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Persistent Poverty and Cancer Mortality Rates: An Analysis of County-Level Poverty Designations

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ABSTRACT

Background: Cancer mortality is higher in counties with high levels of (current) poverty, but less is known about associations with persistent poverty. Persistent poverty counties (with ≥20% of residents in poverty since 1980) face social, structural, and behavioral challenges that may make their residents more vulnerable to cancer.

Methods: We calculated 2007 to 2011 county-level, age-adjusted, and overall and type-specific cancer mortality rates (deaths/100,000 people/year) by persistent poverty classifications, which we contrasted with mortality in counties experiencing current poverty (≥20% of residents in poverty according to 2007–2011 American Community Survey). We used two-sample *t* tests and multivariate linear regression to assess mortality by persistent poverty, and compared mortality rates across current and persistent poverty levels.

Results: Overall cancer mortality was 179.3 [standard error (SE) = 0.55] deaths/100,000 people/year in nonpersistent poverty counties and 201.3 (SE = 1.80) in persistent poverty counties (12.3% higher, $P < 0.0001$). In multivariate analysis, cancer mortality was higher in persistent poverty versus nonpersistent poverty counties for overall cancer mortality as well as for several type-specific mortality rates: lung and bronchus, colorectal, stomach, and liver and intrahepatic bile duct (all $P < 0.05$). Among counties experiencing current poverty, those counties that were also experiencing persistent poverty had elevated mortality rates for all cancer types as well as lung and bronchus, colorectal, breast, stomach, and liver and intrahepatic bile duct (all $P < 0.05$).

Conclusions: Cancer mortality was higher in persistent poverty counties than other counties, including those experiencing current poverty.

Impact: Etiologic research and interventions, including policies, are needed to address multilevel determinants of cancer disparities in persistent poverty counties.

Introduction

Cancer is the second leading cause of death among men and women in the United States (1). Over the last several decades, advances in cancer prevention, diagnosis, and care have resulted in improved early detection tests, lower cancer mortality, higher survival rates, and overall better outcomes for patients (2, 3). Despite these advances, disparities continue to exist across the cancer control continuum among people living in poverty (2). Individual-level poverty is associated with substantial cancer risk (4) because of increased exposure to carcinogens, low educational attainment, and lack of access to care (2, 5) In addition, people living in poverty have high rates of cancers caused by occupational, recreational, or lifestyle exposures (e.g., colorectal, laryngeal, liver, and lung) and by human papillomavirus infection (e.g., anal, cervical, and oral; refs. 2, 3, 5, 6).

Many studies use area-level measures of poverty (e.g., at the county level) to (1) approximate individual-level poverty, despite concerns raised with the validity of such a practice (7), as well as (2) reflect some dimension of the social and physical environment in which people live (8). The most common area-level definition used in such studies is "≥20% of population living in poverty" (refs. 2, 5, 6, 9; i.e., current poverty). However, additional definitions exist, including persistent poverty (10), which is defined as "≥20% of population living in poverty since 1980" (11, 12).

Persistent poverty counties represent an important subgroup of counties experiencing current poverty over time, yet little empirical research has investigated the impact that the duration of time over which these counties have experienced high levels of poverty has on disease burden. Warnecke and colleagues (13) suggest that health disparities are the result of social, institutional, physical, individual, and biological factors, which impact health directly, indirectly, and interactively. Several of these factors vary for persistent poverty versus other counties, even when compared with other counties experiencing current poverty. Compared with other areas, persistent poverty counties have greater minority populations, more children under the age of 18, less formal education, and greater unemployment (12, 14, 15). In addition, residents of these counties face greater exposure to cancer risk factors [e.g., higher rates of obesity (14) as well as cigarette smoking, sun exposure, alcohol consumption, and human papillomavirus infection (16)]. Little research is available to help understand the environmental and multilevel influences on health that could vary for persistent poverty counties versus other counties. However, differences in social and health policies, institutional resources and access, social support, and issues around embodiment (17) of social inequity into physical inequity may negatively impact health in persistent poverty counties (13, 18, 19). Understanding the burden of mortality from cancer (overall and from selected cancer sites) in counties experiencing persistent poverty can provide insight into potential causal mechanisms linking county-level poverty and other contextual factors to health outcomes and cancer disparities.

