**University at Albany, State University of New York**
**Scholars Archive**

Epidemiology & Biostatistics Faculty Scholarship

Epidemiology and Biostatistics

2014

# The relationship between area poverty rate and site-specific cancer incidence in the United States

Francis P. Boscoe
*University at Albany, State University of New York*, fboscoe@albany.edu

Christopher J. Johnson
*Cancer Data Registry of Idaho*

Recinda L. Sherman
*University of Miami*

David G. Stinchcomb
*Westat, Inc.*

Ge Lin
*University of Nebraska Medical Center*

*See next page for additional authors*

Follow this and additional works at: http://scholarsarchive.library.albany.edu/epi_fac_scholar

Part of the Epidemiology Commons, and the Neoplasms Commons

## Recommended Citation

**Authors**

Francis P. Boscoe, Christopher J. Johnson, Recinda L. Sherman, David G. Stinchcomb, Ge Lin, and Kevin A. Henry

Original Article

# The Relationship Between Area Poverty Rate and Site-Specific Cancer Incidence in the United States

Francis P. Boscoe, PhD[1]; Christopher J. Johnson, MPH[2]; Recinda L. Sherman, PhD[3]; David G. Stinchcomb, MS[4]; Ge Lin, PhD[5]; and Kevin A. Henry, PhD[6]

**BACKGROUND:** The relationship between socioeconomic status and cancer incidence in the United States has not traditionally been a focus of population-based cancer surveillance systems. **METHODS:** Nearly 3 million tumors diagnosed between 2005 and 2009 from 16 states plus Los Angeles were assigned into 1 of 4 groupings based on the poverty rate of the residential census tract at time of diagnosis. The sex-specific risk ratio of the highest-to-lowest poverty category was measured using Poisson regression, adjusting for age and race, for 39 cancer sites. **RESULTS:** For all sites combined, there was a negligible association between cancer incidence and poverty; however, 32 of 39 cancer sites showed a significant association with poverty (14 positively associated and 18 negatively associated). Nineteen of these sites had monotonic increases or decreases in risk across all 4 poverty categories. The sites most strongly associated with higher poverty were Kaposi sarcoma, larynx, cervix, penis, and liver; those most strongly associated with lower poverty were melanoma, thyroid, other nonepithelial skin, and testis. Sites associated with higher poverty had lower incidence and higher mortality than those associated with lower poverty. **CONCLUSIONS:** These findings demonstrate the importance and relevance of including a measure of socioeconomic status in national cancer surveillance. *Cancer* 2014;120:2191–8. © 2014 The Authors. *Cancer* published by Wiley Periodicals, Inc. on behalf of American Cancer Society. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

**KEYWORDS:** poverty, socioeconomic status, surveillance, incidence, health disparities.

## INTRODUCTION

The ongoing monitoring of the relationship between socioeconomic status (SES) and health is an essential element of public health surveillance. Most diseases and adverse health conditions exhibit an SES gradient, typically with those who are poorer materially having higher morbidity and mortality.[1,2] This gradient has been evident since at least the nineteenth century and is true even in affluent countries and nations with social safety nets designed to limit absolute deprivation.[3,4] For cancer, the picture is particularly complex, as access to health care, utilization of screening, and behavioral and occupational risk factors all exhibit strong influences on incidence rates and are simultaneously associated with SES. This association results in SES gradients in cancer incidence in both directions, depending on the anatomic site. Sites associated with lower SES in the United States include lung,[5-7] colorectal,[6-8] cervical,[6,7,9] oral,[10] and liver[11] and those associated with higher SES include breast,[6,7,12] prostate,[6,7,13] thyroid,[14] and skin.[6,15,16] Although these relationships are well-established, they occupy a specialized niche in the literature and are rarely reported in standard population-based statistics. For example, an interactive Web site published by the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) program features data by cancer site, age, sex, and race/ethnicity, but not SES.[17] A similar Web site from the North American Association of Central Cancer Registries (NAACCR) includes the same variables and adds state within the United States.[18] The most comprehensive review of SES and cancer in the United States remains the monograph by Singh et al from 2003, but this covered only 6 cancer sites (breast, cervical, colorectal, lung, prostate, skin) and is now 10 years old.[19] The relationships between SES and cancer incidence are dynamic, which highlights the need for ongoing

**Corresponding author:** Francis P. Boscoe, PhD, New York State Cancer Registry, 150 Broadway, Suite 361, Albany, NY 12204; Fax: (518) 473-6789; fpb01@health.ny.gov

[1]New York State Cancer Registry, Albany, New York; [2]Cancer Data Registry of Idaho, Boise, Idaho; [3]Department of Public Health Sciences, University of Miami, Miami, Florida; [4]Westat, Inc., Rockville, Maryland; [5]Department of Health Services Research and Administration, University of Nebraska Medical Center, Omaha, Nebraska; [6]Department of Epidemiology, Rutgers School of Public Health and Rutgers Cancer Institute of New Jersey, New Brunswick, New Jersey

surveillance. The most familiar example is lung cancer, where incidence rates lag behind the shifting popularity and social acceptability of smoking among different sectors of the population.[20]

