Neighborhood Context and Breast Cancer

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Introduction

Most research on breast cancer incidence and outcomes—including etiology, incidence, screening, diagnosis, treatment, and mortality—has focused on identifying individual-level risk factors such as race, health behaviors, and family history. Yet in research into other medical conditions, there has been a growing interest in how characteristics of place may impact health. In particular, people's neighborhoods can help shape their individual risk factors for a range of health outcomes. Neighborhood context can put people at greater risk for adverse health outcomes, as well as exert protective effects that can preserve or improve health.

Although we have long known that there are regional variations in breast cancer outcomes within the U.S., and across and within other countries,[1, 2] explanations for these variations have focused primarily on examining the extent to which individual-level risk factors (e.g., age, parity, health behaviors, socioeconomic status) account for regional variation. This approach is useful for giving us a basic idea of the role of known individual risk factors in explaining breast cancer distribution. It also helps identify gaps in our knowledge of the range of risk factors that influence breast cancer incidence and outcomes. However, this approach is limited in two ways. First, it overlooks the importance of examining how neighborhoods might shape known breast cancer risk factors, which is important to understand for intervention purposes. Second, it ignores investigation of whether neighborhoods affect breast cancer risk in ways that go beyond shaping known individual-level risk factors. Unique aspects of the neighborhood service environment, social environment, or physical environment may impact breast cancer outcomes. Examples of the service environment include access to risk reduction services, medical care, transportation, employment, food outlets and supermarkets. The social environment includes such factors as crime, neighborhood crowding and social support. The physical environment includes the built environment, environmental pollution, and the health effects of a person's physical surroundings.

Research has only begun to explore how neighborhood context might affect breast cancer. Yet, given what we know about regional variation in breast cancer incidence and outcomes, and about the association between some neighborhood characteristics and cancer incidence and outcomes, breast cancer research is likely to benefit from further investigating the potential role of neighborhood context in putting people at risk for breast cancer.

We begin with an overview of some of the major conceptual and methodological issues related to conducting research on neighborhoods and health. We then review the current evidence of the effects of neighborhood context on breast cancer incidence and outcomes. We conclude by describing priority areas for future research in this area.

Conceptualizing Neighborhood Effects on Health

Much of the recent research on the relationship between neighborhood context and health distinguishes between the compositional and contextual effects of neighborhoods.[3-5]

Compositional effects exist when associations between neighborhoods and health are explained by the population characteristics of residents (e.g., age, race, or socioeconomic characteristics of residents). For example, breast cancer incidence may be higher in some neighborhoods simply because more older women live there. As another example, if breast cancer mortality rates are higher in some neighborhoods, and those neighborhoods have a high proportion of African Americans, a compositional explanation would be that there is no longer an association after controlling for the race/ethnicity of individual residents. Some researchers conclude that neighborhood effects on health can be explained entirely by the compositional effects of individual-level variables. However, even if this were true, it would still be important to understand why people with certain risk factors are clustered in the same neighborhood, whether characteristics of the neighborhood are responsible for the clustering of risk factors, and whether interventions at the individual or neighborhood level might be most effective at improving health outcomes.

Contextual effects are characteristics of neighborhoods that impact residents' health beyond a simple summation of the compositional effects measured among individual residents. In other words, the effect of the whole neighborhood is greater than the sum of the individual parts. Investigation of contextual effects requires that multilevel data be used to examine how characteristics of neighborhoods are associated with individual-level health outcomes, over and above individual-level characteristics. For example, research demonstrates that living in poorer socioeconomic environments is associated with greater risk of heart disease,[6] morbidity,[7, 8] and mortality,[9-11] even after controlling for individual-level socioeconomic factors.

There are a number of ways to conceptualize and categorize the potential contextual effects of neighborhoods. One promising method is to categorize neighborhood context in terms of characteristics of the neighborhood service environment, social environment, and physical environment.

The neighborhood service environment may affect residents' access to and quality of preventive and screening services, medical care, transportation, and supermarkets. These neighborhood service characteristics might impact the risk of higher cancer incidence and poor breast cancer outcomes of all residents, regardless of their own personal factors.

The social environment of neighborhoods can affect multiple risk factors for breast cancer. For example, research indicates that neighborhood socioeconomic context is associated with a higher risk of obesity[12] and smoking,[13, 14] controlling for individual SES measures. Neighborhood social norms may affect individual breast cancer risk factors such as breast-feeding and other health behaviors. Neighborhoods with greater actual or perceived crime rates can affect whether residents are too fearful to leave home to access services in their neighborhood, or too fearful to walk for exercise. Stressful neighborhood social environments may add to an individual's stress, which can adversely affect health.

The physical environment of neighborhoods can expose residents to environmental pollutants that

can put all residents at greater risk of unfavorable health outcomes, regardless of their individual characteristics (see Section I of this paper), although individual-level stressors may modify the potential health impact of pollutant exposures.[15, 16] In addition, characteristics of the built environment affect whether people have healthy housing, workplace, and recreational options.

Characteristics of these neighborhood environments may affect health through direct, indirect, and interactive pathways. Some neighborhood characteristics, such as air and water quality, potentially affect health directly. Most neighborhood characteristics are conceptualized as having indirect effects on health. For example, neighborhood socioeconomic deprivation may indirectly affect the health of residents through a number of pathways, such as through poor service availability, through unsafe places for work and recreation, and by increasing psychosocial stress.

Moreover, neighborhood characteristics may interact with either other neighborhood characteristics or with individual characteristics to affect breast cancer incidence and outcomes. A stressful neighborhood environment can make people more susceptible to the harmful effects of exposure to contaminants in the neighborhood.[17, 18] Neighborhood characteristics may interact with individual-level characteristics, so that some neighborhood characteristics only affect, or are more likely to affect, some people based on their personal characteristics (e.g., age, pre-existing health conditions, or income). For example, being exposed to a low-quality health and social service environment in a poor neighborhood may only or particularly affect poor individuals, whereas higher-income residents might access services both inside and outside of their neighborhood. Interactions between individual-level and neighborhood-level characteristics are crucial to examine as they suggest how neighborhood and individual characteristics can make people either more vulnerable or more resilient to other neighborhood and individual risk factors.

Future research on the impact of neighborhoods on cancer and other health outcomes needs to examine specific direct, indirect, and interactive pathways through which neighborhoods impact health. Attention also needs to be paid to the level of neighborhood or place that is most relevant to the pathway being studied. For example, access to the health and social service environment might be measured using neighborhood boundaries (e.g., municipal boundaries) that are different from the boundaries of neighborhoods considered when examining residents' perceptions of trust, safety, and social networks in their neighborhood (e.g., smaller geographical areas). In addition, neighborhood boundaries may need to be extended based upon place of employment, to include commuting routes and aspects of the built environment of the workplace, since these can also impact health. Studies of neighborhoods also need to address rural, as well as urban and suburban, environments.

Methodological Issues in Studying Neighborhood Context and Health

There have been a number of comprehensive overviews of the methodological challenges of examining neighborhood effects on health.[5, 19-21] We briefly discuss some of the methodological

challenges as they relate to future work on neighborhood effects on breast cancer.

Throughout history, researchers have examined regional variations in health outcomes and have analyzed ecological data to examine how characteristics of place are associated with rates of disease and mortality. Although ecological analyses of aggregate-level data are useful, researchers must be cautious about interpretation of such analyses. The "ecological fallacy" is inferring individual-level relationships from associations observed at the aggregate level. For example, if cities with a higher proportion of African Americans have higher breast cancer mortality rates, one cannot conclude that African Americans are more likely to die from breast cancer. On the other hand, without individual-level data, one similarly cannot conclude that living in a neighborhood with a high proportion of black residents causes higher breast cancer mortality. It may be that the racial/ethnic composition of residents in the neighborhood accounts for the association (compositional effects), with black residents, and not white residents, having higher breast cancer mortality rates. The difference in mortality rates could also result from individual-level confounding, for example, if African Americans have lower socioeconomic status and lower levels of health insurance. Mortality differences could also result from the contextual effects of group-level variables related to physical proximity to medical services, availability and uptake of screening, cultural factors that impact patterns of health care usage, etc. Therefore, data at both the individual and neighborhood level are needed to examine how place affects disease and mortality.

With the introduction of multilevel modeling techniques and more accessible software,[22, 23] there are opportunities to rigorously test how neighborhood contextual factors impact health outcomes, using data at both individual and neighborhood levels. The use of multilevel techniques is one of the best ways to disentangle the complexities of how neighborhood and individual factors separately and jointly relate to health, although these techniques have limitations. Models are only as good as the data that is put into them, and the greatest challenge to multilevel modeling is that researchers often lack the most appropriate data to address important research questions. For example, we may have neighborhood SES variables, but not individual SES variables. What data at the individual and neighborhood level do we need to best address how neighborhoods impact breast cancer outcomes?

