Assessing the Coverage of US Cancer Center Primary Catchment Areas

Amy E. Leader[1], Christopher McNair[2], Christina Yurick[3], Matthew Huesser[3], Elizabeth Schade[3], Emily E. Stimmel[4], Caryn Lerman[5], and Karen E. Knudsen[2,6]

ABSTRACT

Background: Cancer centers are expected to engage communities and reduce the burden of cancer in their catchment areas. However, the extent to which cancer centers adequately reach the entire US population is unknown.

Methods: We surveyed all members of the Association of American Cancer Institutes ($N = 102$ cancer centers) to document and map each cancer center's primary catchment area. Catchment area descriptions were aggregated to the county level. Catchment area coverage scores were calculated for each county and choropleths generated representing coverage across the US. Similar analyses were used to overlay US population density, cancer incidence, and cancer-related mortality compared with each county's cancer center catchment area coverage.

Results: Roughly 85% of US counties were included in at least one cancer center's primary catchment area. However, 15% of US counties, or roughly 25 million Americans, do not reside in a catchment area. When catchment area coverage was integrated with population density, cancer incidence, and cancer-related mortality metrics, geographical trends in both over- and undercoverage were apparent.

Conclusions: Geographic gaps in cancer center catchment area coverage exist and may be propagating cancer disparities. Efforts to ensure coverage to all Americans should be a priority of cancer center leadership.

Impact: This is the first known geographic analysis and interpretation of the primary catchment areas of all US-based cancer centers and identifies key geographic gaps important to target for disparities reduction.

See related commentary by Lieberman-Cribbin and Taioli, p. 949

Introduction

Cancer center commitment to its catchment area

Cancer centers have had a longstanding commitment of reducing the cancer burden in the populations that they serve. In 2012, the National Cancer Institute (NCI) solidified this commitment by requiring that dedicated cancer centers identify and describe their catchment area, as well as document ongoing research that specifically addresses the cancer burden, risk factors, incidence, mortality, morbidity, and inequities in the catchment area (1). In 2016, NCI updated this requirement to include a section dedicated to Community Outreach and Engagement (2). Although there is some leeway in how a cancer center defines its catchment area, it is typically defined as where the majority of patients with cancer treated by a center reside, where research participants live, the boundaries of a cancer center or hospital's marketing approach, or a combination of these options (3). Catchment areas are almost always defined using a data-driven approach and are frequently informed by a community advisory board. A cancer center must continually monitor their catchment area (4) and ensure that their research is driven by the needs and population burden of the catchment area (5).

Cancer health disparities

The first report of differences in cancer outcomes by race or ethnicity was published almost 50 years ago (6, 7). Black Americans have had the highest overall cancer-related death rate of any racial or ethnic group in the United States (US) for more than four decades (8). Since then, socioeconomic, behavioral, systemic, and environmental factors have been identified to contribute to cancer disparities. For example, it is estimated that eliminating socioeconomic disparities could prevent 34% of cancer-related deaths among all US adults between the ages of 25 and 74 (9). Older adults tend to have lower levels of health literacy and greater difficulty navigating the health care system than younger adults (10). Health risk behaviors are known to cluster and are more likely seen in individuals with lower educational attainment, putting them at greater risk of cancer (11). Type of health insurance, or the lack of it, has contributed to differing rates of early diagnosis, surgery, and cancer outcomes (12–14). More recently, attention has been focused on environmental factors, such as where people live, in identifying root causes of cancer disparities.

Cancer disparities as a function of where people live

Cancer incidence and mortality, as well as disparities, display strong geographic patterns across the US (15). The environment where individuals work, live, and play is increasingly being recognized as important across the cancer control continuum, including cancer risk, detection, diagnosis, treatment, and survivorship (16, 17). Americans living in rural communities are disproportionately bearing the burden of cancer disparities due to high rates of modifiable risk factors, social

[1]Division of Population Science, Medical Oncology, Sidney Kimmel Cancer Center, Thomas Jefferson University, Philadelphia, Pennsylvania. [2]Department of Cancer Biology, Sidney Kimmel Cancer Center, Thomas Jefferson University, Philadelphia, Pennsylvania. [3]Sidney Kimmel Cancer Center, Thomas Jefferson University, Philadelphia, Pennsylvania. [4]Association of American Cancer Institutes, Pittsburgh, Pennsylvania. [5]USC Norris Comprehensive Cancer Center, Los Angeles, California. [6]American Cancer Society, Atlanta, Georgia.

Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

A.E. Leader and C. McNair contributed equally as the co-senior authors of this article.

Corresponding Author: Amy E. Leader, Sidney Kimmel Cancer Center, Thomas Jefferson University, 834 Chestnut Street, Suite 314, Philadelphia, PA 19107. Phone: 215-955-7739; E-mail: amy.leader@jefferson.edu

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or environmental factors, and less access to cancer care (18, 19). Populations living within distinct rural areas, such as residents of Appalachia (20), the deep South (21), or indigenous people on tribal lands (22), have been the focus of rural cancer research for years. Similarly, it is well known that Americans living in urban communities also experience a disproportionate cancer burden due to factors related to economics, environmental or social pressures (23). Those residing in extremely rural or urban areas may need additional or unique resources and support from cancer centers whose catchment areas serve these geographies and populations.

Study purpose

Although each of the NCI-designated cancer centers is required to define and report its catchment area to the NCI, the extent to which these cancer center primary catchment areas adequately cover the US population is unknown. Furthermore, there are other cancer centers that are not NCI-designated and are not required to disclose their catchment area. As part of the Association of American Cancer Institute's (AACI) Presidential Initiative, all AACI-member cancer centers were surveyed to understand the geographic coverage of cancer center primary catchment areas across North America. County-level catchment area data were integrated with population density, cancer incidence, and cancer-related mortality metrics. The data presented herein are, to our knowledge, the first comprehensive study to report and map cancer center catchment areas across the US. Findings suggest gaps in cancer center coverage and have the potential to influence policy that distributes cancer resources and care adequately to all.

Materials and Methods

Primary catchment area survey design and distribution

An online survey (Supplementary Fig. S1) was developed to capture the following information: The name of the cancer center and its geographically defined primary catchment area, with a suggested response in zip code or county format. The survey was limited in size and scope to maximize response rates and was distributed through the AACI network via the Presidential Initiative.