The ubiquity of race/ethnicity data, in contrast, has led to a well-developed literature on racial/ethnic disparities in cancer that creates an impression that this is a more relevant variable than SES. However, to the extent that researchers have tried to disentangle these 2 concepts, SES has proven more robust,[21,22] even as some have argued the 2 are so tightly interwoven as to be inseparable.[23] Indeed, Penner and Saperstein found that 20% of the persons in a long-term longitudinal study changed their racial self-identification at least once, and the changes corresponded to changes in SES.[24]

The shortage of SES reporting within cancer surveillance is driven in part because it is rarely collected by public health data systems. SES is collected by certain surveys, but surveys are not an effective means of ascertaining cancer incidence, both because of the rarity of many cancers and difficulties with accurate self-reporting for many anatomic sites of cancer.[25] Residential address is therefore typically used as a proxy for SES in population-based cancer research. This is not as large a limitation as it may seem at first glance. An area-based SES measures captures conditions that affect all individuals living in the same neighborhood and SES has been shown to be an independent predictor of health outcomes.[26-28] Because of concerns over patient confidentiality, SES assignment is most often performed at the county level, which tends to be problematic, particularly in large urban counties where populations are highly heterogeneous. New York County (Manhattan) is perhaps the most striking example, being classified in the poorest grouping by all commonly used measures despite containing some of the wealthiest neighborhoods in the world. A similar pattern holds in Los Angeles County, Cook County (Chicago), and Miami-Dade County in Florida; just these 4 counties alone account for 1/16th of the US population. County-level analysis has the effect of diminishing or even reversing the apparent relationship between SES and cancer incidence.[29]

Census tracts are defined by a partnership between the US Census Bureau and local authorities prior to each decennial census and are intended to include a relatively homogeneous population group of approximately 4000 people. Thus, tract-level SES measures do not tend to have the same heterogeneity issues as county-level SES measures. Although neighborhood factors that impact health do not necessarily follow predefined areal units,[30] because tracts are intended to be homogeneous populations, SES measures at the tract-level should minimize this issue.

Here, we report on the results of an effort to bring SES into the mainstream of cancer surveillance in the United States, using the census-tract level poverty rate as the measure of SES. Poverty rate is one of several measures, along with income, education, and occupational category, often used to measure SES in US health studies.[20] It was selected here as the sole SES indicator available. Beginning in 2011, US registries were encouraged to assign a code to each cancer diagnosis based on the poverty level of the census tract of residence at the time of diagnosis, retroactive to 1995. The code was intentionally simple, consisting of 5 categories: poverty rates of $< 5\%$, 5% to $< 10\%$, 10% to $< 20\%$, $\geq 20\%$, and unknown. One reason for this simplicity was to ensure that an individual census tract could not be identified based on the code, as some registries consider the release of a census tract to potentially enable individual identification when combined with other available demographic and clinical information. Each of the state and regional registries contributing to national cancer statistics have multiple census tracts that fall into each of the above categories. A second reason for this choice of code values was to conform with recommendations from prior research in this area.[19,28,31] The SES gradients presented here are, to our knowledge, the most detailed published for the United States, in terms of both the breadth of anatomic sites and geographic coverage.

## MATERIALS AND METHODS
### Incidence and Mortality Data
We obtained cancer incidence data from NAACCR for 16 states (Arizona, Colorado, Connecticut, Florida, Georgia, Hawaii, Idaho, Iowa, Louisiana, Minnesota, New Hampshire, New Jersey, New York, Texas, Utah, West Virginia) and Los Angeles County, California for diagnosis years 2005 through 2009. These areas cover 42% of the US population, defined as the 50 states plus the District of Columbia, as measured by the 2010 census. Each of these registries was certified by the NAACCR for data completeness and timeliness at the gold or silver level for these years.[32] Each registry consented to the use of its data for this project, and the project was reviewed and approved by NAACCR's Institutional Review Board. Cancer mortality data for the same states were obtained from SEER.[33]

The analysis included 2.9 million malignant tumors categorized by age (5-year age groups 0-4 through 80-84,

then 85+), sex, race/ethnicity (white, black, American Indian/Alaska Native [AI/AN], Asian/Pacific Islander [API], and Hispanic), poverty category, and anatomic site (39 distinct sites and 3 site groupings). We included all sites for which the SEER program has published Cancer Stat Fact Sheets,[34] plus several other sites of particular interest. Together these accounted for 99.1% of all reported malignant cancers. The number of tumors per site ranged from approximately 2000 (vagina) to 436,000 (prostate). Equivalent International Classification of Diseases for Oncology, Third Edition (ICD-O-3) codes for the included sites can be found on the SEER web site.[35] The HPV-related cancer category combined penis, vagina, vulva, cervix, anus, and the oral cancer subsites nasopharynx, oropharynx, hypopharynx, and tonsil. The tobacco-related cancer category combined oral cavity and pharynx, esophagus, larynx, lung and bronchus, and urinary bladder. The "all sites combined" category also included the 0.9% of cancers not counted in one of the site categories.