When conceptualizing neighborhood effects, we need to measure neighborhood in a way that is consistent with the conceptual framework being employed. Using census tract as a measure of neighborhood, for example, is often a convenient way of categorizing neighborhoods, but it does not necessarily reflect well the borders or boundaries within which people interact or experience their neighborhoods. What level of neighborhood and what neighborhood variables do we need to best examine our questions about neighborhoods and breast cancer? Do we need to use different levels of neighborhood when studying, for example, those from the service environment versus those from the social environment?

Finding an association between neighborhood context and health, independent of individual factors, does not necessarily mean that there is a causal pathway from neighborhood context to health. People may select into or out of neighborhoods based on their health (reverse causation), or there may be other unmeasured factors that affect both where people live and their health (omitted variable bias or selection bias). What data or analytic techniques do we need to best examine causal relationships between neighborhood context and breast cancer?

Other issues related to time are often ignored or understudied in research on neighborhoods and health. Duration of living in a particular neighborhood (exposure to neighborhood) may matter, so may changes in the neighborhood itself over time. Moreover, a woman's age at the time of a critical neighborhood exposure may be particularly relevant with breast cancer. Exposure to toxic environments may be more important in breast cancer etiology at particular critical ages or stages of life.[24]

When using multilevel models to test for contextual effects of neighborhood characteristics while controlling for individual factors, care needs to be paid to not over-control for individual-level variables that are on the causal pathway between neighborhoods and health. This is especially important when a direct individual analog exists for a group-level exposure. For example, if we explore an association between neighborhood-level SES and cancer while controlling for individual-level SES, we are indeed controlling for one of the pathways through which neighborhood SES may affect cancer. For example, living in a low socioeconomic environment may lead to less quality education, lower status occupational opportunities, and lower income, which ultimately impact health. If we want to examine how neighborhood context creates and maintains breast cancer risk factors, rather than examining only whether neighborhood context matters over and above known risk factors, it will be important to ask: What individual-level variables do we need to control for as confounders, and which ones do we need to examine as modifying variables and/or mediators on the causal pathway between neighborhood context and breast cancer? In addition, we need to study how neighborhood-level variables modify individual-level compositional effects. For example, neighborhood or other area-level effects, such as metro-area racial segregation or income inequality, could modify observed relationships between individual-level factors and health outcomes.[17, 18, 25, 26]

Overview of Review on Neighborhood Context and Breast Cancer

Research on neighborhoods and breast cancer has favored some areas of inquiry over others. A fair amount of research has been conducted on how urban/rural status relates to breast cancer, as well as how neighborhood socioeconomic context relates to breast cancer. Our review will therefore begin by discussing these two areas. We then discuss a growing and important area of breast cancer research, neighborhood racial/ethnic context. Next, we provide an overview of research on neighborhoods and breast cancer in three subsections on the neighborhood service environment, the neighborhood social environment, and the neighborhood physical

environment. Although we discuss these literatures separately for simplicity, they have much overlap. Our conceptual model is based on the hypothesis that the urban/rural, socioeconomic, and racial/ethnic contexts of neighborhoods impact breast cancer and other health outcomes. Further, these factors operate through neighborhood service, social, and physical environments. After summarizing limitations and gaps in research in each of these areas, we conclude with recommendations for high priority directions for future research.

Urban/rural differences in breast cancer

"Geographic location is one of the strongest predictors of breast cancer incidence."[1] An urban excess of cancer incidence and mortality has been observed throughout the world, which has generated many hypotheses about place-based environmental exposures and behaviors that can influence cancer risk.[27] Increased incidence rates of breast cancer have also been observed in urban areas in California.[28]

Concept/Exposure Definition

Urbanization is measured by population density, metropolitan area size, or other measures of city or place population.[29] Some researchers have also used percent of the population involved in agriculture as a marker of rural status.[30] The level of urbanization can be measured at different geographic scales. These include state, metropolitan area, county, region, zip code, census tract, or block group. Some researchers call for increased attention to categorizing urban areas into finer categories (e.g., differences between central cities and suburban areas),[28] while others point out that heterogeneity within rural areas needs to be better addressed.[29]

Biologic Plausibility for Urban/Rural Differences

The urban excess of breast cancer incidence could be due to a number of factors. Looking at compositional explanations, it may be that living in urban areas is associated with known individual-level breast cancer risk factors, such as later age at first birth, lower parity, higher alcohol consumption, and higher use of hormone replacement therapy. Although these may be interpreted as simply compositional effects, those with their eye to interventions might also ask why urban living leads to higher rates of these different individual-level risk factors in the first place—investigating the indirect effects of urban/rural residence on breast cancer incidence.

Moreover, there may be contextual characteristics of urban areas that clearly affect breast cancer incidence. Many urban areas have higher levels of hazardous air pollutants from traffic and industrial sources than do rural places.[31] Urban areas also have more industrial waste sites and potential for ground water contamination from industry. Rural women often have more favorable breast cancer risk factor profiles (higher parity, earlier age first full term pregnancy, less alcohol use). On the other hand, rural women are more likely to mix or apply pesticides to crops or livestock and to live in areas with high levels of agricultural pesticide use.[32] Also, there are some rural areas in California that experience high levels of particle air pollution, largely due to dust from agricultural sources.[33, 34] Finally, light at night has been implicated in increased risk of breast cancer in

several epidemiologic studies (see Section I, Chapter H). Disruption of melatonin resulting from night exposure to light could be responsible for much of the urban-rural difference in breast cancer incidence rates.[35] Disentangling the complex effects of all of the possible direct, indirect, and interactive effects of rural/urban residence and breast cancer incidence is extremely difficult. In addition, there are urban/rural differences in access to health care resources that may affect breast cancer screening, diagnosis, treatment, and mortality.

Incidence/Etiology

Although higher incidence rates of breast cancer have been observed in urban areas compared to rural areas throughout the world,[28, 36, 37] the reported urban excesses have generally been modest, in the range of 1.1 to 1.8.[36] Robert et al. found that the urban excess of breast cancer incidence in Wisconsin persisted even when differences in individual-level risk factors and individual and neighborhood SES were accounted for.[38] This study simultaneously modeled individual-level reproductive factors, mammography use, family history of the disease, body mass index, alcohol intake, individual SES, as well as neighborhood-level socioeconomic status and urbanization. In multilevel models, urban women still had higher risk for breast cancer after adjusting for these individual-level and neighborhood-level factors.

A recent study from California considered individual risk factors for breast cancer in combination with neighborhood measures of socioeconomic status and urbanization.[1] The authors examined data from the California Teachers Study, a large cohort study following female professional school employees for cancer incidence since 1995. Within the cohort, breast cancer incidence rates were higher for women residing in the San Francisco Bay area and the Southern Coastal area, compared to women in the rest of California. Adjustment for personal risk factors and neighborhood-level socioeconomic status and urbanization did not diminish regional differences in incidence rates. The authors conclude that regional differences are not attributable to the compositional effects of individual level known breast cancer risk factors or to area measures of socioeconomic status and urbanization. Because individual level socioeconomic status was not available (although as an occupational cohort of professional women it is likely to be somewhat homogenous with respect to individual level socioeconomic status), it was not possible to examine contextual effects of neighborhood socioeconomic status while controlling for individual socioeconomic status.

In a recent ecologic study conducted in North Carolina, Hall et al. compared incidence rates in urban and rural areas among white and non-white women.[36] Urbanization, based on county of residence at diagnosis, was examined in nine categories. The incidence rates for in situ and invasive breast cancer were highest in the most urban areas for white women. For non-white women, rates of in situ cancer were highest among urban women, and rates of invasive cancer were highest among rural women. Although this was limited by being an ecologic rather than a multilevel study, it suggests that future multilevel research attend to urban/rural differences in

different types of breast cancer and their distribution by race.

Reynolds et al. explored the relationship between breast cancer incidence and urbanization, neighborhood SES, and region in California.[28] Because California is considered 85% "urban" by U.S. Census criteria, this study sought to minimize the heterogeneity of areas with this designation to better assess differences between various environments. They categorized urbanization, based on metropolitan area size and population density, into four categories: urban, suburban, city and small town/rural. This classification scheme allowed for the distinction between the densely-populated urban cores and the suburban areas of large metropolitan regions, all of which fall under the U.S. Census rubric of "Urbanized Areas" (i.e. population greater than 1 million). The category of "City" included U.S. Census defined Places with more than 50,000 people outside of an Urbanized Area, thus distinguishing between suburban cities and more remote cities located outside of large metropolitan areas. After adjustment for region, neighborhood SES, and race/ethnicity, women in the suburban and city groups were still at increased risk for breast cancer, but the women in the most urban category were not. This was true for all cases combined as well as for both the ductal and lobular cases that were examined separately. The urban and suburban areas were both located within the largest metropolitan areas of the state. To our knowledge, this is the first study to try to distinguish the difference in breast cancer incidence between urban and suburban women. Its results indicate that there may be important differences within places previously aggregated as urban in many studies. This study assigned urbanization and neighborhood SES at a very detailed level of geography, the census block group, while the two previously mentioned similar studies used zip code level[38] and county level.[36] However, this California study only included invasive cases and did not include individual-level measures of SES. This study did not present analyses for separate race/ethnic groups, which might be considered in the future, in light of the findings of the North Carolina study of different patterns for in situ and invasive cases and for whites and non-whites.