Survey data collection

The survey was emailed to cancer center directors, using a master file list from AACI. Membership to AACI requires that a cancer center have a wide range of cancer-related clinical disciplines related to patient care, including a broad portfolio of cancer clinical trials, and should actively participate in cancer-related community prevention, education, and screening activities. All NCI clinical or comprehensive cancer centers are members of AACI, plus an additional 31 cancer centers that are not NCI-designated. Data were collected using Survey Monkey. Responses were excluded from centers that either: (i) represented basic science centers without a clinical presence or (ii) had indeterminate catchment areas, as only NCI-designated centers are required to define a catchment area. In addition, responses from 3 AACI cancer centers operating as one larger entity were merged to a single institution for downstream analysis. Each institution's response was subsequently annotated or interpreted to a represent primary coverage at the county level.

Data sources

Population density data

Population density metrics were assessed using the US Census Bureau 2014–2018 American Community Survey 5-year estimates and supplemental estimates (24).

Cancer incidence and mortality data

Cancer Incidence and mortality metrics were assessed using the Centers for Disease Control and Prevention's (CDC) 1999–2018 USCS Cancer Statistics Report (25), with county-level data from the 2014 to 2018 combined dataset. Importantly, data from Kansas and Minnesota were not available at the county-level using the CDC report due to state legislation. In addition, data for US territories (excluding Puerto Rico) were not available through this data source. Age-adjusted incidence and mortality rates were used for all downstream analysis and mapping.

Statistical analysis

Coverage scores

Catchment Area Coverage Scores were generated by totaling the number of AACI cancer centers that claimed a county within its primary catchment area. Although downstream analysis, including the percentage of total coverage, was limited to the US, Catchment Area Coverage Scores were also generated for AACI members in Canada (Supplementary Fig. S2).

Overlay scores

Overlay scores for population density, cancer incidence, and cancer-related mortality rates were generated using the following methodology: Each individual metric was assessed at the county level. Next, metrics for each county were split into quintiles, with the highest quintile (5) representing the largest population, cancer incidence rate or mortality rate and 1 the lowest. Overlay scores were then generated for both counties with AACI center catchment area coverage ("covered") and those without ("uncovered"). For covered counties, overlay scores were calculated by subtracting each county's quintile for the respective metric from its Catchment Area Coverage Score, resulting in an overlay score. For example, a county with primary catchment area coverage from a single AACI center (1) in the highest population density quintile (5) would have an overlay score of -4 ($1 - 5 = -4$). As each uncovered county's Catchment Area Coverage Score $= 0$, overlay scores for uncovered counties are representative simply of their respective population density, cancer incidence, or mortality quintile. Importantly, overlay score distribution percentages were calculated using only the number of counties in each respective category as the denominator (covered using only covered counties as a denominator whereas uncovered using only uncovered counties).

Data visualization

Canadian shapefiles and census tracts obtained from Statistics Canada (26). All maps and choropleths were generated using the Urbnmapr package in R that included state, county, and territory level shapefiles (27).

Data availability statement

The raw data file containing the response from each cancer center is available upon request.

Results

Primary catchment area survey distribution and data collection

One hundred and two surveys were sent to AACI cancer center directors. We received 102 responses, or a 100% response rate. We excluded responses from basic science centers ($n = 7$), as well as centers with catchment areas that were indeterminate ($n = 4$; Supplementary Table S1). In addition, responses from 3 distinct AACI centers (Mayo Clinic Minnesota, Arizona, FL) were merged to a single catchment area for analysis purposes. The resulting 89 AACI center responses were analyzed and subsequently mapped to the county level (**Fig. 1**).

Primary catchment area coverage across the US

Catchment-Area Coverage Scores were calculated for each county in the US as shown in **Fig. 2A**. Coverage score values ranged from 0 (no AACI center primary catchment area coverage, 14.9% of all US counties) to 5 (included in the primary catchment area of 5 distinct cancer centers, <1% of US counties). Geographically, counties with higher coverage scores tended to cluster along the East coast (**Fig. 2B**). Half of all counties in the US (51.3%) were covered by a single center (**Fig. 2A** and **B**). In addition, each AACI center was mapped to the state(s) in which any portion of their primary catchment area resided (**Table 1**). California represented the state with the largest number of institutions claiming any portion of the primary catchment area coverage ($n = 10$), whereas 8 states as well as the Virgin Islands had no claimed AACI center coverage as a primary catchment area within state lines. Furthermore, the percentage of counties with coverage from at least a single AACI center was calculated for each state to determine states with potential gaps in cancer coverage. Although many states displayed coverage across all counties, 5 states and one US territory were sparsely covered, with coverage rates under 75% (New York, Missouri, Florida, Arizona, Delaware, Puerto Rico).

Primary catchment area coverage—population density integration

To better determine the downstream impact of AACI center coverage across the US, county level population density metrics were obtained from the US Census Bureau 2014–2018 estimates. Population density estimates were split into quintiles and plotted as shown in Supplementary Fig. S3. To integrate population density data with primary catchment area information, counties were split into those that were "covered" by an AACI Center as a primary catchment area ($n = 2{,}748$) and those that were "uncovered" ($n = 483$) and population density overlay scores calculated (Supplementary Fig. S4). Counties with a negative Population Density Overlay Score represent cancer center "undercoverage" relative to their population, whereas a positive overlay score represents "overcoverage." As shown in **Fig. 3A**, Population Density Overlay Score values ranged from −4 (high population density and low cancer center coverage score) to 1 (higher cancer center coverage score than population density). Interestingly, only 22.3% of covered counties exhibited balanced coverage, whereas 2.1% of covered counties were overcovered as defined by this metric. Significantly, 75.4% of counties with AACI center coverage in the US were undercovered as determined by a county's Population Density Overlay Score. With respect to geographical distribution, much of the Southwest and Plains region exhibited balanced coverage, whereas the Northeast, Appalachia, and Great Lakes regions displayed the largest concentration of undercoverage (**Fig. 3B**).

With regard to uncovered counties, each county's Population Density Overlay Score is representative of its population density alone, as the Catchment Area Coverage Score is 0 for each of these counties. Interestingly, although the majority of counties were in the first, and thus least densely populated quintile (51.5%), 22.6% of uncovered counties were in the fifth quintile, suggesting that there are a significant number of counties within the highest population density quintile with no primary cancer center coverage (Supplementary Fig. S5A). Geographically, the majority of these population dense, uncovered regions fall in the Southeast and US island territories (Supplementary Fig. S5B).