### Populations

We used custom single-year sex and age-specific census-tract level populations developed by Woods & Poole, Inc. for the use of the SEER program. These populations used the same 2000 census definitions as the geocoded cancer cases but were informed by both the 2000 and 2010 censuses. Among other advantages, these populations were able to reflect a number of large, upscale retirement communities that were constructed after 2000.

The Woods & Poole populations did not include information on race/ethnicity. To obtain this, we applied the census-tract level race/ethnicity proportions from the 2010 census (Summary File 1, Tables PCT12H-PCT12O) to the Woods & Poole estimates, using a 2010-to-2000 census tract crosswalk obtained from Geo-Lytics, Inc. The census tables contain 14 race/ethnicity categories (white, black, AIAN, Asian, Native Hawaiian or other Pacific Islander, multiple, and some other race, each cross-tabulated by both Hispanic and non-Hispanic), which we consolidated into the same 5 categories as the cases. To achieve this, all Hispanic groups were combined into a single Hispanic category, Asians and Native Hawaiians/Pacific Islanders were combined as API, non-Hispanics of multiple race were assigned to 1 of the 4 non-Hispanic groups based on the proportion of these groups in each census tract, and non-Hispanics of some other race were assigned to either AIAN or API based on the proportion of these 2 groups in each census tract. The latter choice was made because these persons tend to have origins in Central and South Asia and

Central and South America. The multiple race and other race groups represented a very small proportion of the total population, 2.0% and 0.2%, respectively.

### Poverty

All cases were geocoded by the individual registries to 2000 census tracts and a census tract poverty level was assigned to each case based on the percentage of individuals living below the poverty level according to the 2005-2009 American Community Survey (ACS). The poverty categories used were < 5%, 5%-< 10%, 10%-< 20%, and ≥ 20%. Approximately 3% of the cases did not have census tracts and/or poverty levels assigned and were excluded from the analysis. Geocoding rates tended to be lower in states with larger shares of post office box or rural route addresses, and also for cases diagnosed in 2008 and 2009, reflecting the fact that geocoding is an ongoing and labor-intensive process. Sensitivity analyses were performed excluding various state/year combinations with poorer geocoding, but had no effect on the results at our reported precision (data from this and subsequent sensitivity analyses are not shown). For reasons of confidentiality protection, we did not have access to the actual census tract for each patient.

We used the ACS 2005 to 2009 poverty variable because it is the sole source of small-area poverty data that corresponds to our study period. However, the 5-year combined ACS sample is not as large as the 2000 census long form, and has a larger margin of error for its point estimates. We conducted sensitivity analyses comparing results from error in covariates models for the ACS poverty estimates with results from models that consider the ACS poverty estimates to be known, and found the estimates of risk to have 95% confidence intervals that were nearly entirely overlapping. Furthermore, the potential impact of SES misclassification due to ACS estimates is ameliorated by our use of 4 poverty categories and by grouping results for the entire study population. Nonetheless, for individual census tracts, there may be sizable differences between the actual poverty rate and that estimated via the ACS given the high sampling error in the ACS estimates.[36]

### Cancer Rates

We calculated site- and sex-specific, age-adjusted rates stratified by the 4 poverty categories, both stratifying and adjusting for race/ethnicity. We determined whether a monotonic increase or decrease in cancer rates was seen across the 4 poverty categories by comparing the magnitude of the point estimates in each category for each site/sex combination, and calculated the risk ratios of the

highest to lowest poverty category. As a validity check, we also tested for trend across the poverty categories using Poisson regression. Once the cancer sites associated with poverty were identified, we compared the age-adjusted incidence and mortality rates for these groups of sites.

All cancer rate calculations were performed using SEER*Stat (version 8.0.1). Statistical analysis was conducted using R (version 3.0.0) and the SAS (version 9.3) GLIMMIX procedure, and the error in covariates sensitivity analysis was conducted using WinBUGS; the code is available from the authors by request.