Screening

Women living in rural areas have lower mammography screening rates than women living in urban areas. Based on data from a national survey in 1998-1999, 66.7% rural women vs. 75.4% of urban women ages 40 years and older had a mammogram in the last two years (the Healthy People 2010 goal is 70%).[39] Rural residents also have slightly lower clinical breast examination rates (73.0% of rural women vs. 78.2% of urban women).[39] While these differences in screening rates are statistically significant, they are not very large in absolute terms. Future studies need to address heterogeneity within urban and rural areas with respect to breast cancer screening, using individual-level data on screening uptake and group-level data on screening availability.

Diagnosis

Urban women have greater access to mammography screening and medical facilities, which leads to earlier diagnosis. The rates of

ductal carcinoma in situ, a precancerous lesion detected almost exclusively through screening, have increased faster in urban women than in rural women in the U.S.[40] In California, a recent analysis of cancer registry data indicated that approximately the same proportion of cases in urban and rural areas was diagnosed with early stage disease.[41] This assessment was done at the county level. In California, county-level data is too large to account for heterogeneity within counties or to accurately categorize regions as rural, urban or suburban.

Treatment

Rural women face geographic barriers to obtaining optimal breast cancer treatment, and are less likely than urban women to receive breast conserving surgery.[42-45] Because rural women have to travel greater distances to receive radiation treatment, they are less likely to receive the recommended level of radiation treatment after breast conserving surgery.[46-48] The farther women live from a treatment facility, the less likely they are to receive the appropriate follow-up care.[46, 49] This appears to be particularly true in patients under 65 years of age.[47] Rushton and West used geographic information system (GIS) technology to identify regions of high mastectomy rates in southeastern Iowa and concluded that areas of high rates correlated with areas without radiation facilities.[50]

Mortality

In the United States, breast cancer mortality rates are higher in urban areas compared to rural areas, as is true for incidence rates.[51] However, no clear urban-rural patterns emerge when examining the most recent breast cancer mortality rates by county in California.[52] For example, some of the highest rates were reported in Merced County, which is a largely agricultural county, and the counties with the lowest mortality rates were a mix of rural and urban, such as Santa Clara County and Butte County. These rates were for all races combined. As stated previously, data aggregated by county in California is not adequate to disentangle the effects of rural, urban and suburban residence. No studies have examined breast cancer mortality rates in California by detailed categorizations of urbanization, even though the relevant scales are readily available.

Limitations and Future Directions for Studying Urban/Rural Differences in Breast Cancer

By definition, rural areas have fewer residents, making it difficult to conduct population-based studies that have adequate representation of rural residents. In addition, breast cancer rate calculations in rural areas are sensitive to limitations in the numerator, due to missing cancer cases, or cases that have been miscoded, such as cases coded to the hospital area rather than the patient's residential area. In addition, the breast cancer rate's denominator may be based on inaccurate estimates of population size.

Definitions of urban and rural vary greatly, and the geographic scales used range in size from very small, such as block group, to large, such as county. This makes it difficult to compare results across studies. The large degree of heterogeneity among populations and environments within a county are likely to mask trends at smaller geographical levels, but few studies to date have evaluated patterns of urban/rural risk at finer

levels of geographic detail. Future studies should examine rural/urban status in conjunction with other risk factors at multiple levels of geography (neighborhood block, tract, city, county).

Most research on urban/rural differences in breast cancer does not have accurate information on timing of exposure. How long have individuals lived in a rural or urban environment or neighborhood? Do rural/urban environments exert stronger effects at particular life stages? Most research examines rural/urban residence at time of diagnosis, but does not examine exposures at critical ages or life stages. Future research might examine residential history to help focus analyses on the critical exposures or timing of exposures that lead to greater breast cancer incidence in urban areas.

Most epidemiologic studies of breast cancer to date do not include comprehensive multilevel exposure histories. Ideally, such data would consist of an array of important individual- and neighborhood-level risk and protective factors. Lack of data makes it difficult to separate unique aspects of urban/rural status from neighborhood SES, individual SES, and other individual risk and protective factors. Without multilevel data, it is difficult to conceptualize, let alone measure, how particular individual and neighborhood pathways link urban/rural residence to breast cancer outcomes. However, for research to move forward, we need to have not only better multilevel data, but also clearer analytic strategies for examining specific pathways that may link rural/urban residence to breast cancer.

Although most research has examined rural vs. urban areas, there should be closer examination of more detailed categorization of urban areas (i.e., central city versus suburban) and of rural areas.[29] Moreover, examining what accounts for variation in breast cancer within rural areas and within urban areas might also provide clues about individual- and neighborhood-level factors that work together and separately to influence breast cancer incidence and outcomes.

Rural/urban variations in breast cancer incidence and mortality need to be examined with respect to race and ethnicity. For example, there is a well-documented cross-over in breast cancer incidence rates, with younger black women having higher rates than younger white women, while older black women have lower rates than older white women. No studies have examined in comprehensive fashion how urban, suburban or rural differences might impact these rates. In addition, future research should examine how ethnicity and immigrant status modifies the association between rural/urban residence and breast cancer. This should include investigating the effects of urban/rural status and race/ethnicity using individual- and group-level data on residence history, socioeconomic status, screening, and breast cancer risk factors.

Some of the work on screening and treatment that looks at distance traveled for medical care could examine the interactive effects of SES and race/ethnicity. Having to travel a greater distance for screening and medical care may be more problematic for rural residents with low income than for rural residents with higher income.

Finally, future investigations should also consider different histologic subtypes of breast cancer, especially lobular cases, which appear to be

particularly elevated in the highly urbanized areas of California.[28]

Neighborhood Socioeconomic Context and Breast Cancer Outcomes

A number of articles summarize research on the relationship between neighborhood socioeconomic context and health outcomes.[53-55] Recent research on neighborhood socioeconomic context has emphasized the use of multilevel models to examine how both individual- and neighborhood-level SES relate to health. In breast cancer research, higher SES is consistently related to elevated breast cancer incidence. Indeed, SES is particularly important to examine in relation to breast cancer because breast cancer incidence is one of the few health problems that is associated with higher, rather than lower, SES. Yet little attention has been paid to the potential multilevel nature of the relationship between SES and breast cancer. Most breast cancer studies use either individual SES or neighborhood SES, but not both. At this point, we do not know whether SES has a compositional effect (serving as a proxy for one or more individual-level breast cancer risk factors) or a contextual effect (serving as proxy for a neighborhood-level environmental exposure and/or greater access to screening and medical care). Therefore, examining SES and its effects in a multilevel and comprehensive way may provide better clues about the risk factors and combination of risk factors that need to be addressed to reduce breast cancer incidence and improve outcomes.

Concept/Exposure Definition

Socioeconomic status often refers to a person's standing in a social hierarchy that affords differential access to resources. Individual-level SES is measured in various ways, but often focuses on education, income, and occupation, and, less frequently, on assets, home ownership, car ownership, and other aspects of material circumstances. SES may be estimated using separate measures (i.e., education and income), or by a composite index that combines individual SES measures. SES at the group level is often restricted to household income, or the income of one's spouse, and does not include the status of one's neighbors or neighborhood. When it is measured, neighborhood SES is almost always estimated using census data in the U.S. by block, block group, tract, zip code, or metropolitan statistical area. Sometimes neighborhood SES is measured by aggregating the individual reports of SES of neighborhood residents who participated in a survey. Following the conventions for measuring individual SES, neighborhood SES is sometimes measured using separate indicators, such as percent poverty, median family income, percent of residents with at least a college education, percent of residents who are white collar workers, and unemployment rates. These measures are then combined to create multilevel indices of neighborhood SES or neighborhood deprivation.[56, 57] The idea is that just as people are part of a social hierarchy in society, the neighborhoods people reside in have a hierarchy as well. Those neighborhoods lower on the hierarchy often have fewer resources and greater health challenges. Researchers have yet to agree on the most ideal system for capturing the complex interplay of compositional and contextual effects that contribute to social class and socioeconomic status. But there is little doubt that such factors are integral to achieving a greater

understanding of the etiology and progression of breast cancer.