This study will examine (overall and type-specific) cancer mortality rates for persistent poverty counties versus nonpersistent poverty counties. In addition, this study will compare poverty-related disparities in mortality rates for three mutually exclusive groups: (i) not

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experiencing current poverty, (ii) experiencing current but not persistent poverty, and (iii) experiencing current and persistent poverty. These analyses will identify potential differences in conclusions based on these definitions. The findings of this study can motivate future studies to further examine persistent poverty and its relation to cancer, and to identify potential causal mechanisms and help inform and locate future interventions to reduce cancer disparities.

Materials and Methods

Data sources and measures

Cancer mortality

Data on county-level cancer mortality came from the National Center for Health Statistics (NCHS), accessed through SEER*Stat (NCI; ref. 20). NCHS links data from the National Death Index with population estimates to calculate age-adjusted mortality rates from a variety of causes, including cancer. From NCHS, we gathered 2007 to 2011 age-adjusted mortality rates for each county in the United States for (i) all cancer types and for highly prevalent cancer types: (ii) lung and bronchus, (iii) colorectal, (iv) breast, and (v) prostate; and for selected infection-associated cancer types: (vi) cervical, (vii) oropharyngeal, (viii) stomach, and (ix) liver and intrahepatic bile duct cancers. Mortality rates were calculated as number of deaths per 100,000 people, except for breast and cervical cancers (calculated as deaths per 100,000 females) and prostate cancer (calculated as deaths per 100,000 males).

Poverty definitions

The first definition of county-level poverty was persistent poverty (our focal poverty classification). The U.S. Department of Agriculture (USDA) defines counties as experiencing persistent poverty if they had ≥20% of residents classified as poor (i.e., below the federal poverty level) by the decennial censuses in 1980, 1990, and 2000, and by the American Community Survey's (ref. 21; ACS) 5-year (2007–2011) estimates (10). The second definition was current poverty (2, 5, 6, 9), that is, if counties had ≥20% of residents below the federal poverty level according to the ACS 5-year (2007–2011) estimates.

Sociodemographics

To characterize each group of counties, we gathered total population (from ACS 2007–2011; ref. 21), metropolitan status (from the USDA's rural–urban continuum codes; ref. 22), Census region, sex and racial/ethnic compositions, levels of educational attainment, unemployment rate, and median household income in $1,000s (from ACS 2007–2011 estimates; ref. 21).

Statistical analysis

First, we generated descriptive statistics for the sociodemographic variables to characterize (i) all U.S. counties, (ii) all nonpersistent poverty counties, and (iii) persistent poverty counties.

Our primary inferential analysis assessed differences in cancer mortality rates for counties experiencing persistent poverty versus counties not experiencing persistent poverty (i.e., mutually exclusive groups covering all U.S. counties). This approach is most similar to existing studies examining disparities in cancer burden associated with (current) area-level poverty. We calculated the mean and standard error (SE) of the county-level mortality rates (for all cancers and for each cancer type under study) separately for nonpersistent poverty counties and for persistent poverty counties. We used two-sample *t* tests to evaluate unadjusted differences in the cancer mortality rates across persistent poverty groups. Next, we conducted multivariate linear regression to estimate adjusted differences in cancer mortality, controlling for county-level metropolitan status, Census region, percent of residents that are female, racial/ethnic composition, education levels, unemployment, and median household income (these variables were considered potential confounders).