Primary catchment area coverage—cancer incidence integration

Population density integration was able to establish areas of both balanced and unbalanced cancer center coverage with respect to US county-level populations, cancer incidence was next used to highlight the potential for cancer-specific impact in primary catchment area coverage. Cancer incidence rates were split into quintiles, indicating

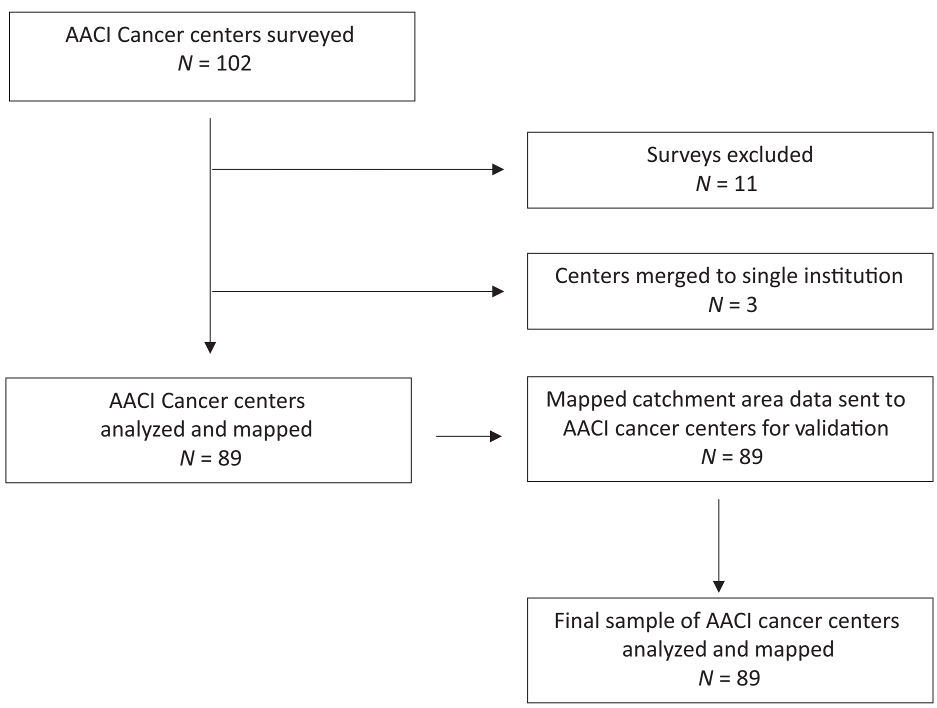
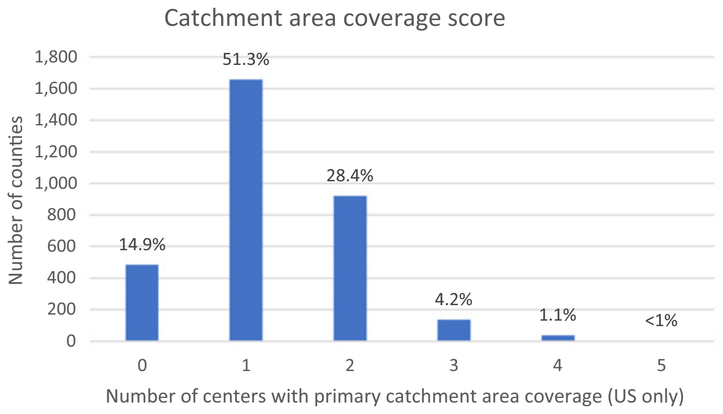


Figure 1.
Primary Catchment Area Survey CONSORT Diagram. AACI Cancer Centers were surveyed using the AACI network and asked to self-define its primary catchment area. Surveys were excluded from centers without a clinical operation and those that had catchment areas that were in development or not defined. Responses from separate AACI centers existing within the same institution were merged to a single site. Cancer center responses were mapped to the counties indicated in the responses, a follow-up survey was sent for confirmation, and responses were finalized for downstream analysis.

A



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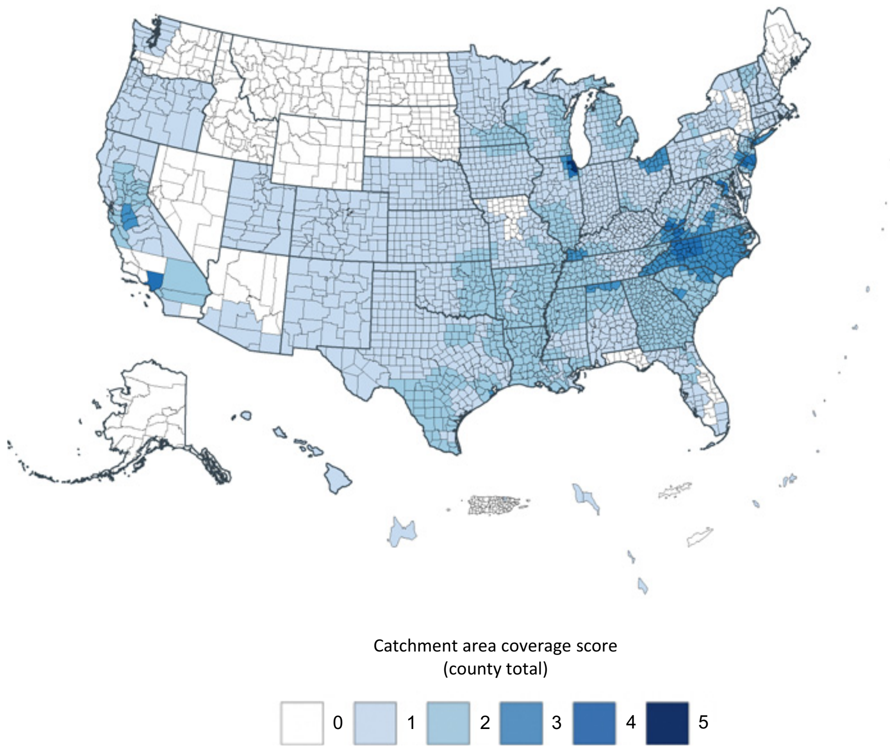

Figure 2.
Primary Catchment Area Coverage Distribution. **A,** Distribution of CACS's by score. Number of counties and percentages are inclusive only of counties in the US and outlying territories. **B,** Choropleth of the US, and US territories with county-level Catchment Area Coverage Scores (CACS) displayed. Scores were calculated for each county by totaling the number of cancer centers which defined a county within its primary catchment area.

counties with the highest cancer incidence rates (quintile 5) to lowest (quintile 1) and subsequently mapped as shown in the choropleth in Supplementary Fig. S6 (county-level data from Minnesota and Kansas were unavailable from due to state legislation).

