 Adult Women)	0.99 (0.91, 1.07)	1.06 (0.86, 1.32)	1.04 (0.84, 1.30)	1.07 (0.86, 1.33)	1.04 (0.86, 1.26)	1.14 (0.91, 1.42)	0.84 (0.65, 1.09)	0.73 (0.45, 1.19)	0.97 (0.72, 1.30)
Primary Care Providers (per 10,000 Residents)	1.04+ (1.00, 1.08)	1.01 (0.92, 1.11)	1.01 (0.92, 2.26)	1.01 (0.92, 1.12)	1.02 (0.95, 1.10)	1.04 (0.96, 1.12)	1.00 (0.92, 1.10)	0.93 (0.69, 1.26)	1.06 (0.94, 1.18)
% Black Pop (10% Change)	1.01 (0.53, 1.91)	0.91 (0.45, 1.81)	0.87 (0.44, 1.70)	0.90 (0.94, 1.29)	1.01 (0.52, 1.98)	0.87 (0.53, 1.42)	0.85 (0.27, 2.70)	0.87 (0.07, 11.33)	0.82 (0.47, 1.43)
% Hispanic Pop (10% Change)	1.12** (1.00, 1.25)	1.10 (0.93, 1.30)	1.11 (0.94, 1.30)	1.10 (0.94, 1.06)	0.94 (0.77, 1.14)	1.00 (0.81, 1.25)	1.00 (0.82, 1.22)	0.92 (0.57, 1.48)	1.05 (0.81, 1.35)
Person-Level Predictors									
Age at First EDW Mammo-gram	0.98** (0.97, 0.99)	1.02 (0.99, 1.06)	1.03 (0.99, 1.07)	1.02 (0.99, 1.06)	1.02 (0.99, 1.04)	1.03 (0.99, 1.07)	0.84 (0.19, 3.77)	1.01 (0.96, 1.07)	1.02 (0.97, 1.07)
Non-Hispanic Black (ref:	1.02 (0.82, 1.27)	0.70 (0.27, 1.85)	0.77 (0.36, 1.65)	0.74 (0.30, 1.86)	0.75 (0.34, 1.68)	0.83 (0.17, 3.99)	0.84 (0.19, 3.77)	4.85 (0.03, 955.32	0.77 (0.09, 7.00)

Non-Hispanic White)								)	
Hispanic (ref: Non-Hispanic White)	1.53** (1.34, 1.76)	1.03 (0.62, 1.71)	0.93 (0.51, 1.69)	1.04 (0.65, 1.68)	1.01 (0.63, 1.61)	1.00 (0.70, 1.64)	0.86 (0.34, 2.19)	0.76 (0.18, 3.23)	0.91 (0.42, 1.97)
EDW Mammo-gram Count	1.20** (1.18, 1.22)	1.25** (1.15, 1.35)	1.27** (1.16, 1.38)	1.26** (1.17, 1.36)	1.22** (1.15, 1.29)	1.27** (1.15, 1.41)	1.25** (1.12, 1.40)	1.16* (1.02, 1.32)	1.19* (1.05, 1.34)
Prior Pap Test	0.44** (0.41, 0.47)	0.33** (0.24, 0.45)	0.33** (0.23, 0.47)	0.32** (0.22, 0.46)	0.35** (0.25, 0.50)	0.34** (0.24, 0.48)	0.38** (0.24, 0.60)	0.62 (0.25, 1.55)	0.38** (0.22, 0.64)
Prior Clinical Breast Exam	2.05** (1.89, 2.22)	2.07** (1.44, 2.97)	2.21** (1.53, 3.22)	2.14** (1.45, 3.16)	2.07** (1.49, 2.88)	2.48** (1.52, 4.05)	2.15* (1.07, 4.33)	2.17 (0.24, 19.42)	2.71* (1.22, 6.01)
Breast Cancer History	1.63** (1.37, 1.93)	1.06 (0.64, 1.76)	1.04 (0.63, 1.71)	1.05 (0.63, 1.74)	1.13 (0.75, 1.71)	1.01 (0.75, 1.40)	0.99 (0.45, 2.17)	1.01 (0.27, 3.82)	1.18 (0.53, 2.62)
Household Income ($1,000 Change)		1.00 (0.99, 1.02)							
Income Depen-dents			1.12+ (1.00, 1.25)						
Federal Poverty Level (10% Change)				0.99 (0.95, 1.04)					
Insured					0.48 (0.18, 1.28)				
Employed						1.17 (0.70, 1.98)			
English Speaker							0.81 (0.28, 2.34)		
High School Grad (ref: Non-High								0.97 (0.22, 4.16)	

School Grad)									
Some College or More (ref: Non-High School Grad)								1.70 (0.20, 14.40)	
Single (ref: Married)									0.87 (0.19, 3.95)
Separated / Widowed (ref: Married)									0.75 (0.42, 1.33)
Intercept	0.96 (0.78, 1.18)	13.79** (7.79, 24.39)	12.65** (6.92, 23.15)	13.37** (7.54, 23.71)	11.20** (6.49, 19.33)	7.00** (3.24, 15.12)	13.37** (5.62, 31.82)	15.04* (1.83, 123.71)	13.09** (5.47, 31.35)
Tau_{00}	0.072**	0.048**	0.026*	0.043*	0.032*	0.000*	0.000*	0.000*	0.004

Note: Due to changing population sizes based on available data, measures of percent county-level variance explained and change in deviance were not calculated for these models.

**p<0.001, *p<0.05, +p<0.10 (approaching significance)