## RESULTS

Figure 1 presents the sex-specific risk ratios of the highest to lowest residential poverty category for each cancer site. A majority of cancer sites show a significant relationship with poverty rate. Twenty-four of the 31 sites for which there are data for both sexes have a 95% confidence interval that excludes unity, as do all 8 of the sex-specific sites. Fourteen of these 32 sites are associated with higher poverty and 18 are associated with lower poverty. HPV and tobacco-related cancers are also associated with higher poverty. The sites most strongly associated with higher poverty are Kaposi sarcoma, larynx, cervix, and penis; those most strongly associated with lower poverty are melanoma, thyroid, and other nonepithelial skin. Sites with monotonic increases or decreases across all 4 poverty categories are indicated with symbols. Thirteen of the 31 sites for which there are data for both sexes show monotonic increases or decreases, along with 6 of the sex-specific sites. Adjusting for age and race, cancer incidence differed significantly by poverty category for nearly all sex-site combinations; the only exceptions were bone and joint, eye and orbit among females, and nasal cavity among females. This analysis included instances where the relationship between poverty and incidence was not monotonic, and the interpretation of such patterns may be less clear.

For all sites and both sexes combined, the difference in risk between the greatest and lowest poverty category is less than 2%, suggesting that the individual site-specific risks effectively cancel one another out. The sites that are associated with higher poverty, however, tend to be much more lethal. These sites have an age-adjusted incidence of 159.1 per 100,000 and age-adjusted mortality of 107.7 per 100,000 for diagnosis years 2005 to 2009. The sites associated with lower poverty have an incidence rate of 260.3 per 100,000 and a mortality rate of 68.9. These figures exclude the rare sites Kaposi sarcoma and mesothelioma, which were not included in our source of mortality data.[33]

On the whole, male rates were more sensitive to poverty level than female rates: of the 7 sites for which males and females have nonoverlapping confidence intervals (liver and interhepatic bile duct, miscellaneous, lung and bronchus, anus, colon and rectum, oral cavity and pharynx, kidney), males have the higher risk for all but kidney. This finding is also evidenced by the slight differences between sexes for all sites combined.

The above findings are net of any race/ethnicity effects. Race/ethnicity-stratified results further illustrate that poverty is an independent predictor of cancer incidence. This relationship is seen in Figure 2, which contrasts differences between blacks and whites for 4 cancer sites. In general, although the race-specific incidence rates tend to differ, the poverty gradients are similar. For melanoma in particular, a site for which there is a biological component driving differences between race groups, there is about a 20-fold difference in rates between whites and blacks, but the relationship between poverty and incidence remains. Hodgkin lymphoma, in contrast, is notable because the poverty gradients do differ by race.

## DISCUSSION

We have presented what is to our knowledge the most comprehensive assessment of the relationship between SES and cancer incidence for the United States. There is a negligible relationship between local poverty rate and cancer incidence overall, but 32 of 39 individual cancer sites show such an association, with 14 sites associated with higher poverty and 18 sites associated with lower poverty. This includes 19 sites with stronger evidence of a relationship as indicated by a monotonic increase or decrease across all 4 poverty categories. The combined categories of HPV-associated and tobacco-associated cancers also are positively associated with poverty.