Biologic Plausibility for Neighborhood Socioeconomic Context

Epidemiologic studies suggest that neighborhood SES may affect breast cancer incidence and outcomes through a number of indirect and interactive pathways. Neighborhood SES over the life course may affect the individual SES attainment of residents, which then impacts personal risk factors for breast cancer incidence and outcomes. Most research also conceptualizes neighborhood SES as having potential contextual effects on health independent of individual SES. Neighborhood SES can affect breast cancer incidence and outcomes through its effects on the service, social, and physical environments of neighborhood residents.[54]

Until recently, there has been little data to suggest that neighborhood socioeconomic context has direct biological links to breast cancer. However, recent data support a conceptual model whereby aggregate-level neighborhood factors could more directly affect biologic pathways that increase risk of breast cancer. For example, recent data on laboratory animals suggest that social deprivation may increase breast cancer incidence through up-regulation of stress-related cell-signaling pathways and modulation of the immune system.[58] Shorter sleep cycles due to noise or crime, combined with higher levels of ambient light, lead to depressed melatonin levels and have been suggested to increase risk of breast cancer among women in specific neighborhoods.[59]

Incidence

While much is known about the association between individual SES and breast cancer incidence, little is known about potential contextual effects of neighborhood SES. The well-documented positive association between breast cancer incidence and higher individual-level SES[37] is partly driven by socioeconomic variations in established breast cancer risk factors, most importantly, later age at first birth and nulliparity or lower parity.[60, 61] However, the association between individual SES and breast cancer remains even after adjustment for these known individual-level risk factors.[38, 62] A number of breast cancer studies use neighborhood SES measures to look at breast cancer incidence, but these studies use neighborhood SES as a proxy for individual-level SES, because no individual SES data are available.[63] Although these studies are useful in detecting SES patterns in breast cancer incidence across neighborhoods, no conclusions can be made about whether neighborhood SES context might contribute independently to breast cancer incidence beyond individual SES.

In a case-control study in Wisconsin, neighborhood SES was still associated with increased risk of breast cancer, even after controlling for individual-level SES.[38] This suggests that there may be something about higher-SES neighborhoods that contributes to breast cancer incidence. However, most epidemiologic studies of breast cancer only examine SES at the level of individuals or households, and not at the neighborhood level.

Screening

Women with lower individual SES are less likely to have mammograms than are higher SES women.[64-66] Based on a national survey, 82.5% of women with annual household incomes of $50,000 or more had a mammogram in the last two years, compared to 68.4% of women with incomes under $15,000.[66] Women with low income are also less likely to have the recommended frequency of clinical breast exams.[67] Reasons for these persistent disparities include financial limitations that restrict access to care, such as lack of health insurance, and no usual source of health care.[65]

As with research on breast cancer incidence, there is little evidence about whether screening rates correlate more strongly with individual-level, as opposed to neighborhood-level, SES. However, Rosenberg and colleagues,[68] using the Black Women's Health Study data, found that among African American women, regular mammography use was associated with higher neighborhood SES, but not after controlling further for individual-level SES.

Diagnosis

Studies have reported that low-SES women are more likely than high-SES women to be diagnosed with late stage breast cancer, and higher-SES women are more likely to be diagnosed with localized disease,[69-73] although these findings have not been entirely consistent.[74-76] Using national SEER data from 1995 through 1999, a higher percentage of women living in areas of high poverty were diagnosed with more advanced stages of breast cancer; conversely, a higher percentage of women in areas of low poverty were diagnosed with localized breast cancer.[73] This disparity in diagnosis by poverty residence was seen across all racial/ethnic groups. Again, limiting SES measurement to either the individual level or the neighborhood level, but lacking information on both, hampers our understanding of how socioeconomic inequalities in diagnosis might be patterned across both individuals and neighborhoods.

In interesting studies, Catalano, Satariano, and Ciemins showed that in situ and local breast tumors in black and white women were less likely to be detected during periods of high area unemployment.[77, 78] Chronic unemployment rates, which are more prevalent in lower-SES and predominantly minority neighborhoods, may also delay cancer detection by the same "distraction" model.

Treatment

Breast conserving surgery (BCS) is currently the preferred method of treatment for stage I and stage II breast cancers.[73] BCS is more common in high-SES neighborhoods, compared to low-SES neighborhoods[73] and in urban areas versus rural areas.[45] BCS rates have increased since the 1980s in all neighborhood SES groups, but rates are still highest in the highest-SES neighborhoods.[73] This finding could be due to the fact that individual high-SES women are more likely to be diagnosed at an early stage, or that high SES results in greater group-level access and awareness of services, or both. Many of these potential relationships have been assumed rather than tested. There may also be treatment norms that vary by neighborhood, and operate independently of the individual SES of women.

Mortality

While women living in the highest-SES neighborhoods have the highest incidence rates of breast cancer, women living in the poorest-SES neighborhoods have the lowest survival rates,[73, 79] including in the San Francisco Bay Area.[80] The reasons for the socioeconomic difference in survival rates are not clearly established,[81-83] and are particularly obscured by lack of multilevel data on SES, information on access and use of health care, and tumor biology data. Potential explanations include disparities in access to health care, which influence stage at diagnosis; disparities in access to optimal treatments; and differences in tumor biology, such as estrogen receptor status, histology, and grade. However these factors do not completely explain the differences in survival.[71, 84]

The recent study by Bouchardy et al. in Switzerland found that adjusting for later stage at diagnosis, different tumor characteristics, and treatment differences explained less than half of the excess mortality in the low-SES women.[83] SES in this study was based on most recent occupation. Rutqvist et al. reported from Sweden that the SES differences in stage-specific survival were mostly explained by non-breast cancer mortality.[85] Lagerlund et al. found that Swedish women of higher SES had a better prognosis for survival than did lower-SES women, even after adjusting for age, tumor characteristics, parity, and cohabitation. The observed survival benefit with high SES was most pronounced in women under 50 years of age.[76] It is interesting to note that socioeconomic disparities in breast cancer survival exist even in ethnically homogenous, affluent countries like Sweden and Switzerland, with excellent health care systems and health care access. Different methods were used to measure and aggregate SES across studies, and there does not appear to be a uniform or agreed-upon method for addressing SES in studies of breast cancer mortality.

Limitations and Future Directions for Studying Neighborhood Socioeconomic Context and Breast Cancer Outcomes

As this review has demonstrated, it is clear that higher SES is positively related to breast cancer incidence, screening, and treatment, but inversely related to stage at diagnosis and mortality. What is not at all clear is how individual and neighborhood SES contribute to these patterns through separate or joint effects. Individual SES or neighborhood SES have been examined separately in studies of breast cancer incidence and outcomes, but rarely together. This is an example of how breast cancer research has been severely limited by the norms of data collection and the ways in which data is analyzed in cancer studies. Whereas many other areas of health research have multilevel socioeconomic data, breast cancer studies have been behind in collecting, accessing, and analyzing such data.[86, 87]

Regarding breast cancer incidence, future research could examine whether there are factors associated with living in high-SES areas that contribute to increased breast cancer risk, over and above individual SES. In terms of the neighborhood service environment, do women living in higher-SES neighborhoods use medical care systems that are more likely to emphasize hormone use? In terms of the neighborhood social environment, are

there particular social norms in higher-SES areas that produce behaviors putting women at greater risk of breast cancer? Examples might be social norms encouraging alcoholic beverage consumption (consumption in excess of two drinks per day is associated with increased breast cancer risk) and aspects of the workplace that discourage breast-feeding or impact childbearing (breast-feeding has a protective effect on breast cancer risk beyond that of parity alone).[88] In terms of the neighborhood physical environment, do higher-SES neighborhoods expose women to more toxic chemicals of a specific kind? A survey in Newton, Massachusetts found that women in areas with the highest incidence of breast cancer were more likely to report use of professional lawn services and higher routine use of home pesticides than women in low-incidence areas.[89] Other studies suggest that dry cleaning and other chemical exposures may contribute to breast cancer risk in high-SES women. These are examples of the kind of research that might link individual- and neighborhood-level SES to increased breast cancer risk.

The influence of neighborhood SES on stage at diagnosis, treatment, and survival needs further attention as well. In these cases, lower SES is related to adverse breast cancer outcomes in the same way it is related to other health outcomes—with lower SES people or places being at a disadvantage. Future research needs to examine the relative and joint roles of individual SES and neighborhood SES in exposing people to neighborhood service, social, and physical environments that increase or decrease breast cancer risk. The idea is not only to examine whether there are independent effects of neighborhood SES on breast cancer incidence and outcomes, but also to explore explanations for these contextual effects. Looking simultaneously at other health conditions and outcomes may also provide clues about the neighborhood conditions that affect risk for all diseases, along with those that may specifically influence breast cancer risk.