To integrate cancer incidence with primary catchment area coverage, Cancer Incidence Overlay Scores were calculated for each county using the methodology described above (**Fig. 3**; Supplementary Fig. S7). Interestingly, 7.2% of counties were overcovered as defined by their Cancer Incidence Overlay Scores, compared with 2.1% using population density metrics, whereas only 20.6% of counties had balanced coverage compared with their incidence rates (**Fig. 4A**). However, 72% of counties with AACI center coverage were undercovered as defined by their Cancer Incidence Overlay Scores. Importantly, trends in coverage were dispersed across the US; the Great Lakes, Appalachia, and Northeast displayed a sizeable concentration of undercovered counties while the Southwest and Rocky Mountain areas exhibited the most overcovered and balanced areas, respectively (**Fig. 4B**). Counties without AACI cancer center coverage were spread across cancer incidence quintiles, with 31.4% of uncovered counties in the first quintile (lowest incidence) and the second through fifth quintiles ranging from 15.1% to 21.4% of uncovered counties, exhibiting a fairly even distribution (Supplementary Fig. S8A). The concentration of highest age-adjusted incidence in areas without coverage was seen throughout Maine and parts of the Midwest, with Alaska also displaying increased cancer incidence without AACI center coverage (Supplementary Fig. S8B).

Primary catchment area coverage—cancer-related mortality integration

To determine how primary catchment area coverage associates with cancer-related mortality, age-adjusted cancer-related mortality rates were split into quintiles and mapped (Supplementary Fig. S9). Cancer Mortality Overlay Scores were next calculated for each county in both covered and uncovered areas (Supplementary Fig. S7). With respect to

Table 1. Primary catchment area coverage by state.

State	Counties with AACI center coverage (%)	No. of Centers	AACI Center
Alaska	0.00%	0	
Alabama	100.00%	3	Vanderbilt Ingram, St Jude, O'Neal UAB
Arkansas	100.00%	2	Winthrop, St Jude
American Samoa	100.00%	1	University of Hawaii
Arizona	40.00%	2	University of Arizona, Mayo Clinic Arizona
California	91.40%	10	USC Norris, UCSF Helen Diller, UCLA Jonsson, UCI Chao, UC San Diego, UC Davis, Stanford, Loma Linda, City of Hope, Cedars Sinai
Colorado	100.00%	1	University of Colorado
Connecticut	100.00%	2	Yale, Memorial Sloan Kettering
District of Columbia	100.00%	2	Georgetown Lombardi, George Washington
Delaware	33.30%	1	University of Penn Abramson
Florida	64.20%	4	University of Florida Health, University of Miami Sylvester, Moffitt, Mayo Clinic Florida
Georgia	100.00%	2	Emory Winship, Augusta Georgia
Guam	100.00%	1	University of Hawaii
Hawaii	100.00%	1	University of Hawaii
Iowa	100.00%	3	St Jude, Mayo Clinic, University of Iowa Holden
Idaho	0.00%	0	
Illinois	100.00%	6	University of Illinois, University of Chicago, St Jude, Siteman, Northwestern Lurie, Loyola Cardinal Bernardin
Indiana	100.00%	2	University of Chicago, Indiana Simon
Kansas	100.00%	2	University of Kansas, St Jude
Kentucky	100.00%	4	Vanderbilt Ingram, University of Cincinnati, St Jude, U of Kentucky Markey
Louisiana	100.00%	2	St Jude, LSU Feist-Weiller
Massachusetts	100.00%	2	Harvard Dana Farber, Boston
Maryland	100.00%	4	Georgetown Lombardi, Johns Hopkins Sidney Kimmel, University of Maryland Greenebaum, George Washington
Maine	0.00%	0	
Michigan	100.00%	2	University of Michigan Rogel, Wayne State Karmanos
Minnesota	100.00%	2	Mayo Clinic, University of Minnesota Masonic
Missouri	72.20%	3	University of Kansas, St Jude, Siteman
Northern Mariana Islands	100.00%	1	University of Hawaii
Missouri	100.00%	2	University of Mississippi, St Jude
Montana	0.00%	0	
North Carolina	100.00%	4	Wake Forest Baptist, University of North Carolina Lineberger, St Jude, Duke
North Dakota	0.00%	0	
Nebraska	100.00%	1	University of Nebraska Buffett
New Hampshire	100.00%	1	Dartmouth Hitchcock
New Jersey	100.00%	6	Jefferson Sidney Kimmel, Rutgers, Memorial Sloan Kettering, Columbia Herbert Irving, Temple Fox Chase, University of Penn Abramson
New Mexico	100.00%	1	University of New Mexico
Nevada	0.00%	0	
New York	72.60%	9	University of Rochester Wilmot, University of Vermont, Mount Sinai Tisch, Stony Brook, Roswell Park, NYU Perlmutter, Memorial Sloan Kettering, Columbia Herbert Irving, Albert Einstein
Ohio	100.00%	4	University of Cincinnati, Ohio State James, Cleveland Clinic, Case
Oklahoma	100.00%	2	University of Oklahoma Stephenson, St Jude
Oregon	100.00%	1	OHSU Knight
Pennsylvania	88.10%	5	Jefferson Sidney Kimmel, Penn State, University of Pittsburgh Hillman, Temple Fox Chase, University of Penn Abramson
Puerto Rico	1.30%	1	Puerto Rico
Rhode Island	100.00%	1	Brown University
South Carolina	100.00%	4	St Jude, MUSC Hollings, Augusta Georgia, Duke
South Dakota	0.00%	0	
Tennessee	100.00%	2	Vanderbilt Ingram, St Jude
Texas	100.00%	6	St Jude, UT Southwestern Simmons, MD Anderson, UT San Antonio Mays, UT Austin Livestrong, Baylor Duncan
Utah	100.00%	1	University of Utah Huntsman

(Continued on the following page)

Table 1. Primary catchment area coverage by state. (Cont'd)

State	Counties with AACI center coverage (%)	No. of Centers	AACI Center
Virginia	98.50%	7	Wake Forest Baptist, VCU Massey, U Virginia, St Jude, Georgetown Lombardi, George Washington, Duke
Virgin Islands	0.00%	0	
Vermont	100.00%	2	University of Vermont, Dartmouth Hitchcock
Washington	100.00%	1	Fred Hutchinson
Wisconsin	100.00%	3	University of Wisconsin Carbone, Medical College of Wisc, Mayo
West Virginia	100.00%	4	Wake Forest Baptist, U Virginia, St Jude, Duke
Wyoming	0.00%	0	

Note: Cancer centers were stratified by the state(s) represented in their county-level primary catchment area. A single center can be represented across multiple states.