In general, cancer sites associated with behavioral risk factors such as tobacco, alcohol and intravenous drug use, sexual transmission, and poor diet tend to be associated with higher poverty. In contrast, cancer sites associated with overdiagnosis are associated with lower poverty, notably skin, thyroid, and prostate. Overdiagnosis refers to the clinical detection of asymptomatic tumors, often through advanced medical technology, that would otherwise remain undetected and uncounted. Many of these relationships are well established, but others have received limited attention because of their rarity, and others have been obscured as a consequence of using county as the level of analysis. For example, Jemal et al reported "no striking socioeconomic status disparities" for HPV-associated cancers beyond cervical, penile and anal among
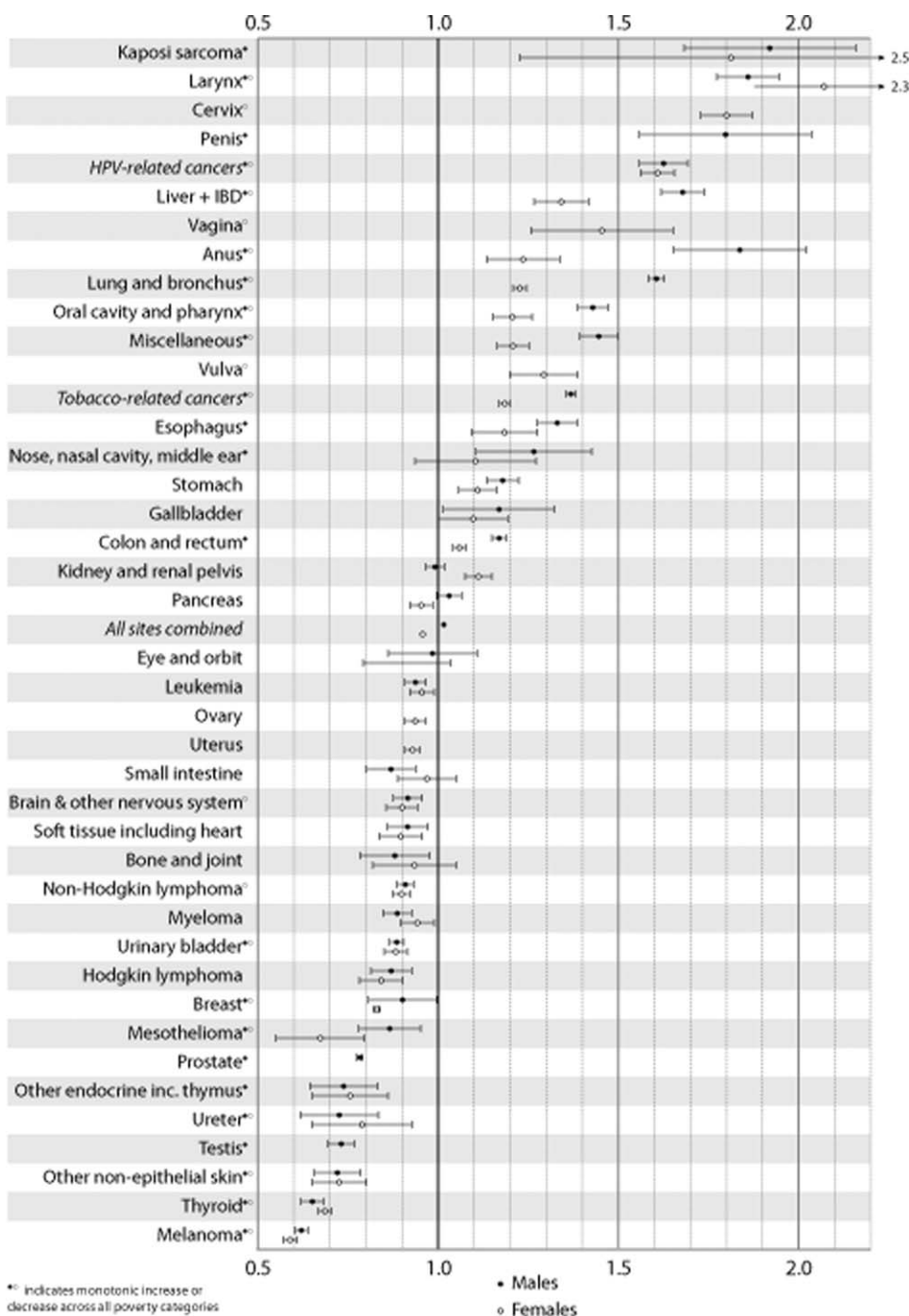
**Figure 1.** Risk ratios of cancer incidence between highest and lowest poverty category, United States, 2005 through 2009. IBD indicates inflammatory bowel disease.

men,[37] whereas in the current study using census tract poverty measures such a relationship is seen for every HPV-related site.

Our results are consistent with those reported by Clegg et al,[6] who used individual-level poverty as obtained through the National Longitudinal Mortality Study.