Then, we contrasted mortality rates across three mutually exclusive groups of counties that cover the entire United States: counties defined as (i) not experiencing current poverty, (ii) experiencing current but not persistent poverty, and (iii) experiencing current and persistent poverty. This approach provides insight into distinctions between definitions of poverty; that is, by examining whether and to what extent persistent poverty counties differ from current (but not persistent) poverty counties and from counties not experiencing current poverty, we can generate evidence to identify these counties as a vulnerable setting deserving of additional etiologic and intervention research. We generated the mortality rates for these three types of counties to allow for descriptive comparisons. In addition, we conducted two-sample *t* tests and multivariate linear regression to assess unadjusted and adjusted (respectively) differences in cancer mortality between currently impoverished counties that were nonpersistent poverty (group 2) versus currently impoverished counties that were also persistent poverty (group 3).

Analyses used a two-sided P value of 0.05. Per federal regulations, this project was exempt from review by an institutional review board because it involved secondary analysis of publicly available, deidentified datasets.

Results

A total of 395 counties were defined as experiencing persistent poverty (**Table 1**), representing 20,668,553 residents. Persistent poverty counties were primarily rural (83.0%) and concentrated in the Southern Census region (79.2%). Persistent poverty counties were demographically distinct from nonpersistent poverty counties ($P < 0.05$ for all comparisons between persistent poverty and nonpersistent poverty counties for variables in **Table 1**). Compared with other counties in the United States, persistent poverty counties had lower percentages of non-Hispanic white residents (mean = 56.6% vs. 81.6% in nonpersistent poverty counties; $P < 0.0001$) and higher percentages of non-Hispanic black residents (mean = 24.7% vs. 6.6%; $P < 0.0001$) and Hispanic residents (mean = 10.8% vs. 7.7%; $P < 0.01$), with lower percentages of residents who obtained a high school or bachelor's degree (both $P < 0.0001$). In addition, median household income was almost one-third lower in persistent poverty counties [mean = $32,339; median = $32,156; interquartile range (IQR) = $28,705–$36,020] versus nonpersistent poverty counties (mean = $47,154; median = $44,745; IQR = $39,883–$51,440; $P < 0.0001$).

In 2007–2011, a total of 871 counties were classified as experiencing current poverty, comprised of 395 persistent poverty counties and 476 experiencing current but not persistent poverty. These subgroups of current poverty counties (i.e., also experiencing persistent poverty vs. not also experiencing persistent poverty) were demographically similar to each other (all $P > 0.05$ for all comparisons).

Comparing cancer mortality rates for persistent poverty counties versus nonpersistent poverty counties

For the whole United States, the 2007 to 2011 overall cancer mortality rate was 182.1 (SE = 0.6) deaths per 100,000 people per year. This figure was 179.3 (SE = 0.6) in nonpersistent poverty counties and 201.3 (SE = 1.8) in persistent poverty counties, indicating that overall cancer mortality was 12.3% higher in persistent poverty

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Table 1. Descriptive statistics for counties in the United States by poverty characteristics, 2007–2011.

	All United States ($k = 3{,}143$)			Nonpersistent poverty ($k = 2{,}748$)			Persistent poverty ($k = 395$)			
	N	%		*N*	%		*N*	%		*P*
Metropolitan status										<0.0001
Nonmetropolitan	1,976	62.8		1,648	60.0		328	83.0		
Metropolitan	1,167	37.1		1,100	40.0		67	17.0		
Census region										<0.0001
Northeast	217	6.9		214	7.8		3	0.8		
Midwest	1,055	33.6		1,012	36.8		43	10.9		
South	1,423	45.3		1,110	40.4		313	79.2		
West	448	14.3		412	15.0		36	9.1		
	Mean	**Median**	**IQR**	**Mean**	**Median**	**IQR**	**Mean**	**Median**	**IQR**	***P***
% of residents that are female	50.0	50.5	(49.6–51.2)	50.0	50.5	(49.6–51.1)	50.3	50.7	(49.6–51.9)	0.03
Racial/ethnic composition										
% Non-Hispanic white	78.5	85.8	(67.3–94.2)	81.6	87.4	(72.9–94.5)	56.6	55.4	(37.1–76.8)	<0.0001
% Non-Hispanic black	8.8	2.0	(0.5–10.1)	6.6	1.7	(0.5–7.9)	24.7	22.7	(0.8–43.5)	<0.0001
% Hispanic	8.1	3.2	(1.5–8)	7.7	3.4	(1.7–8.2)	10.8	1.9	(0.9–5.3)	<0.01
Education levels										
% High school degree or higher	83.7	85.2	(79.2–89.1)	85.0	86.1	(81.2–89.5)	74.7	74.7	(70.4–79.1)	<0.0001
% Bachelor's degree or higher	19.3	17.1	(13.3–22.8)	20.0	17.8	(14.1–23.5)	14.3	12.2	(10.1–15.6)	<0.0001
% Unemployed	8.1	7.9	(5.8–10.0)	7.6	7.5	(5.6–9.6)	11.5	10.9	(8.6–13.5)	<0.0001
Household income, $1,000s	45.3	43.4	(37.8–50.2)	47.2	44.7	(39.9–51.4)	32.3	32.2	(28.7–36.0)	<0.0001