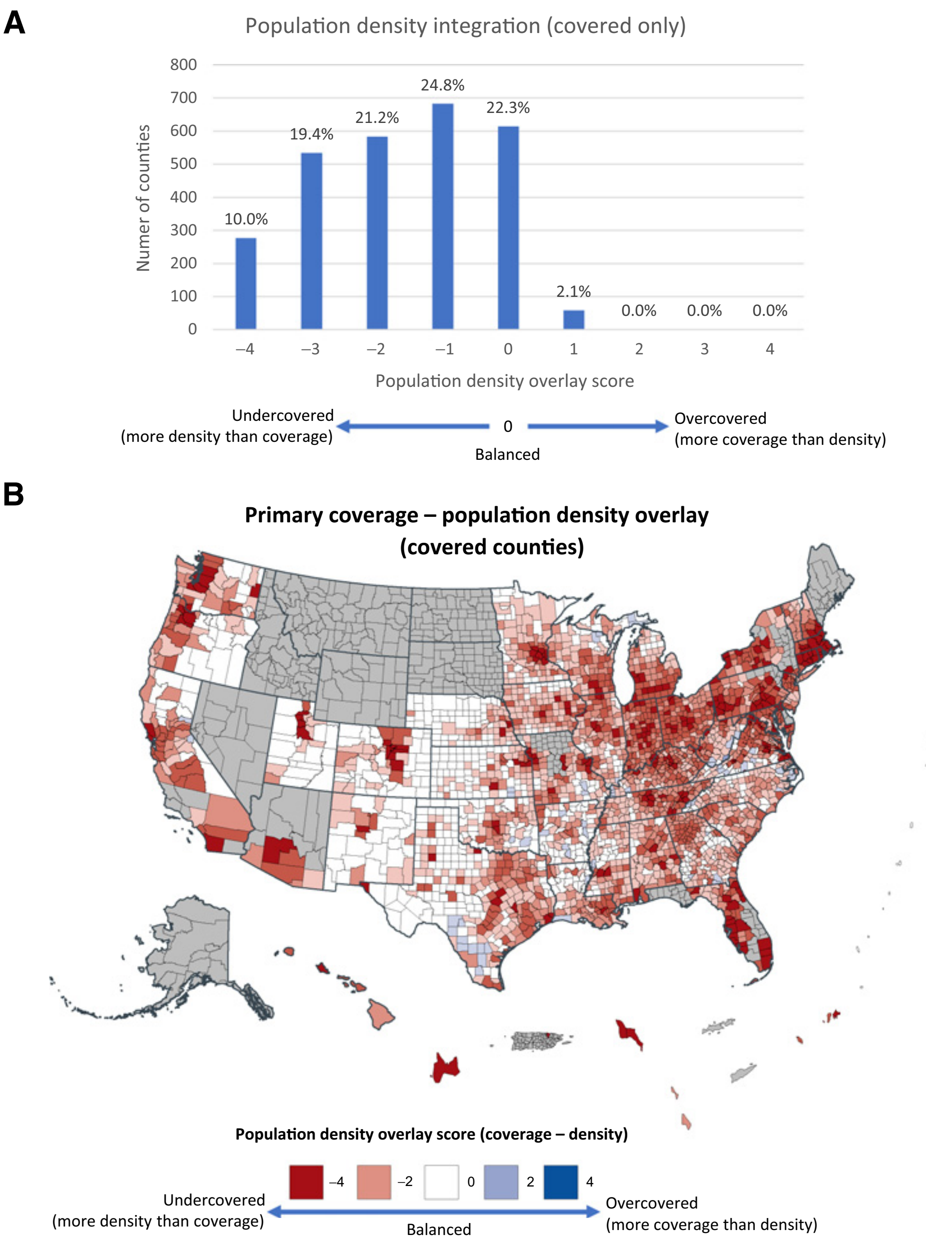

Figure 3.
Integration of Primary Catchment Area with Population Density. **A,** Distribution of PDOS's across all "covered" counties in the US and outlying territories, where negative score represents undercoverage, 0 represents balanced, and a positive score overcoverage. **B,** Choropleth displaying the geographical distribution of PDOS's across counties with catchment area coverage (gray indicates unavailable data and "uncovered" counties).