The point estimates of the high-to-low poverty category risk ratios reported here agree within 1 decimal place for lung, colorectal, prostate, breast, and melanoma, which is all the more remarkable considering their study contained less than 1/200th the number of cases for comparable sites. The only possible exception was for cervix where the
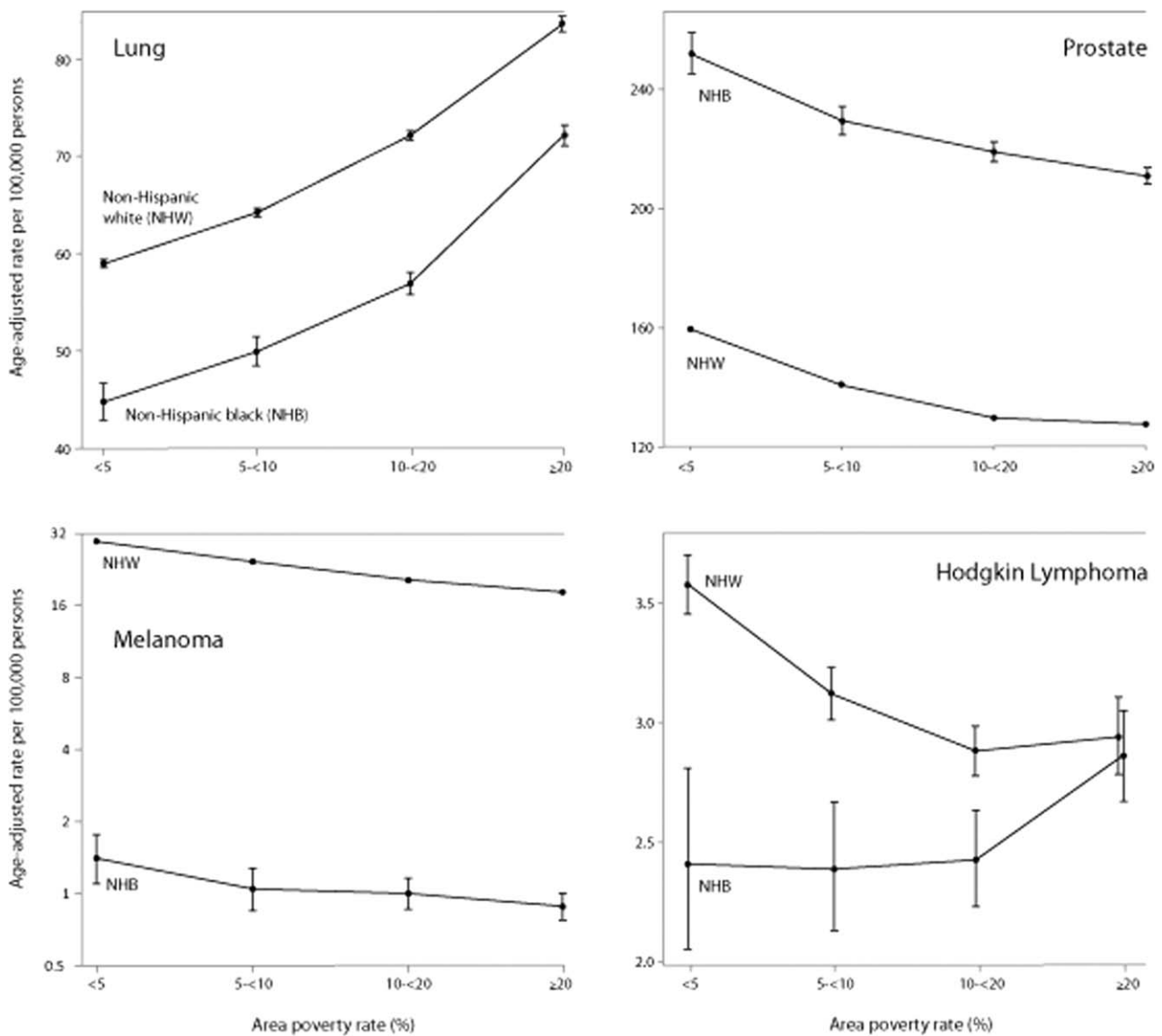
**Figure 2.** Race-specific cancer rates by poverty category, non-Hispanic whites and non-Hispanic blacks, both sexes combined except for prostate. (A) Lung and bronchus, (B) prostate, (C) melanoma, and (D) Hodgkin lymphoma. For (C), a logarithmic scale was used for clarity, and confidence intervals for non-Hispanic whites were smaller than the point symbol used.

results from Clegg et al suggest a stronger poverty gradient, though based on only 116 cases.[6] Although individual and area SES are widely accepted as representing different dimensions of risk,[26,27] in the case of cancer incidence this difference may be less critical. If so, the design of the present study has the advantage of using population-based data collected as part of ongoing, routine cancer surveillance that does not require contacting patients or linking to individual-level surveys.

The SES effects we report are independent of race, as race was adjusted for in the analysis. This is further illustrated by the graph of race-stratified results for selected

sites (Fig. 2). To our knowledge, race-specific poverty gradients for melanoma have not previously been reported because of the rarity of this disease among nonwhites; more commonly, melanoma reporting is restricted to white non-Hispanics.[6,15,16] More detailed analysis of race-stratified results will be the focus of future work, building on other research that has consistently found independent race and SES effects in cancer incidence.[38-40]

Although use of the official US government–defined poverty rate has a long history in the field of cancer epidemiology, it does have many critics, who focus on its failure to incorporate noncash income, among many other

issues.[41] There could very well exist an alternative measure of poverty or deprivation that would reveal a clearer relationship with cancer. However, because many of the problems with poverty definition and measurement would likely result in random misclassification, any bias in our results should be toward the null. A further limitation is that because we did not know the identities of the census tracts, only their poverty categories, we were unable to add spatial effects to our models. Disease rates in areas that are geographically proximate are often correlated, and spatially correlated observations do not satisfy the assumption of independence. Ignored, residual spatial correlation may bias estimates of parameters and lead to underestimated standard errors.[42] However, because we aggregated data by poverty category over the states in the study, this limitation is not as likely to be relevant than had we used census tract as the unit of analysis. Information on the specific behavioral risk factors (smoking, HPV status, and so forth) of each cancer patient would have informed our results, but such information is not typically collected by central cancer registries.