Note: *P* values indicate results of χ^2 tests (for metropolitan status and Census region) and two-sample *t* tests comparing demographic characteristics for nonpersistent poverty counties versus persistent poverty counties.
Abbreviation: IQR, interquartile range.

counties than in nonpersistent poverty counties [unadjusted parameter estimate (est.) = 22.0 additional deaths per 100,000 people per year; $P < 0.0001$; **Table 2**)]. After controlling for county-level sociodemographics, the difference in overall cancer mortality rate for persistent poverty versus nonpersistent poverty counties was attenuated but still statistically significant (adjusted est. = 8.3 additional deaths; $P < 0.0001$). For each cancer type, cancer mortality was 11% to 50% higher in persistent poverty counties than in nonpersistent poverty counties in unadjusted analyses (**Table 2**; **Fig. 1**; all $P < 0.0001$). After adjusting for demographic characteristics, mortality was higher in persistent poverty counties than nonpersistent poverty counties for lung and bronchus cancer (adjusted est. = 2.9 additional deaths; $P < 0.001$), colorectal cancer (adjusted est. = 1.7; $P < 0.0001$), stomach cancer (adjusted est. = 0.4; $P = 0.01$), and liver and intrahepatic bile duct cancer (adjusted est. = 0.5; $P < 0.01$).

Comparing cancer mortality rates among counties (i) not experiencing current poverty, (ii) experiencing current but not persistent poverty, and (iii) experiencing current and persistent poverty

Counties that were not experiencing current poverty (or, as a result, persistent poverty) had lower cancer mortality rates than other counties (**Table 3**). For example, the overall cancer mortality rate was 177.6 (SE = 0.6) in noncurrent poverty counties, compared with 187.4

Table 2. Comparisons of 2007–2011 cancer mortality rates for the entire United States versus counties defined by persistent poverty.

	Nonpersistent poverty (ref)		Persistent poverty			Unadjusted difference		Adjusted difference	
	Mean	SE	Mean	SE	% Diff	Est.	*P*	Est.	*P*
All cancer types	179.3	0.6	201.3	1.8	12.3	22.0	<0.0001	8.3	<0.0001
Lung and bronchus	52.3	0.3	60.9	1.0	16.5	8.6	<0.0001	2.9	<0.001
Colorectal	17.1	0.1	20.1	0.3	17.7	3.0	<0.0001	1.7	<0.0001
Breast	21.6	0.2	24.1	0.5	11.9	2.6	<0.0001	0.9	0.10
Prostate	22.8	0.2	28.2	0.7	24.0	5.5	<0.0001	1.1	0.08
Cervical	2.5	0.1	3.7	0.2	50.1	1.2	<0.0001	0.4	0.07
Oropharyngeal	2.5	0.0	3.2	0.1	29.6	0.7	<0.0001	0.1	0.38
Stomach	2.9	0.0	4.1	0.2	43.2	1.3	<0.0001	0.4	0.01
Liver and intrahepatic bile duct	5.0	0.1	6.3	0.2	27.6	1.4	<0.0001	0.5	<0.01

Note: Cancer mortality rates are expressed as deaths per 100,000 people per year except breast and cervical cancers (deaths per 100,000 females per year) and prostate cancer (deaths per 100,000 males per year). Two-sample *t* tests were used to estimate unadjusted differences in cancer mortality rates for counties not in persistent poverty (reference category) versus counties in persistent poverty, and multivariate linear regressions were used to estimate adjusted differences in cancer mortality rates. Adjusted models controlled for county-level metropolitan status; Census region; percentage of residents who are female, non-Hispanic black, Hispanic, with a bachelor's degree or higher, and unemployed; and median household income.
Abbreviations: Diff, difference; Est., estimate; ref, reference; SE, standard error.