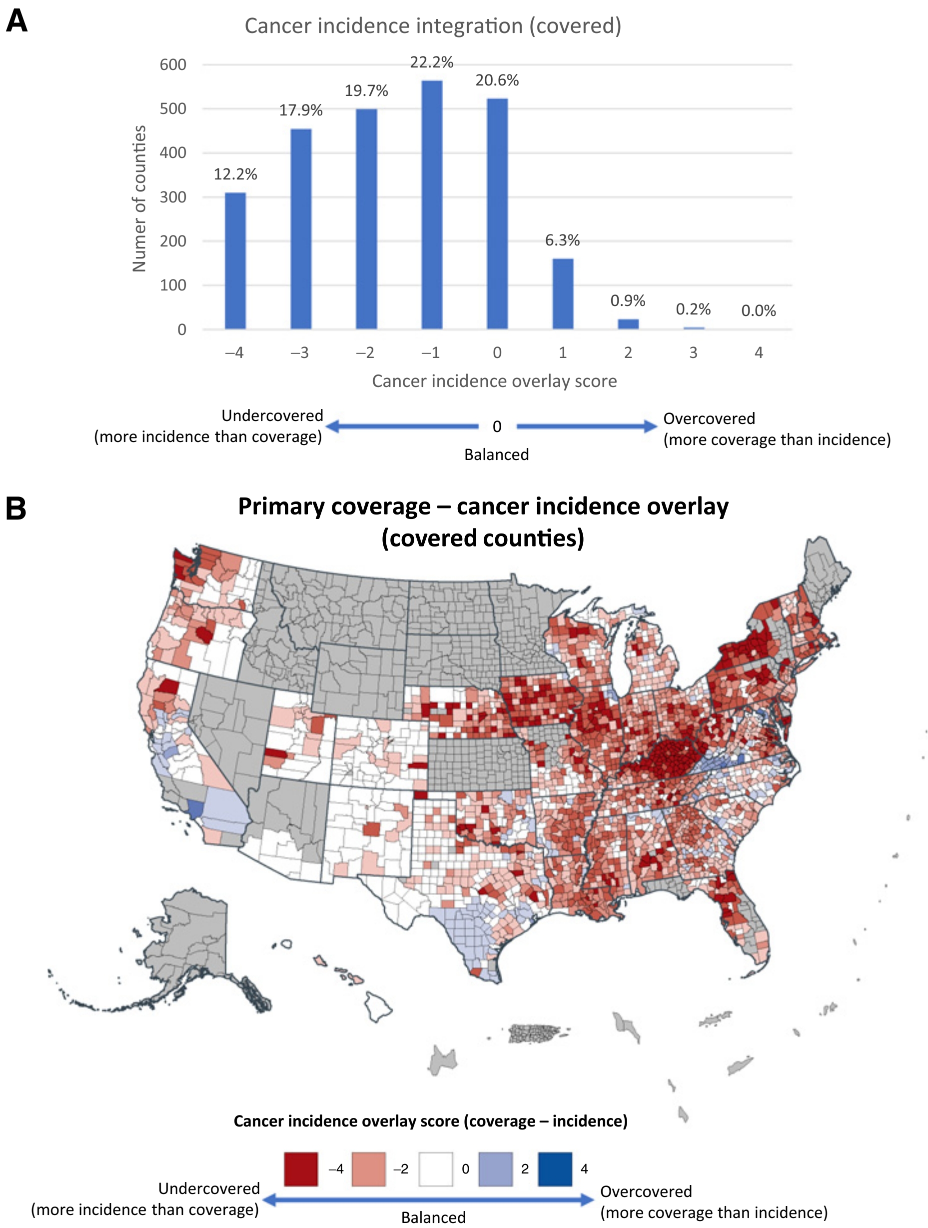

Figure 4.
Integration of Primary Catchment Area with Cancer Incidence Rates. **A,** Distribution of CIOS's across all "covered" counties in the US. **B,** Choropleth displaying the geographical distribution of Cancer Incidence Overlay Scores across all counties with catchment area coverage (gray indicates unavailable data and counties not without AACI center coverage).

counties with AACI coverage, only 20% exhibited a balanced Cancer Mortality Overlay Score, whereas 7.7% were found to be overcovered (**Fig. 5A**). Significantly, 72.3% of counties covered by a primary catchment area were determined to be undercovered, as defined by overlay with relative cancer-related mortality rates. Cancer Mortality Overlay Score undercoverage was identified to be most concentrated in Appalachia, the Great Lakes, and Southern US, whereas balanced and overcovered counties were sparsely distributed in the Midwest and along the eastern coast (**Fig. 5B**). Counties without AACI center catchment area coverage skewed toward lower cancer-related mortality quintiles (60% of uncovered counties in the first and second quintile, Supplementary Fig. S10A). However, high cancer-related mortality in uncovered counties was identified across Maine, Alaska, and parts of the Rockies suggesting potential areas for concern (Supplementary Fig. S10B).

Discussion

To our knowledge, this is the first study to systematically assess the coverage of cancer center primary catchment areas. Although 85% of US counties were covered by a cancer center primary catchment area, 483 US counties (15%) were uncovered by a cancer center. This translates into over 25 million Americans being excluded from the attention and resources that cancer centers typically devote to population-level efforts in their catchment-area counties. When catchment area coverage was integrated with population density, cancer incidence, and cancer-related mortality metrics, geographical trends in both over- and undercoverage were apparent.

The most disconcerting finding from this study may be the large number of Americans who are residing outside of a cancer center primary catchment area. "Undercoverage" appears to be greatest in the Appalachian and Southern US, where cancer disparities have

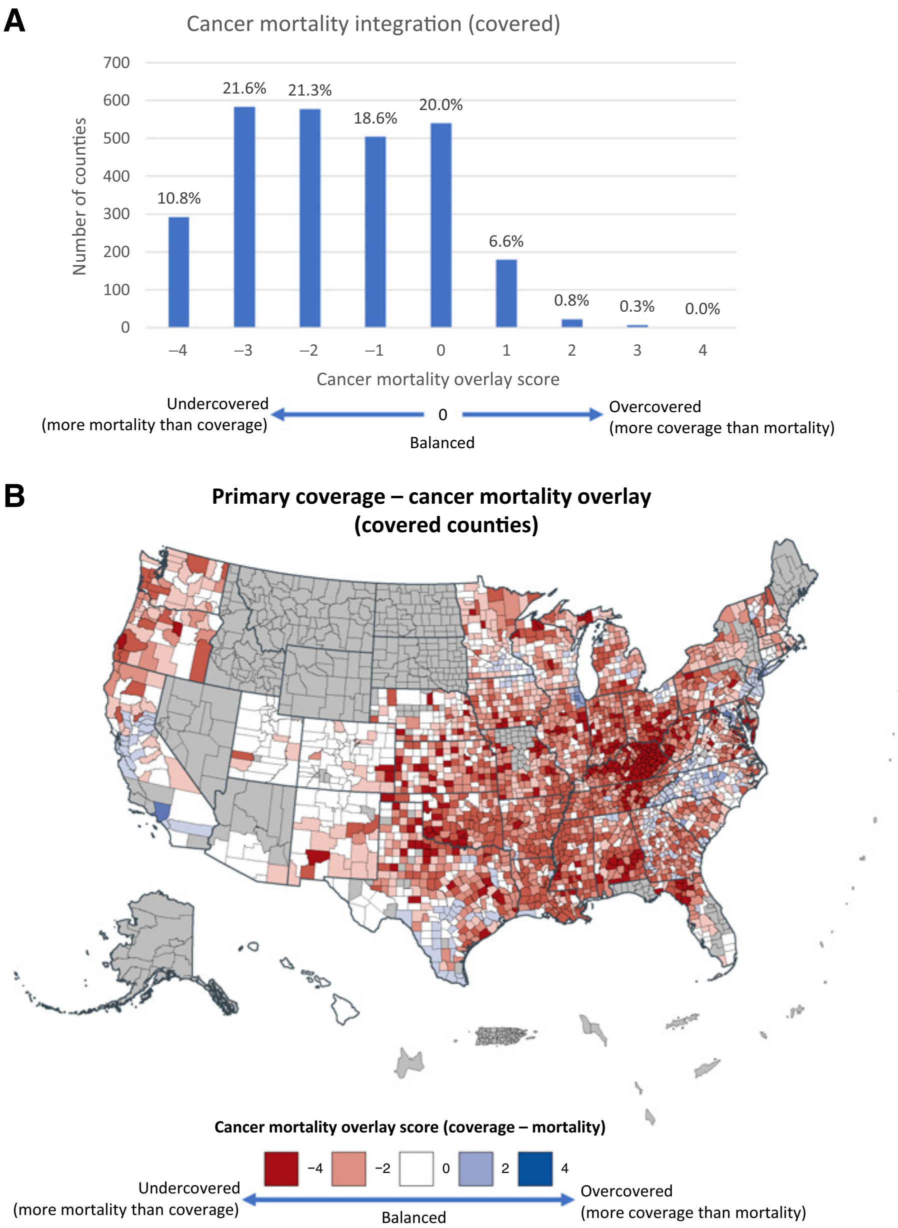

Figure 5.
Integration of Primary Catchment Area with Cancer Mortality Rates. **A,** Distribution of CMOS's across all "covered" counties in the US. **B,** Choropleth displaying the geographical distribution of Cancer Mortality Overlay Scores across all counties with catchment area coverage (gray indicates unavailable data and counties without AACI center coverage).

historically been large and continue to persist. Patients in these geographic areas are known to have poorly informed beliefs about cancer prevention and screening (28, 29), are less likely to begin timely cancer treatment (30), and are less likely to enroll in a clinical trial (31). Eight states, almost all with large rural populations, were entirely uncovered by a primary catchment area, leaving those patients to travel great distances for high-quality cancer care. Failure to adequately service these communities with accessible and culturally tailored high-quality cancer care will continue to propagate cancer disparities.