One question regarding mammography screening is whether rates of mammographic screening in a neighborhood may be a crude measure of social norms regarding mammography. Perhaps women in neighborhoods with lower mammography rates are less likely to be urged and supported in getting timely and routine mammograms by neighborhood friends and relatives. Indeed, there may even be a level of skepticism of the medical care system or of the importance of screening that varies by the SES of neighborhoods.

It will also be important to examine multilevel interactions between individual and neighborhood SES. Although living in lower-SES neighborhoods might be detrimental to the health behaviors and health care access of all residents, it might be particularly detrimental to those with lower individual SES (a double jeopardy hypothesis). Moreover, neighborhood SES may interact with race, age, and other factors in ways that are detrimental to women's health. As will be discussed briefly below, it is important to examine race/ethnicity and SES simultaneously, especially when investigating neighborhood SES. Racial and ethnic minorities are much more likely to live in lower-SES neighborhoods than are white people, even at the same individual income level.[90]

Little is known about how multilevel SES and age interact over the life course to affect breast cancer

incidence and outcomes. Most studies only look at SES at time of diagnosis. Early life SES may also have an important impact on breast cancer risk and only a few studies have looked at this issue.[91-93] Wrensch et al. noted that there was some indication that early-life high SES was associated with increased risk in women over 50 years of age in Marin County, California.[92] This is consistent with other health research indicating that SES in both childhood and adulthood are related to health and health risk factors in adulthood.[94-96] In the absence of long-term prospective studies beginning in childhood, collecting information on residential histories and asking women about their childhood SES might help us understand whether SES over the life course has a cumulative impact on breast cancer incidence and outcomes, and whether individual and neighborhood SES are particularly important to breast cancer at certain ages or stages of life.

Neighborhood Racial/Ethnic Context and Breast Cancer

Research consistently demonstrates that race and ethnicity are related to all aspects of breast cancer, from incidence to mortality. Section II, Chapter A, of this paper specifically addresses our knowledge of racial and ethnic differences in breast cancer. Despite the importance of race and ethnicity in predicting breast cancer incidence and outcomes, little research has examined how the racial/ethnic composition of neighborhoods might contribute to breast cancer. This is a strong limitation of current research, since minority racial and ethnic groups live, on average, in very different types of neighborhoods than do white people. Indeed, it is wrong to discuss the health impact of race in this country without recognizing that different races live in different neighborhood contexts where health risk factors are developed and maintained.

Concept/Exposure Definition

Racial composition refers to the distribution of racial/ethnic groups within a neighborhood. Racial composition is usually measured in simple ways, such as looking at the percentage of African Americans, Hispanics, or racial/ethnic minorities in a neighborhood. Racial composition is sometimes categorized to indicate whether a neighborhood is racially/ethnically mixed, mostly white, or mostly racial/ethnic minority.

Racial residential segregation (also referred to as "racial segregation") refers to the fact that individuals are unevenly distributed across neighborhoods by race/ethnicity. Historical and discriminatory patterns of uneven industrial development, the movement of economic opportunities away from inner cities, real estate speculation, discrimination in government and private financing, and exclusionary zoning have led to systemic racial segregation among diverse communities, with important implications for community health and individual well-being.[97-103] In a world with no racial segregation, the racial composition of all neighborhoods would be the same, reflecting the racial composition of the nation as a whole. Racial segregation measures the variation in racial composition of neighborhoods. It is commonly measured using smaller residential units, such as census tracts, within a larger area unit, such as a city or county.[104] In essence, it measures whether a specific neighborhood looks similar to or different

from the racial/ethnic composition of other neighborhoods within a given city or county.

Biologic Plausibility for Neighborhood Racial/Ethnic Context and Breast Cancer

There are two general pathways through which racial segregation may impact health.[8, 105-109] First, racial segregation produces and reinforces economic segregation in the U.S.[90, 110, 111] As a result, people of different racial/ethnic groups live in very different types of neighborhood socioeconomic environments. For example, African Americans are more likely than whites to live in lower-SES neighborhoods, on average, even when African Americans and whites at the same income level are compared.[90] Therefore, racial segregation can negatively affect health indirectly through its impact on neighborhood SES, and also through its impact on the individual SES attainment of residents.

Second, living in a racially segregated area may be related to health outcomes over and above socioeconomic pathways. Studies show that racial segregation is associated with differential exposure to a host of health risks, including substandard housing, chemically toxic environments, lack of access to adequate medical services, and social isolation.[15, 105, 112, 113] Moreover, racial segregation may heighten exposure to and perceptions of discrimination, which can cause acute and chronic stress that leads to poor health outcomes. Living in a neighborhood with a high racial/ethnic minority composition may be related to health outcomes in ways similar to those for racial segregation. However, there may also be some protective aspects of living in neighborhoods that have high racial/ethnic minority composition, and/or are racially segregated. As is discussed in Section II, Chapter D of this paper, immigrants with lower acculturation have lower breast cancer incidence. This is likely due in part to their maintaining health behaviors that are protective of health generally, and against breast cancer specifically. Living in ethnic enclaves may help individuals maintain healthy behaviors consistent with the norms of their country of origin.[105] Ethnic enclaves may also protect immigrants from discrimination in housing and the lending industries, which in turn impacts their individual SES status. Moreover, living among people who are racially or ethnically similar may create a social environment that is more supportive, in some ways, than living as a member of a racial/ethnic minority in a white neighborhood.

Evidence for an Association between Neighborhood Racial/Ethnic Context and Breast Cancer Outcomes

Although racial and ethnic minorities often live in very different neighborhood contexts than do whites, research has paid little attention to examining how the neighborhood context contributes to racial disparities in breast cancer incidence and outcomes. In a study on racial differences in obesity, individual SES somewhat attenuated the association between race and obesity among African American and white women. Moreover, controlling for neighborhood SES even further attenuated the association. Neighborhood context helps explain racial disparities in obesity[12] and self-rated health.[114]

There is very little direct evidence for the impact of neighborhood racial segregation on cancer risk, but evidence has accumulated for its impact on other health conditions. Much previous work has focused on neighborhood racial segregation's impact on hypertension and cardiovascular disease. Some studies using aggregate-level data have shown an association between higher levels of racial segregation and infant and adult mortality rates.[106, 108, 108, 115, 116] However, two recent multilevel studies found only modest associations between racial segregation and self-rated health using three national data sets.[8, 117]

In terms of the neighborhood service environment, highly segregated neighborhoods often face limited availability of high-quality preventive care. Research demonstrates a positive correlation between access variables (transportation barriers, increased distance to health care facilities) and suboptimal treatment patterns.[46, 48, 49, 115, 118-121] Zenk, Tarlov, and Sun[122] examined travel distances to facilities providing low- or no-fee mammography screening in Chicago. They found that even compared to other high-poverty neighborhoods with the highest screening needs, neighborhoods with a greater proportion of African American residents had longer travel distances and travel times.

Individuals living in highly segregated areas may have limited access to economic and social resources for promoting health[112] and for moderating breast cancer risk factors. Clustering of disadvantaged neighborhoods, or "ghettos," may further constrain social and economic resources for minority groups by heightening crime rates and limiting access to resources such as supermarkets, parks and recreational facilities in other parts of the metropolitan area.[105]

In terms of the social environment, racially segregated neighborhoods potentially have both positive and negative effects on breast cancer incidence and outcomes. Social norms and practices of ethnic groups may be easier to transmit and maintain in a neighborhood where most residents share cultural norms and values. To the extent that these shared health behavior practices are unhealthy, living in an ethnic enclave may be detrimental to health. Kandula and colleagues[123] used the 2001 California Health Interview study to examine disparities in cancer screening among non-Hispanic whites (NHWs), Chinese, Filipinos, Koreans, Vietnamese, and other Asians. After adjusting for access to care, some Asian subgroups still had lower rates of cancer screening, compared to NHWs. Foreign-born Asians reported that they did not get screening tests because they did not experience problems or symptoms. In this case, living among other recent immigrants might perpetuate the norm of not accessing Western medicine for screening. Distrust of the medical establishment and long-standing perceived barriers to quality care can also lead members of minority groups to forgo treatment for cancer, even when symptoms are present.[124] Living in a minority neighborhood could reinforce this distrust and perception of barriers.

Yet, on the positive side, recent immigrants may maintain their health advantage longer if surrounded by neighbors with protective health behavior norms and values. Studies on migration, acculturation, and breast cancer incidence

demonstrate that incidence rates increase in women who migrate to high-incidence countries from low-incidence countries. For example, focusing on Hispanic women in California, John and colleagues[125] found that breast cancer risk was lower in Hispanic women who moved to the U.S. after age 20, and those who spoke mostly Spanish. The effects of migration patterns were significantly attenuated once known individual risk factors were included. Higher levels of acculturation were associated with characteristics of Western lifestyle that increase breast cancer risk (higher education, early age at menarche, nulliparity or low parity, late age at first pregnancy, no breast-feeding or short duration, hormone therapy use, height, sedentary lifestyle, and alcohol consumption). Research on migration and acculturation is discussed in more detail in Section II, Chapter D of this paper. However, a research agenda that includes examinational of cultural norms within and across different neighborhood racial/ethnic contexts might enhance our understanding of how healthy behaviors may be promoted and maintained.