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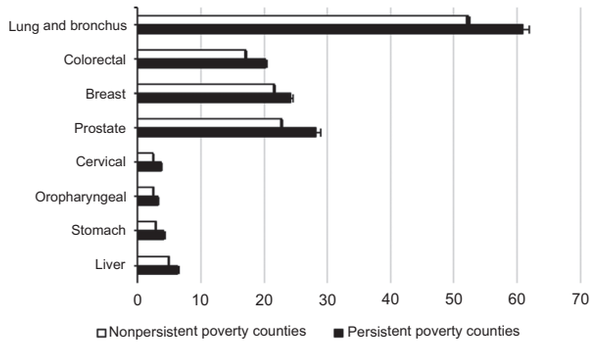

Figure 1.

Age-adjusted cancer mortality rates for nonpersistent poverty versus persistent poverty counties, 2007–2011. Cancer mortality rates are expressed as deaths per 100,000 people per year except breast and cervical cancers (deaths per 100,000 females per year) and prostate cancer (deaths per 100,000 males per year).

(SE = 1.3) in current but not persistent poverty counties and 201.3 (SE = 1.8) in current and persistent poverty counties.

Focusing only on counties experiencing current poverty, those that were also experiencing persistent poverty had significantly elevated cancer mortality rates (**Table 3**). For each cancer type except cervical cancer, cancer mortality was 7% to 19% higher in current and persistent poverty counties than in current but not persistent poverty counties. After adjusting for demographic characteristics, mortality was higher in current and persistent poverty counties than in current but not persistent poverty counties for lung and bronchus cancer (adjusted est. = 2.8 additional deaths per 100,000 people per year; $P < 0.01$), colorectal cancer (adjusted est. = 1.7; $P < 0.001$), breast cancer (adjusted est. = 1.6; $P = 0.03$), stomach cancer (adjusted est. = 0.5; $P < 0.05$), and liver and intrahepatic bile duct cancer (adjusted est. = 0.7; $P < 0.01$).

Discussion

Overall, persistent poverty counties have significantly higher cancer mortality rates than other U.S. counties, including counties experiencing current (but not persistent) poverty, that is, persistent poverty is associated with increased cancer mortality risk, over and above the risk associated with current poverty. Some of these differences are reduced when controlling for other county-level sociodemographic characteristics, suggesting that some of these variables are confounded with each other (e.g., a portion of the unadjusted difference may be due to the effect of rurality on cancer mortality; ref. 23). Additional research is needed to tease apart these differences. However, residents of persistent poverty counties remain at increased risk for death from lung and bronchus cancer, colorectal cancer, stomach cancer, and liver and intrahepatic bile duct cancer. To our knowledge, this study is the first national evaluation of the association between persistent poverty and mortality from a number of cancer sites, as well as the first study to evaluate the difference in magnitude of cancer disparities observed when using a "current poverty" versus a "persistent poverty" definition. The reasons for the observed increases in cancer mortality could be related to factors such as patterns of risk behaviors, infrastructure, health care access, and/or the social determinants of health (13, 24). Importantly, research indicates that material disadvantage, including area-level poverty, can get "under the skin" and change physiologic processing to put individuals at greater risk for cancer and other chronic diseases (17, 25). For example, people living in persistent poverty counties may have higher levels of chronic stress (due to factors such as insecure employment, adverse experiences, social isolation, etc.) that could give rise to physiologic aberrations (e.g., chronic inflammation) that result in elevated cancer incidence (26). The implications of these findings are two-fold. First, etiologic research is needed to untangle the complex, multilevel causal relationships that give rise to these disparities. Second, given that overall cancer mortality in persistent poverty counties is 12% higher than all other U.S. counties, and 7% higher than other counties experiencing current (but not persistent) poverty, interventions are urgently needed to

Table 3. Comparison of 2007–2011 cancer mortality rates for three mutually exclusive groups of U.S. counties: (i) not experiencing current poverty, (ii) experiencing current but not persistent poverty, and (iii) experiencing current and persistent poverty.