Similarly, in some parts of the country, populations were "over-covered" by multiple cancer centers, creating potential opportunities for redistribution of valuable and expensive resources. In counties covered by more than one cancer center catchment area, coalitions among cancer centers to align and synergize efforts may be appropriate (32, 33). State comprehensive cancer control coalitions may also play a role in working with cancer centers to ensure cancer equity across each state (34). Having cancer centers publicly report their catchment areas, through NCI or AACI, would allow for more transparency and could spur efforts to realign catchment areas. "Right-sizing" catchment area coverage across the country should be a priority of all cancer centers and of national cancer center leadership. In this study, catchment area data are reported at the county level. However, it is increasingly being recognized that cancer disparities are propagated at the community and neighborhood level. The built environment, as well as neighborhood isolation and concentration of poverty due to decades-long discriminatory practices, have been shown to be associated with increased cancer-related mortality (35, 36). It is possible that neighborhood factors beyond merely deprivation or poverty, such as the social environment, and other contextual factors, may be associated with cancer survivorship or mortality (37). Nevertheless, these findings provide clear evidence that "place" is an important factor in cancer risk, outcomes, and disparities. Most cancer centers recognize this evidence base, as a large focus of their community outreach work occurs within neighborhoods and communities across their catchment areas.

Although this study is the first of its kind to aggregate and visualize cancer center primary catchment areas, there are limitations. Catchment areas were self-reported by each cancer center without validation; however, we attempted to verify each catchment area through publicly available data on each cancer center website and with cancer center directors. Cancer center focus on COE has only been in effect since 2016 and most likely has not yet affected long-term outcomes of cancer incidence and mortality. In addition, although the catchment areas were valid at the time of data collection (December 2020), some cancer centers may have altered their catchment area footprint because the survey was fielded. For example, Huntsman Cancer Institute recently expanded its primary catchment are to include states within the Mountain West Region that is not reflected in these data. Furthermore, some cancer centers have secondary catchment areas that were not reflected in these data. The data on population density, cancer incidence, and cancer-related mortality are not real-time data. Population estimate, cancer incidence, and cancer-related mortality data may change over time, and it is unclear how trends will change in response to changes in screening or diagnoses due to the COVID-19 pandemic. We used a simple summed score to calculate over- and undercoverage of catchment areas; future work could build on this methodology with more intricate analyses. Finally, the survey only collected information about catchment area coverage, not priorities within a cancer center's catchment area. A survey, including this question, and others related to priorities and initiatives, is being designed and distributed to cancer centers in a follow-up AACI study.

The current study joins a growing body of research that aims to understand how cancer center community outreach and engagement efforts can best meet the needs of the population, now and in the future (38). Findings from our study show where the gaps are, geographically, in the distribution of effort and resources from US cancer centers. From here, we can begin to work toward catchment area equity, where every American is covered by a primary cancer center catchment area, linking all populations to a cancer center home. Other areas of interest stemming from this study include mapping cancer center catchment areas against maps of cancer risk behaviors, social determinants of health, or health service utilization to begin to understand the upstream factors and their relationship to catchment area coverage. Understanding the extent of community outreach and engagement by each cancer center, in each catchment area, is also important. We hope that these maps spark discussions within and across cancer centers about the role that catchment areas have played in the first 50 years of our commitment to eradicating cancer (39, 40), and how we can leverage them in the years to come to reduce and ultimately eliminate cancer disparities.

Authors' Disclosures

No disclosures were reported.

Authors' Contributions

A.E. Leader: Data curation, investigation, writing–original draft, writing–review and editing. **C. McNair:** Data curation, software, formal analysis, investigation, visualization, methodology, writing–original draft, writing–review and editing. **C. Yurick:** Data curation, investigation. **M. Huesser:** Resources, data curation, writing–review and editing. **E. Schade:** Data curation, investigation. **E.E. Stimmel:** Resources, data curation, writing–review and editing. **C. Lerman:** Writing-review and editing. **K.E. Knudsen:** Conceptualization, resources, data curation, supervision, visualization, writing–original draft, project administration, writing–review and editing.

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References

1. National Institutes of Health, National Cancer Institute. Cancer Center Support Grants (CCSGs) for NCI Designated Cancer Centers (P30). PAR-12–298. Available from: https://grants.nih.gov/grants/guide/pa-files/par-12-298.html.
2. National Institutes of Health, National Cancer Institute. Cancer Center Support Grants (CCSGs) for NCI Designated Cancer Centers (P30). PAR-17–095. Available from: https://grants.nih.gov/grants/guide/pa-files/PAR-17-095.html.
3. Paskett ED, Hiatt RA. Catchment areas and community outreach and engagement: the new mandate for NCI-Designated Cancer Centers. Cancer Epidemiol Biomarkers Prev 2018;27:517–9.
4. Blake KD, Ciolino HP, Croyle RT. Population health assessment in NCI-Designated Cancer Center catchment areas. Cancer Epidemiol Biomarkers Prev 2019;28:428–30.
5. Tai CG, Hiatt RA. The population burden of cancer: research driven by the catchment area of a cancer center. Epidemiol Rev 2017;39:108–22.
6. Fontaine SA, Henschke UK, Leffall LD Jr, Mason CH, Reinhold AW, Schneider R, et al. Comparison of the cancer deaths in the black and white U.S.A. population from 1949 to 1967. Med Ann Dist Columbia 1972;41:293–8.
7. Burbank F, Fraumeni JF Jr. U.S. cancer mortality: nonwhite predominance. J Natl Cancer Inst 1972;49:649–59.
8. DeSantis CE, Miller KD, Goding Sauer A, Jemal A, Siegel RL. Cancer statistics for African Americans, 2019. CA Cancer J Clin 2019;69:211–33.
9. Siegel RL, Jemal A, Wender RC, Gansler T, Ma J, Brawley OW. An assessment of progress in cancer control. CA Cancer J Clin 2018;68:329–39.
10. Kadambi S, Loh KP, Dunne R, Magnuson A, Maggiore R, Zittel J, et al. Older adults with cancer and their caregivers—current landscape and future directions for clinical care. Nat Rev Clin Oncol 2020;17:742–55.
11. Meader N, King K, Moe-Byrne T, Wright K, Graham H, Petticrew M, et al. A systematic review on the clustering and co-occurrence of multiple risk behaviours. BMC Public Health 2016;16:657.
12. Ko NY, Hong S, Winn RA, Calip GS. Association of insurance status and racial disparities with the detection of early-stage breast cancer. JAMA Oncol 2020;6:385–92.
13. Evans N III, Grenda T, Alvarez NH, Okusanya OT. Narrative review of socioeconomic and racial disparities in the treatment of early-stage lung cancer. J Thorac Dis 2021;13:3758–63.
14. Falcone M, Liu L, Farias A, Zhang J, Kang I, Li M, et al. Evidence for racial/ethnic disparities in emergency department visits following breast cancer surgery among women in California: a population-based study. Breast Cancer Res Treat 2021;187:831–41.
15. Division of Cancer Epidemiology and Genetics. National Cancer Institute. 2017 U.S. Atlas of Cancer Mortality. Bethesda, MD. Available from: https://dceg.cancer.gov/research/how-we-study/descriptive-epidemiology/cancer-mortality-atlas.
16. Gomez SL, Shariff-Marco S, DeRouen M, Keegan THM, Yen IH, Mujahid M, et al. The impact of neighborhood social and built environment factors across the cancer continuum: current research, methodological considerations, and future directions. Cancer 2015;121:2314–30.