In terms of the neighborhood physical environment, people of color and people living in low-income or economically disadvantaged areas are disproportionately exposed to environmental pollutants,[15, 126, 127] which adversely affect their health and well-being. An environmental justice conceptual framework can encourage new insights into the junctures of the political economy of social inequality with racial discrimination, environmental degradation, and health. According to the U.S. EPA definition, "Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."[128] Most important, application of an environmental justice perspective to some of the noted disparities in the burden of breast cancer has not been fully explored, but may be relevant, particularly with respect to the greater burden of incidence among young African American women and worse survival rates among some minority and low-income women.

Limitations and Future Directions for Studying Neighborhood Racial/Ethnic Context and Breast Cancer

Few studies have directly examined how the different neighborhood contexts of racial and ethnic groups may affect breast cancer incidence and outcomes. This is an important gap in the literature, conceptually and empirically. For example, in a study of breast cancer mortality in the San Francisco Bay Area, O'Malley and colleagues[80] found that less than 3% of white women in the study resided in poverty neighborhoods, compared to 48% of black women in the study. These different neighborhood contexts must contribute to racial/ethnic disparities in breast cancer, yet they remain generally unaddressed and poorly understood.

Research on racial segregation and breast cancer incidence, screening, diagnosis, treatment, and mortality would further our understanding of the complex barriers that women face, and the contexts in which they face them. Segregation, even when the adverse health effects are experienced by individuals, occurs at a group level, based on social class and racialized

hierarchies. By definition, segregation refers to an imbalance in the distribution of a specific demographic group across a geographic region, such as a metropolitan area. Therefore, the community health effects of segregation must be examined and remedied through policy decisions and interventions at the regional, metropolitan, state, or national levels. In general, the structural forces that create segregation tend to operate regionally, as evidenced by many current political and economic regions where economic growth and environmental quality are not optimal for communities of color, the working class, and the poor.[26] From a public health perspective, the rationale for taking a regional approach to examining links between segregation, environments, and health disparities is twofold: First, economic trends, transportation planning, and industrial clusters tend to be regional in nature, even as zoning, facility siting, and urban planning decisions tend to be local.[101] Second, research that examines how health inequities play out regionally could have implications for the development of interventions and policy initiatives that ameliorate fundamental drivers of environmental health and disease among diverse communities.

As we conduct research on racial segregation and breast cancer, we need to discuss the variety of intervention options implied by our studies. For example, if racial segregation is related to a host of breast cancer risk factors, we likely want to address not only each of those factors, but we would also want to ameliorate the social, political, and cultural factors that lead to and perpetuate residential segregation.[129, 130] Similarly, as we consider how to continue to improve access to breast cancer screening among African American women and in African American neighborhoods, we need to simultaneously consider how to ensure that all women have access to the diagnostic and treatment services that would make early screening worthwhile.[131]

Neighborhood Service Environment and Breast Cancer

Some aspects of the neighborhood service environment may put women at greater risk for developing breast cancer. Some research indicates that there is neighborhood variation in the availability of supermarkets and healthy, affordable food.[132] Availability of recreational resources is related to physical activity levels.[133] Transportation services also vary by neighborhood, and can affect the ability of many residents to access available services, resources, and social and recreational opportunities.[134]

Obviously, aspects of the neighborhood medical service environment may put women at greater risk for poor cancer screening, diagnosis, treatment, and mortality outcomes. A large literature discusses the importance of access to mammography, early diagnosis, and appropriate treatment. This research shows that there is much regional variation in both access to and use of these services, and some of this research has been summarized earlier in this chapter.

A number of initiatives have targeted low-income neighborhoods for increasing access to mammography. For example, the North Carolina Breast Cancer Screening Program used lay health advisor networks to increase uptake of screening mammography among older, minority women in

impoverished rural areas.[135] Similar projects have been established in urban areas.[136] The Witness project, which uses cancer survivors and lay health advisors to increase awareness, knowledge, access to screening, and early detection in the African American population, is now implemented in 22 states at 33 different sites. Results suggest that individual as well as group-level barriers need to be overcome. For example, neighborhood transportation may impede access to medical services, even if appropriate screening, diagnosis, and treatment services are available.

Future Directions for Research on the Neighborhood Service Environment and Breast Cancer

We need to better understand how neighborhoods vary in access to appropriate services that would lead to prevention of breast cancer, earlier diagnosis, and better treatment. It will be important to examine how individual characteristics interact with the available service environment. For example, poor people or older adults may be particularly vulnerable to the lack of appropriate neighborhood services.

There are currently efforts in some cities to improve access to healthy affordable food, and to improve transportation systems. Examining the impact of these interventions on breast cancer and other health risk factors—such as health behaviors (eating habits, nutrition) and health care access and use—would help us understand which risk reduction interventions should be highest priority.

Finally, lack of minority access to state-of-the-art clinical trials and other aspects of optimal breast cancer treatment is a well-documented problem.[136] In the absence of universal health care, it is imminently worth investigating not only individual-level barriers, but also neighborhood characteristics that can be targeted to improve access to preventive and medical care services. The available literature demonstrates that disparities in breast cancer outcomes are related to patient-, provider-, and health system-level factors, but relatively little work has been done at the level of neighborhood.

Neighborhood Social Environment and Breast Cancer

While an increasing body of research has linked racial and income segregation with poor health outcomes,[105, 107] little remains known about the mechanisms that mediate this link. Research suggests that metropolitan-level segregation shapes neighborhood-level social environments in ways that impact health. As discussed above, segregation has been linked with poorer environmental quality, poorer housing conditions, and reduced community access to parks, health care facilities, and transportation. Residential segregation is also linked with neighborhood levels of crime, social cohesion, and trust.[137] Using trust as an index of social capital, the Social Capital Community Benchmark Survey (SCCBS) found that residents of racially diverse communities were less likely to trust other people, including members of their own race. They were also more likely to be personally isolated. In addition, people in racially diverse communities were less likely to connect with neighbors across class lines.[138] Asesina and Ferrar[139] also found lower interpersonal trust in racially heterogeneous communities and communities with high income

inequality. Marcshall and Stolle[140] extend this work by examining the neighborhood conditions in Detroit that foster generalized trust. They found racial differences in how trust develops. Racial heterogeneity was positively correlated with levels of interpersonal trust for African Americans, but was not a significant factor among whites. Neighborhood sociability, or the amount of formal and informal social interactions occurring within the neighborhood, was also positively correlated with the formation of generalized trust for African Americans, but not for whites. What determined white residents' level of interpersonal trust was the socioeconomic status of the neighborhood.

These differences in the way that neighborhood racial and socio-economic context influences residents' levels of interpersonal trust can help us understand how, in the context of a highly segregated metro area, various dimensions of neighborhood racial composition could affect health behaviors potentially linked to breast cancer. In addition, these differences may help us better understand some of the contradictory effects of segregation for whites versus African Americans on various health and social outcomes.[107, 110, 137, 141] Neighborhood social factors that have been studied in recent research on health include, but are not limited to: social connectedness of neighbors, social disorganization, violence, cultural norms and practices, civic engagement, and political environments.[142] However, little research has specifically examined neighborhood social factors and breast cancer. The social environment of neighborhoods can affect breast cancer incidence and outcomes through a number of pathways. Living in more stressful neighborhood environments can "get under the skin"[143] by way of repeated assaults, resulting in chronic stress. Neighborhoods with high crime, high unemployment, low social cohesion and trust, and greater experiences of racism and discrimination can elevate stress in residents.[77, 78, 105] People living in areas with limited access to service facilities may require more effort, energy, and time to achieve the basic tasks of daily living. A diagnosis of breast cancer, which may limit mobility while increasing the need for travel (e.g., to medical facilities), can present an additional challenge for people in neighborhoods with limited resources.

The social environment can also produce social norms and practices that shape the health behaviors and risk factors of individuals. Berkman and Kawachi[144] suggest that neighborhoods with high social capital may be able to reinforce positive social norms and health behaviors. Some behavioral or risk factors that may be affected by neighborhood norms include smoking, exercise, and obesity. Datta and colleagues[145] analyzed multilevel data from the Black Women's Health Study and found that African American women living in neighborhoods with higher poverty had higher smoking prevalence, even after controlling for demographic factors, education, occupation, and several other neighborhood SES variables, which is consistent with previous research.[13, 14] Neighborhood socioeconomic context is associated with a higher risk of obesity,[12] controlling for individual SES measures. Cubbin, Hadden, and Winkleby[146] found that neighborhood socioeconomic deprivation, over and above individual SES, was associated with physical inactivity. Neighborhood

social structures and social norms also have a strong impact on smoking[147] and physical activity patterns[148] among younger women.