In addition to the race-specific analysis mentioned above, we also intend to investigate SES gradients by stage at diagnosis. For a site with a positive screening effect such as colorectal cancer, we might reasonably hypothesize that earlier stage cancers would be less associated with higher poverty than later stage cancers, because access to and use of health care is itself related to SES. We also intend to investigate the extent to which the cancer-SES relationships vary meaningfully between states. Because NAACCR has elevated the census tract poverty indicator to a required, as opposed to optional, data item for central cancer registries beginning with cases diagnosed in 2014, the number of states available for analysis is expected to grow appreciably. This action will help ensure that data on SES will be more readily available to researchers in US cancer surveillance data sources.

## FUNDING SUPPORT

## CONFLICT OF INTEREST DISCLOSURES

The authors made no disclosures.

## REFERENCES

1. Syme SL. Social and economic disparities in health: thoughts about intervention. *Milbank Q.* 1998;76:493-505.
2. Syme SL. Reducing racial and social-class inequalities in health: the need for a new approach. *Health Aff (Millwood).* 2008;27:456-459.
3. McLaren G, Bain M. *Deprivation and Health in Scotland: Insights from NHS Data.* Edinburgh, UK: Information Statistics Division, National Health Service in Scotland; 1998.
4. Adler NE, Boyce WT, Chesney MA, Folkman S, Syme LS. Socioeconomic inequalities in health: no easy solution. *JAMA.* 1993;269:3140-3145.
5. Sidorchuk A, Agardh EE, Aremu O, Hallqvist J, Allebeck P, Moradi T. Socioeconomic differences in lung cancer incidence: a systematic review and meta-analysis. *Cancer Causes Control.* 2009;20:459-471.
6. Clegg LX, Reichman ME, Miller BA, et al. Impact of socioeconomic status on cancer incidence at diagnosis: selected findings from the surveillance, epidemiology and end results: National Longitudinal Mortality Study. *Cancer Causes Control.* 2009;20:417-435.
7. Singh GK, Williams SD, Siahpush M, Mulhollen A. Socioeconomic, rural-urban, and racial inequalities in US cancer mortality: part I-all cancers and lung cancer and part II-colorectal, prostate, breast, and cervical cancers. *J Cancer Epidemiol.* 2011;2011:107497.
8. Aarts MJ, Lemmens VE, Louwman MW, Kunst AE, Coebergh JW. Socioeconomic status and changing inequalities in colorectal cancer? A review of the associations with risk, treatment and outcome. *Eur J Cancer.* 2010;46:2681-2695.
9. Benard VB, Johnson CJ, Thompson TD, et al. Examining the association between socioeconomic status and potential human papillomavirus-associated cancers. *Cancer.* 2008;113:2910-2918.
10. Johnson S, McDonald JT, Corsten MJ. Socioeconomic factors in head and neck cancer. *J Otolaryngol Head Neck Surg.* 2008;37:597-601.
11. Shebl FM, Capo-Ramos DE, Graubard BI, McGlynn KA, Altekruse SF. Socioeconomic status and hepatocellular carcinoma in the United States. *Cancer Epidemiol Biomarkers Prev.* 2012;21:1330-1335.
12. Klassen AC, Smith KC. The enduring and evolving relationship between social class and breast cancer burden: a review of the literature. *Cancer Epidemiol.* 2011;35:217-234.
13. Cheng I, Witte JS, McLure LA, et al. Socioeconomic status and prostate cancer incidence and mortality among the diverse population of California. *Cancer Causes Control.* 2009;20:1431-1440.
14. Li N, Reitzel LR, Xu L, Sturgis EM. Impact of enhanced detection on the increase in thyroid cancer incidence in the United States: review of incidence trends by socioeconomic status within the Surveillance Epidemiology, and End Results Registry, 1980-2008. *Thyroid.* 2013;23:103-110.
15. Clarke CA, Moy LM, Swetter SM, Zadnick J, Cockburn MG. Interaction of area-level socioeconomic status and UV radiation on melanoma occurrence in California. *Cancer Epidemiol Biomarkers Prev.* 2010;19:2727-2733.
16. Singh SD, Ajani UA, Johnson CJ, et al. Association of cutaneous melanoma incidence with area-based socioeconomic indicators–United States, 2004-2006. *J Am Acad Dermatol.* 2011;65:S58.e1-e12.
17. National Cancer Institute, Surveillance Epidemiology and End Results (SEER) Program. Fast Stats: An interactive tool for access to SEER cancer statistics. http://seer.cancer.gov/faststats. Accessed August 2, 2013.
18. North American Association of Central Cancer Registries. NAACCR Fast Stats: An interactive tool for quick access to key NAACCR cancer statistics. http://www.naaccr.org/ Accessed August 2, 2013.
19. Singh GK, Miller BA, Hankey BF, Edwards BK. *Area Socioeconomic Variations in U.S. Cancer Incidence, Mortality, Stage, Treatment, and Survival, 1975-1999.* NCI Cancer Surveillance Monograph Series, Number 4. NIH Publication No. 03-5417. Bethesda, MD: National Cancer Institute; 2003.
20. Williams DR, Kontos EZ, Viswanath K, et al. Integrating multiple social statuses in health disparities research: the case of lung cancer. *Health Serv Res.* 2012;47:1255-1277.
21. Pollack CE, Chideya S, Cubbin C, Williams B, Dekker M, Braveman P. Should health studies measure wealth? A systematic review. *Am J Prev Med.* 2007;33:250-264.