	(i) Not current poverty		Current poverty								
			(ii) Not persistent poverty (ref)		(iii) Persistent poverty			Unadjusted difference (ii vs. iii)		Adjusted difference (ii vs. iii)	
	Mean	SE	Mean	SE	Mean	SE	% Diff	Est.	*P*	Est.	*P*
All cancer types	177.6	0.6	187.4	1.3	201.3	1.8	7.4%	13.9	<0.0001	9.6	<0.0001
Lung and bronchus	51.3	0.3	57.0	0.7	60.9	1.0	6.7%	3.8	<0.01	2.8	<0.01
Colorectal	17.0	0.1	17.6	0.3	20.1	0.3	14.7%	2.6	<0.0001	1.7	<0.001
Breast	21.5	0.2	22.0	0.4	24.1	0.5	9.7%	2.1	<0.0001	1.6	0.03
Prostate	22.4	0.2	24.3	0.5	28.2	0.7	16.3%	4.0	<0.0001	0.4	0.65
Cervical	2.3	0.1	3.2	0.3	3.7	0.2	13.8%	0.4	0.26	0.8	0.08
Oropharyngeal	2.4	0.0	2.8	0.1	3.2	0.1	14.1%	0.4	<0.01	0.3	0.08
Stomach	2.8	0.0	3.5	0.2	4.1	0.2	19.1%	0.7	<0.01	0.5	0.05
Liver and intrahepatic bile duct	4.8	0.1	5.6	0.1	6.3	0.2	13.7%	0.8	<0.001	0.7	<0.01

Note: Cancer mortality rates are expressed as deaths per 100,000 people per year except breast and cervical cancers (deaths per 100,000 females per year) and prostate cancer (deaths per 100,000 males per year). Two-sample *t* tests were used to estimate unadjusted differences in cancer mortality rates for (ii) counties experiencing current but not persistent poverty (reference category) versus (iii) counties experiencing current and persistent poverty, and multivariate linear regressions were used to estimate adjusted differences in cancer mortality rates. Adjusted models controlled for county-level metropolitan status; Census region; percentage of residents who are female, non-Hispanic black, Hispanic, with a bachelor's degree or higher, and unemployed; and median household income.
Abbreviations: Diff, difference; Est., estimate; ref, reference; SE, standard error.

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reduce the disparate and elevated rates of cancer mortality among residents of these vulnerable, persistent poverty counties.

As noted, the results from this study indicate striking disparities in cancer mortality for persistent poverty counties compared with other counties. Overall cancer mortality rates were 12% higher in persistent poverty counties than in all other (nonpersistent poverty) U.S. counties, which is approaching the magnitude of racial disparities in cancer mortality for blacks versus whites (around 15.8%; ref. 3). Across cancer types, large differences were observed, especially for lung and bronchus cancer (16.5% higher), colorectal cancer (17.7% higher), stomach cancer (43.2% higher), and liver and intrahepatic bile duct cancer (27.6%). Lung and bronchus cancer and colorectal cancer have strong behavioral causes (27), and stomach cancer and liver and intrahepatic bile duct cancer are associated at least, in part, with infections (28); studies and interventions to reduce cancer mortality rates in persistent poverty counties will need to address these cancer risk factors. However, the role of social determinants of health (e.g., poverty and discrimination, access to quality health care, and physical and social environments) cannot be ignored. Persistent poverty counties may have experienced decades of disinvestment in public health and other sectors, resulting in multiple, multilevel vulnerabilities. Conceptual work suggests that even if we address "downstream" causes of disease, such as behavioral risks, disparities may continue to be observed (29) because of the contextual and compositional challenges facing these counties.