Policies and social norms can affect breast-feeding practices at work or in other public spaces. A recent study of women working in semiconductor manufacturing in Taiwan found that "breast-feeding-friendly policies can significantly affect breast-feeding behavior."[149] Internationally, breast-feeding has been demonstrated to have a strong protective effect on breast cancer risk.[88] A variety of barriers discourage breast-feeding among women, even though benefits to mother and child are well established. Women of lower SES are less likely to breast-feed, which may be linked to specific occupations, social conditions, and education. Several aspects of women's reproductive history track very closely with SES,[150] but breast-feeding may be the only factor that can be readily addressed through public health interventions.

In the stress literature, there is a strong body of research on how coping and social support at the individual level moderate health outcomes.[151-153] Several studies have also established an association between social support and breast cancer survival.[154-156] Less attention has been paid to how neighborhood and individual social support may buffer the impact of neighborhood context on breast cancer. An increasing body of animal studies provides evidence that stress and the social environment may impact breast cancer, but little research on this topic has been done with human beings.

Directions for Future Research on Neighborhood Social Environment and Breast Cancer

Gee and Payne-Sturges and Morello-Frosch have developed useful models for conceptualizing the complex interactions between social and physical factors that operate simultaneously at the community and individual levels.[16] Future work should explore how the neighborhood social environment impacts breast cancer, including attention to the neighborhood experiences of: social trust and social capital, social stress, social support and interaction, and social norms and behaviors. Each of these neighborhood social components may lead to risk factors for breast cancer and may moderate the course and outcomes. In particular, social cohesion for whites, African Americans, and Latinas may be a result of different conditions which, in turn, interact with other neighborhood factors to affect health behaviors. More research is needed to determine when and how diverse dynamics of neighborhood racial and ethnic composition promote health, and when they harm. With respect to Hispanic women, California is probably the only state with sufficient numbers to conduct a comprehensive analysis of breast cancer risk factors and outcomes. Howe et al.[157] outline several avenues for investigation among Hispanic women that include country of origin, years living in the U.S., the role of individual and neighborhood level SES, and cultural factors.[26] In addition, see Gee and Payne-Sturges[16] and Morello-Frosch,[26] who have developed useful models for conceptualizing the complex interactions between social and physical factors

that operate simultaneously at the community and individual levels.

Neighborhood Physical Environment—the Built Environment

Our physical environments are the places where we live, work, learn, and play. The quality of our neighborhood physical environment affects our health and well-being. Section of this paper examines biological exposures from the physical environment, focusing on the potential effects of sunlight, artificial light, tobacco smoke, radiation, bacteria, endotoxins (part of the outer cell wall of bacteria), and viruses, so we will not address these topics here.

The built environment is another aspect of our physical environment that affects our health and well-being, and that may be relevant to breast cancer. The built environment includes buildings, housing, parks—any urban, rural and suburban infrastructure—along with the "connective tissue that links these places together," transportation infrastructure.[158, 159] The built environment ranges from large-scale civic environments to the small-scale personal spaces and indoor residential environments where humans spend nearly 80% of their time.

A recent explosion of studies in public health examine how aspects of the built environment (e.g., the availability and accessibility of recreational facilities, pharmacies, stores, and the walkability of a neighborhood) relate to health outcomes such as low birth weight,[160] depression and perceived health status,[161, 162] drug overdose mortality,[163] motor vehicle and pedestrian fatalities,[164] death[165] and several other health outcomes. Moreover, aspects of the built environment have thus far been strongly and consistently associated with levels of obesity and physical activity,[166-168] two established risk factors for breast cancer.

Our physical surroundings can dictate many involuntary physical exposures. The way neighborhoods are constructed influences road patterns, traffic density, noise, and air pollution from vehicle exhaust. The placement of industrial facilities, trucking distribution centers, and waste dumps, which is related to land use policies and zoning, can also greatly impact residents near these sites. The quality of the housing, schools, and other public places, along with the types of building materials used, impact our physical exposures as well. Public policies regarding smoking impact exposures to second-hand smoke. Many involuntary exposures from the built physical environment may be risk factors for breast cancer. For example, the Cape Cod Household Exposure Study, conducted by the Silent Spring Institute has sought to characterize indoor exposures to endocrine disrupting chemicals (EDCs) potentially linked to breast cancer. Testing included household air and dust and women's urine samples from 120 homes for 89 EDCs, including phthalates, alkylphenols, parabens, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), pesticides, and other phenolic EDCs, many of which had not been tested for before in indoor residential environments.[169]

Physical inactivity and obesity are two of only a few known, modifiable, risk factors for breast cancer. There is an emerging literature on the

relationship between obesity, physical activity, and physical attributes of one's neighborhood. These attributes include the number of walkable destinations and the availability of undesirable amenities, such as fast food stores, and desirable amenities, such as supermarkets and recreation facilities. Neighborhood street connectivity and accessibility, high number of non-residential destinations near a home, higher residential density, and greater mix-diversity land use (mixes of residential, office, retail, and public space) have been found to be associated with higher levels of physical activity.[164, 168, 170] In a review of eighteen studies, Owen et al. found that the accessibility of sidewalks, stores, and parks, and perceptions about traffic and busy roads were associated with walking.[171] Less studied is the relation between measures of safety and physical activity levels, although there are suggestions that people who perceive their neighborhood as unsafe are less likely to be physically active.[171, 172]

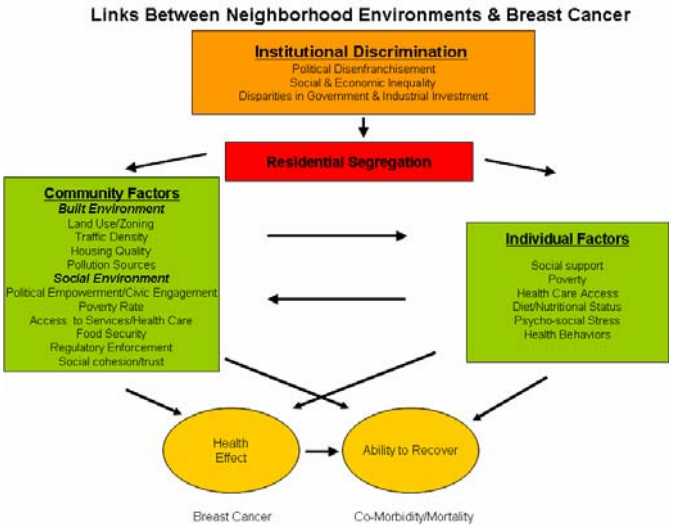
In the literature on obesity/overweight, similar to the physical activity literature, most,[164, 167, 170, 173] but not all,[174] studies have found obesity/overweight to be more prevalent among residents of areas where sprawl makes it more difficult to walk to destinations.[166] Obesity may be related to limited access to food establishments, restaurants and grocery stores that serve healthy food, and/or to increased access to unhealthy food establishments, such as fast-food restaurants.[175] Additionally, there is some evidence that obesity is associated with the amount of time spent in a car,[167] vehicle miles of travel, and commute time.[176] These same measures are highly predictive of polycyclic aromatic hydrocarbon (PAH) exposures from vehicle exhaust,[177] which may also be associated with increased breast cancer risk.

Directions of Future Research on the Neighborhood Physical Environment—the Built Environment *and Breast Cancer*

Addressing the specific aspects of the built environment that may impact breast cancer incidence and outcomes represents a highly productive direction for future breast cancer research. Research into the effects of the built environment may open a new avenue for breast cancer risk reduction by examining how neighborhood attributes may be changed to reduce the burden of breast cancer and other diseases. With greater knowledge about the role of the built environment in determining biological and behavioral risk factors, urban planners, community groups, and public health officials can advocate for changes to the built environment that promote health and reduce risk.

Recent advances in geographic information system (GIS) technology have provided new opportunities to explore the complex relationships between many facets of the physical environment and health. GIS technologies allow for much finer geographic detail in examining environmental exposures. A number of investigators have invested considerable effort in developing GIS-based environmental exposure metrics with an eye towards studying breast cancer. The Cape Cod Breast Cancer and Environment Study, the Western New York Exposures and Breast Cancer Study (WEB Study) and the Long Island Breast Cancer Study have been particularly active in this regard.[178-182]

Some GIS exposure methods have been developed and then applied to case-control studies in which residential histories also have been collected so as to better characterize chronic exposures or exposures in early life. These studies have generated some provocative results regarding biological exposures (see Section I of this paper for detailed descriptions of these studies). The methods used in these studies might be fruitfully used to examine how breast cancer risk factors relate to spatial aspects of the built and social environment and to the interactions among physical and social aspects of the neighborhood environment.