22. Do DP, Frank R, Finch BK. Does SES explain more of the black/white health gap than we thought? Revisiting our approach to understanding racial disparities in health. *Soc Sci Med*. 2012;74:1385-1393.

23. Kagawa-Singer M, Dadia AV, Yu MC, Surbone A. Cancer, culture and health disparities: time to chart a new course? *CA Cancer J Clin*. 2010;60:12-39.

24. Penner AM, Saperstein A. How social status shapes race. *Proc Natl Acad Sci U S A*. 2008;105:19628-19630.

25. Parikh-Patel A, Allen M, Wright ME, California Teachers Study Steering Committee. Validation of self-reported cancers in the California Teachers Study. *Am J Epidemiol*. 2003;157:539-545.

26. Robert S. Socioeconomic position and health: the independent contribution of community socioeconomic context. *Ann Rev Sociol*. 1999;25:489-516.

27. Diez Roux AV, Merkin SS, Arnett D, et al. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med*. 2001; 345:99-106.

28. Gomez SL, Glaser SL, McClure LA, et al. The California Neighborhoods Data System: a new resource for examining the impact of neighborhood characteristics on cancer incidence and outcomes in populations. *Cancer Causes Control*. 2011;22:631-647.

29. Boscoe FP. Towards the use of a census tract poverty indicator variable in cancer surveillance. *J Registry Manag*. 2010;37:148-151.

30. Kwan MP. The uncertain geographic context problem. *Ann Assoc Am Geogr*. 2012;102:958-968.

31. Krieger N, Chen JT, Waterman PD, Rehkopf DH, Subramanian SV. Race/ethnicity, gender, and monitoring socioeconomic gradients in health: a comparison of area-based socioeconomic measures–the public health disparities geocoding project. *Am J Public Health*. 2003;93:1655-1671.

32. Copeland G, Lake A, Firth R, et al, eds. *Cancer in North America: 2005-2009. Volume One: Combined Cancer Incidence for the United States, Canada and North America*. Springfield, IL: North American Association of Central Cancer Registries, Inc.; 2012.

33. National Cancer Institute. Surveillance, Epidemiology, and End Results (SEER) Program. SEER*Stat Database: Mortality - All COD, Aggregated With State, Total U.S. (1969-2010), Katrina/Rita Population Adjustment. Bethesda, MD: National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch; 2013.

34. National Cancer Institute. Surveillance Epidemiology and End Results (SEER) Program. Cancer stat fact sheets. http://seer.cancer.gov/statfacts/. Accessed September 12, 2013.

35. National Cancer Institute. Surveillance Epidemiology and End Results (SEER) Program. Site recode ICD-O-3 (1/27/2003) definition. http://seer.cancer.gov/siterecode/icdo3_d01272003/. Accessed September 12, 2013.

36. Bazuin JT, Fraser JC. How the ACS gets it wrong: the story of the American Community Survey and a small, inner city neighborhood. *Appl Geogr*. 2013;45:292-302.

37. Jemal A, Simard EP, Dorell C, et al. Annual Report to the Nation on the Status of Cancer, 1975-2009, featuring the burden and trends in human papillomavirus (HPV)-associated cancers and HPV vaccination coverage levels. *J Natl Cancer Inst*. 2013;105:175-201.

38. Krieger N, Quesenberry C, Peng T, et al. Social class, race/ethnicity, and incidence of breast, cervix, colon, lung, and prostate cancer among Asian, Black, Hispanic, and White residents of the San Francisco Bay Area, 1988-92 (United States). *Cancer Causes Control*. 1999;10:525-537.

39. Yin D, Morris C, Allen M, Cress R, Bates J, Liu L. Does socioeconomic disparity in cancer incidence vary across racial/ethnic groups? *Cancer Causes Control*. 2010;21:1721-1730.

40. Steinbrecher A, Fish K, Clarke CA, West DW, Gomez SL, Cheng I. Examining the association between socioeconomic status and invasive colorectal cancer incidence and mortality in California. *Cancer Epidemiol Biomarkers Prev*. 2012;21:1814-1822.

41. Blank RM. Presidential address: how to improve poverty measurement in the United States. *J Policy Analysis Manage*. 2008;27:233-254.

42. Mohebbi M, Wolfe R, Jolley D. A poisson regression approach for modelling spatial autocorrelation between geographically referenced observations. *BMC Med Res Methodol*. 2011;11:133.