17. Schootman M, Gomez SL, Henry KA, Paskett ED, Ellison GL, Oh A, et al. Geospatial approaches to cancer control and population sciences. Cancer Epidemiol Biomarkers Prev 2017;26:472–5.
18. Levit LA, Byatt L, Lyss AP, Paskett ED, Levit K, Kirkwood K, et al. Closing the rural cancer care gap: three institutional approaches. J Oncol Pract 2020;16:422–30.
19. Zahnd WE, James AS, Jenkins WD, Izadi SR, Fogleman AJ, Steward DE, et al. Rural-urban differences in cancer incidence and trends in the United States. Cancer Epidemiol Biomarkers Prev 2018;27:1265–74.
20. Arnold C. Appalachia's cancer problem. J Natl Cancer Inst 2017;109:djx045.
21. Partridge EE, Fouad MN, Hinton AW, Hardy CM, Liscovicz N, White-Johnson F, et al. The Deep South Network for cancer control: eliminating cancer disparities through community-academic collaboration. Fam Community Health 2005;28:6–19.
22. Melkonian SC, Jim MA, Haverkamp D, Wiggins CL, McCollum J, White MC, et al. Disparities in cancer incidence and trends among American Indians and Alaska Natives in the United States, 2010–2015. Cancer Epidemiol Biomarkers Prev 2019;28:1604–11.
23. American College of Physicians. Inner-city health care. Ann Intern Med 1997;127:485–90.
24. United States Census Bureau. 2014–2018 American Community Survey. Available from: https://www.census.gov/newsroom/press-kits/2019/acs-5-year.html. Last accessed on August 12, 2021.
25. Centers for Disease Control and Prevention. 1999–2018 U.S. Cancer Statistics Report. Available from: cdc.gov/cancer/uscs/dataviz/download_data.htm. Last accessed on August 12, 2021.
26. Statistics Canada. Available from: statcan.gc.ca/. Last accessed on August 12, 2021.
27. GitHub. Urban Institute. Available from: https://github.com/UrbanInstitute/urbnmapr. Last accessed on August 12, 2021.
28. Aly S, Daniel CL, Bae S, Scarinci IC, Hardy CM, Fouad MN, et al. Cancer-related beliefs and preventive health practices among residents of rural versus urban counties in Alabama. Cancer Prev Res 2021;14:593–602.
29. Vanderpool RC, Huang B, Deng Y, Bear TM, Chen Q, Johnson MF, et al. Cancer-related beliefs and perceptions in Appalachia: findings from 3 states. J Rural Health 2019;35:176–88.
30. Lin CC, Bruinooge SS, Kirkwood MK, Hershman DL, Jemal A, Guadagnolo BA, et al. Association between geographic access to cancer care and receipt of radiation therapy for rectal cancer. Int J Radiat Oncol Biol Phys 2016;94:719–28.
31. LaVallie DL, Wolf FM, Jacobsen C, Buchwald D. Barriers to cancer clinical trial participation among Native elders. Ethn Dis 2008;18:210–7.
32. Simon MA, Fitzgibbon M, Ciecierski C, Cooper JM, Martinez E, Tom L, et al. Building cross-institutional collaborative infrastructure and processes: early lessons from the Chicago Cancer Health Equity Collaborative. Prog Community Health Partnersh 2019;13:5–13.
33. Hiatt RA, Sibley A, Fejerman L, Glantz S, Nguyen T, Pasick R, et al. The San Francisco Cancer Initiative: a community effort to reduce the population burden of cancer. Health Aff 2018;37:54–61.
34. Moore A, Villalobos A, Gardner AL, Staples C, Shafir S. Leveraging the strength of comprehensive cancer control coalitions to support policy, systems, and environmental change. Cancer Causes Control 2019;30:1033–44.
35. Krieger N, Wright E, Chen JT, Waterman PD, Huntley ER, Arcaya M. Cancer stage at diagnosis, historical redlining, and current neighborhood characteristics: breast, cervical, lung, and colorectal cancers, Massachusetts, 2001–2015. Am J Epidemiol 2020;189:1065–75.
36. Fleisch Marcus A, Illescas AH, Hohl BC, Llanos AA. Relationships between social isolation, neighborhood poverty, and cancer mortality in a population-based study of US adults. PLoS One 2017;12:e0173370.
37. Marcus AF, Echeverria SE, Holland BK, Abraido-Lanza AF, Passannante MR. How neighborhood poverty structures types and levels of social integration. Am J Community Psychol 2015;56:134–44.
38. Doykos PM, Chen MS, Watson K, Henderson V, Baskin ML, Downer S, et al. Recommendations from a dialogue on evolving National Cancer Institute-Designated Comprehensive Cancer Center Community Outreach and Engagement requirements: a path forward. Health Equity 2021;5:76–83.
39. National Cancer Institute. 50 Years of the National Cancer Act. Available from: https://www.cancer.gov/news-events/nca50.
40. Del Nero PF, Buller ID, Jones RR, Tatalovich Z, Vanderpool RC, Ciolino HP, et al. A national map of NCI-Designated Cancer Center Catchment Areas on the 50th anniversary of the Cancer Centers Program. Cancer Epidemiol Biomarkers Prev 2022 Jan 31 [Epub ahead of print].