Conclusion: Priority Directions for Future Research

Most breast cancer research has focused on individual-level risk factors, overlooking the potential importance of neighborhood in shaping known individual-level risk factors and itself providing risk factors. Figure 1 provides a framework for how neighborhood environment can be examined in conjunction with individual-level factors in terms of how they might shape breast cancer risk.

Basic Conceptual and Methodological Issues for Future Research

The following are the most important conceptual and methodological issues to be addressed in future research into neighborhood effects on breast cancer.

- Neither individual- nor group-level exposure measurement alone provides sufficient data for understanding breast cancer incidence patterns and outcomes.
- To determine how neighborhood context impacts breast cancer incidence and outcomes for specific social groups, research should proceed at multiple levels, examining both neighborhood characteristics and individual demographic factors (e.g., age, race, individual SES).
- Neighborhood context can be conceptualized as both a risk factor and a protective factor, interacting with individual-level risk factors to affect breast cancer incidence and outcomes.
- Age at exposure and timing and duration of exposure to neighborhood contexts need to be comprehensively explored through detailed residential histories.
- County-level spatial aggregation is insufficient to capture heterogeneity within regions; urban, suburban and rural regions needs to be characterized and evaluated.

- A useful conceptual framework for future investigations would encompass how urban/rural, socioeconomic, and racial/ethnic contexts of neighborhoods impact breast cancer and other health outcomes, and how these factors operate through neighborhood service, social, and physical environments.

High Priority Recommendations

Studies that identify distributions of known risk factors associated with living in metropolitan and affluent areas and also incorporate information on environmental exposures could prove useful. California has a number of population-based surveys that could be combined with existing databases on environmental exposures.[183] We also need studies that examine variations in the breast cancer burden at small levels of geography, in racial/ethnic groups separately, and by tumor subtypes defined by histology, receptor status and stage at diagnosis. In addition, large cohort studies with geographically dispersed populations (e.g. the California Teachers Study) can incorporate both individual and contextual effects. It would be useful for these types of studies to collect information on places of residence at times other than at diagnosis. Likewise, it would be useful to improve the quality and completeness of birthplace information recorded by the California Cancer Registry, and obtain residential history information on study participants whenever possible.

A recent example of the rich and complex nature of neighborhood information is provided by a recent series of articles in the American Journal of Epidemiology.[184] The authors developed a panel of scales that measured seven dimensions of neighborhood environment, with a focus on cardiovascular disease impact (aesthetic quality, walking environment, availability of healthy foods, safety, violence, social cohesion, and activities with neighbors). Many of these factors were strongly correlated with neighborhood socioeconomic position, but the scales provided additional information that was not captured by economic status alone. There are several potential applications of this approach for breast cancer research. First, the authors demonstrate the importance of investigating neighborhood effects tied to specific underlying causal mechanisms. With respect to breast cancer, potential causal mechanisms including a variety of factors that may exert effects independent of individual or neighborhood SES, including social support (e.g. social cohesion), stress (e.g. safety, violence), physical activity (e.g. availability of sidewalks, parks), social norms (e.g. breastfeeding, age at first pregnancy), and environmental contamination (e.g. pollution, air and water quality). When conducting such studies, alternative definitions of neighborhoods should be investigated using clusters of relevant causal factors rather than relying upon census tracts or predetermined geographical boundaries.[185] Second, the authors demonstrate importance of gathering neighborhood-level information from persons who reside in the same neighborhood as study participants. For example, in a case-control study of breast cancer, interviewing neighbors would avoid differential misclassification associated with relying on information from breast cancer cases and controls. Third, the authors demonstrate the ecometric properties of survey measurements, wherein scale items are nested within individuals

who are nested within neighborhoods. In epidemiologic studies of breast cancer, ecometrics principles could be applied to neighborhoods as well as other social groups (e.g. race, ethnicity, specific age groups) for which group-level information may be relevant to the etiology and progression of breast cancer. For breast cancer studies, considerable time and effort will be required to develop the relevant scales and to assess reliability (test-retest agreement) and validity (ability to capture the underlying construct of interest). Particular attention should be paid to the possibility of structural confounding, the presence of "unmeasured influences that facilitate selection into certain environments and discourage selection into others."[185] To the extent that better, more comprehensive neighborhood measurements are taken, the greater the likelihood for identifying political, economic, historical and social processes that cause breast cancer to cluster in specific geographic areas and among particular groups of persons.

Little research has been conducted on specific attributes of the built environment and breast cancer. With advances in GIS technology, scientists now have the ability to more thoroughly explore the connection between attributes of the built environment and breast cancer. Breast cancer researchers could learn from studies of other health outcomes (e.g. cardiovascular disease, diabetes) and the built environment, where most of this research has been conducted to date. We need to examine the degree to which attributes of the built environment may influence breast cancer risk factors and rates. Studies identifying what aspects of the built environment increase physical activity and reduce obesity may be important, especially since interventions aimed at individuals to reduce obesity and increase physical activity have generally not been successful.

Possibilities for applying GIS-based methods to large-scale population-based ecologic studies are more limited. In their studies of childhood cancer,[186-188] and to a lesser-degree, breast cancer,[28] in California, Reynolds and colleagues have used a number of pre-existing databases to characterize potential ambient exposures to agricultural pesticide use, hazardous air pollutants, and automobile exhaust. Since these methods are based on residential address at diagnosis, applying them to studying breast cancer is somewhat problematic, given the long latency of breast cancer and probable importance of exposures during early life and/or during critical periods of mammary growth and development. Addition of residential history information to the California Cancer Registry could greatly enhance the ability of researchers to evaluate these potential exposures. Furthermore, it could be very informative to create a large, geographically-dispersed, cohort of California women in which these GIS-based methods of exposure assessment could be incorporated with individual-level risk factor information and residential histories. Such an approach is currently being utilized by Dr. Reynolds and colleagues in the California Teachers Study, a large cohort of California school professional employees. This cohort is predominantly white and of higher SES. Creating a more ethnically and socioeconomically diverse cohort would provide a better opportunity to study potential exposures to environmental pollutants.

Future research should also focus on the role of health behavior norms and practices that are influenced by neighborhoods. We need to identify social and cultural norms revolving around childbearing, breast-feeding, physical activity, diet, and other factors that may be amenable to interventions aimed at the neighborhood level. Productive areas for future investigation include how neighborhood context reinforce or perpetuate cultural norms among immigrants; how sources of health information that impact behavior may vary by neighborhoods and SES; and what forms of communication (mixed media, bulletins, etc.) are most effective in empowering group and individual decision making to improve health. Research studies and interventions targeted to specific age groups and neighborhood characteristics are likely to be particularly effective.

A growing number of researchers, community activists, breast cancer advocates, and policy makers have taken a more inclusive view of the environment than the definition traditionally used. This viewpoint, which is based on a framework similar to that of the environmental justice movement, includes "holistically considering the effects that SES and other social factors have on exposures to environmental hazards."[189] Research needs to consider models of cumulative risks and multi-stressors, not just single chemicals or single behavioral risk factors.[16, 18, 26, 189] To achieve this goal, future studies of the neighborhood environment will require collaborations between health researchers, policy makers, geographers, environmental scientists, social scientists, and urban planners. Recent advances in GIS, exposure assessments, and methods for examining social processes provide the basis for productive, interdisciplinary research to elucidate the complex connections between breast cancer and the environment.

Research on neighborhood context and health needs to be planned and evaluated in light of future implications for forming policy and planning interventions. Does failure to detect a neighborhood effect on a breast cancer outcome (after controlling for individual risk factors) mean that the neighborhood context does not matter? Or does it mean that there are some neighborhoods that should be targeted for community-based interventions because they have a greater number or proportion of people with known risk factors?[190] Alternatively, if a strong neighborhood effect is found (even after controlling for individual risk factors), what specific economic and/or social policies are needed to improve outcomes in specific neighborhoods? Especially when strong differences in breast cancer mortality or survival are observed by region, the distribution of resources such as access to quality medical care across neighborhoods needs to be targeted as soon as possible to reduce inequalities that adversely impact breast cancer outcomes.

In discussing the importance of neighborhood effects on health, Diez-Roux[19] reminds us: "Neighborhood differences are not 'naturally' determined but rather result from social and economic processes influenced by specific policies. As such, they are eminently modifiable and susceptible to intervention." By comprehensively examining individual- and neighborhood-level risk factors for breast cancer and determinants of adverse breast cancer

outcomes, the California Breast Cancer Research Program will fill important gaps in previous research, and uncover information critical to the design and implementation of interventions that could have a lasting and significant impact on future generations of women.

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