In addition, mortality rates were 7% to 19% higher in counties that experienced both persistent and current poverty compared with counties that only experienced current poverty. These findings suggest that living in a persistent poverty county is associated with additional risk over and above shorter term poverty. Thus, the long-term duration of exposure to poverty in these counties is associated with elevated cancer mortality risk for their residents. Researchers should carefully select and justify their selection when choosing from among these definitions of poverty, because use of one measure versus another may have implications for study findings. In particular, longitudinal studies may benefit from using the persistent poverty definition because it reflects a stable adverse exposure over long periods of time. Additional research, including qualitative investigation, is needed to understand the unique lived experiences among residents of current poverty versus persistent poverty counties, and how differences in these conditions may give rise to disparities within the broader category of "current poverty" counties.

The exact reasons for the elevated cancer mortality rates in persistent poverty counties versus other counties are not yet known. As described above, impoverished counties tend to have high rates of cancer risk behaviors (e.g., smoking and obesity; refs. 14, 16) and low rates of cancer screening (30, 31). In addition, larger scale, infrastructural issues, such as reduced access to health care (32), could contribute to mortality risk. Disinvestment in clinical and public health systems is a problem in any community, but in these persistent poverty counties, which are primarily rural and have had high rates of poverty for more than 30 years, infrastructure may be especially underequipped to deal with the burden of cancer in an aging population now and in the future. It is, therefore, crucial to understand area-level poverty as a marker of exposure to carcinogenic environments.

This study had several strengths. We used several high-quality datasets with near-complete coverage of the U.S. population, including cancer outcomes. Our analysis of cancer mortality by persistent and current poverty categories is an important contribution to the existing research on (i) health outcomes in these counties, (ii) social determinants of cancer, and (iii) poverty-related disparities in cancer. In terms of limitations, our cross-sectional analysis could not account for residential history, precluding a meaningful investigation of duration of exposure to persistent poverty over the life course. In addition, county size (in population and area) is variable across the country, which could affect the statistical power of the analyses. Additional methodologic and theoretical work is needed to explicate the role of county size on geographic studies of health. Finally, this observational, ecological study excluded many individual-level variables relevant to geographic differences in cancer mortality, including in- and out-migration (33) as well as individual-level attitudes (e.g., cancer fatalism; ref. 34) and behaviors (e.g., smoking; ref. 16). Future multilevel studies should incorporate these factors to better characterize the burden of cancer among populations living in persistent poverty counties. A related limitation for ecologic studies, including this one, is that their findings cannot be generalized to individual-level relationships.

In conclusion, persistent poverty counties faced substantially higher cancer mortality rates than other counties, with particularly large disparities for mortality from all cancer types, as well as from lung and bronchus cancer, colorectal cancer, stomach cancer, and liver and intrahepatic bile duct cancer. Future etiologic research should attempt to better understand the higher rates of cancer mortality in these counties. These disparities are likely the result of social, institutional, physical, individual, and biological factors that have developed over more than 30 years of elevated poverty in these vulnerable counties, and targeted, multilevel interventions to reduce them are urgently needed.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

The opinions expressed in this article are the authors' own and do not reflect the view of the NIH, the Department of Health and Human Services, or the United States government.

Authors' Contributions

J.L. Moss: Conceptualization, data curation, formal analysis, validation, investigation, visualization, methodology, writing–original draft, writing–review and editing. **C.N. Pinto:** Conceptualization, investigation, writing–review and editing. **S. Srinivasan:** Conceptualization, resources, supervision, writing–original draft, writing–review and editing. **K.A. Cronin:** Conceptualization, resources, software, supervision, validation, investigation, methodology, writing–original draft, project administration, writing–review and editing. **R.T. Croyle:** Conceptualization, resources, supervision, validation, writing–original draft, project administration, writing–review and editing.

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