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Housing assistance among patients with cancer: SEER-Medicare US Department of Housing and Urban Development data linkage

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Abstract

Background: Lack of stable, affordable housing is an important social determinant of health. Federal housing assistance may buffer against housing vulnerabilities among low-income households, but research examining the association of housing assistance and cancer care has been limited. We introduce a new linkage of Surveillance, Epidemiology, and End Results (SEER) program-Medicare and US Department of Housing and Urban Development (HUD) administrative data.

Methods: Individuals enrolled in HUD public and assisted housing programs between 2006 and 2021 were linked with cancer diagnoses between 2006 and 2019 identified in the SEER-Medicare data from 16 states using Match*Pro (National Institutes of Health, Bethesda, MD) probabilistic linkage software. HUD administrative data include timing and type of housing assistance as well as verified household income. Medicare administrative data are available through 2020.

Results: A total of 335 490 unique individuals who received housing assistance at any time point, including 156 794 who received housing assistance around the time of their diagnosis (at least 6 months before diagnosis until 6 months after diagnosis or death), were matched to SEER-Medicare data. A total of 63 251 individuals receiving housing assistance at the time of their diagnosis were aged 66 years and older and continuously enrolled in Medicare parts A and B fee for service; 12 035 had a diagnosis of lung cancer, 8866 of breast cancer, 7261 of colorectal cancer, and 4703 of prostate cancer.

Conclusions: This novel data linkage will be available through the National Cancer Institute and can be used to explore the ways in which housing assistance is associated with cancer diagnosis, care, and outcomes, including the role of housing assistance status in potentially reducing or contributing to inequities across racialized and ethnic groups.

Cancer is most commonly diagnosed among adults aged 60 years and older in the United States (1). Longstanding inequities in survival and mortality (2,3) and in access to quality care across the cancer control continuum exist for individuals with lower vs higher socioeconomic status and for American Indian or Alaska Native, individuals of Latino origin, and people racialized as Black vs White (4-10). With limited progress on reducing cancer inequities, there has been a call to understand and address factors outside the health-care system, focusing attention on social determinants of health. As highlighted in a recent American Cancer Society blueprint (11) and by the American Society of Clinical Oncology (12), social determinants can affect cancer care, from diagnosis to the end of life.

One crucial social determinant that has received relatively little attention in cancer research is the role of safe and affordable housing. An estimated 21.6 million households were cost burdened by housing in 2021 (spending more than 30% of their income on housing costs) (13,14). Due to a history of structurally racist housing policies, households racialized as Black experience a disproportionate burden of housing insecurity and high levels of toxic exposures in the household and surrounding neighborhood (15-18). A recent systematic review identified 31 studies that examined the association among housing, cancer care, and patient outcomes (19). The review generally found statistically significant associations between individual-level and neighborhood-level housing insecurity and poor outcomes, including lower quality of care, later-stage cancer diagnosis, and worse survival. Few studies examined associations between housing insecurity and cancer treatment in part because of data limitations.

Additionally, only 3 studies examined the association between receipt of federal housing assistance and cancer care and outcomes (20-22). Federal housing assistance programs administered by the US Department of Housing and Urban Development (HUD) seek to buffer against housing vulnerabilities among low-income households. Through a range of program categories, HUD programs annually serve approximately 10 million individuals—including 1.8 million adults aged 62 years and over—and limits their out-of-pocket expenses on rent and utilities to 30% of the households' income (23). There are several plausible mechanisms through which federal housing assistance may affect access to care, including by reducing medical financial hardship, increasing housing stability and decreasing frequent moves, improving housing quality, changing neighborhood context, connecting individuals to other health and social services through on-site coordinators, and lowering levels of stress (24,25).

Most observational research examining cancer diagnosis and survival uses data from population-based cancer registries, which contain detailed clinical information about incident cancers for all individuals within defined geographic locations. The linkage of registry to health insurance enrollment and claims data, as in the Surveillance, Epidemiology, and End Results (SEER) program–Medicare linkage, allows for detailed evaluation of cancer treatment, including surgery, radiation therapy, and chemotherapy, and survivorship care. In this article, we describe a new, National Cancer Institute (NCI)–sponsored data linkage: SEER-Medicare data linked with HUD administrative data on public and assisted housing programs. Findings quantify the linked population, including HUD program participation and basic sociodemographic characteristics of the population. These data can be used to examine associations of housing assistance status as well as cancer care and patient outcomes to inform efforts to reduce inequities.

Methods
SEER-Medicare data
The SEER program is an NCI-supported, population-based initiative to collect and publish information about cancer incidence and survival in the United States. The SEER registries currently cover approximately 48% of the US population (26). Registries report cancer stage, histology, some indicators for treatment, census tract at time of diagnosis, vital status, and cause of death.

Medicare is a federal health insurance program administered by the Centers for Medicare & Medicaid Services for individuals who are 65 years of age or older and individuals with certain illnesses or disabilities who are younger than 65 years of age. In 2020, 62.8 million Americans were enrolled in Medicare, 87% of whom were 65 years of age or older (27). Eligible individuals are entitled to Medicare Part A coverage, which covers inpatient hospital stays, hospice care, skilled nursing facility stays, and some home health services. Medicare Part B coverage is an opt-in program that requires an annual premium and covers certain physician services, outpatient care, medical supplies, and preventive services. Medicare parts A and B offer fee-for-service coverage. In Medicare Part C, also known as Medicare Advantage, plans are operated by private companies (eg, health maintenance organizations). Enrollment in Medicare Advantage increased from 19% of Medicare beneficiaries in 2007 to 48% in 2022 (28). Medicare Part D is a pharmacy benefit that covers prescription drugs for Medicare fee for service and Medicare Advantage and is also managed by private companies. Medicare data include enrollment and claims information for individuals enrolled in Medicare parts A, B, and D.

In collaboration with the Centers for Medicare & Medicaid Services, the NCI links SEER records to Medicare data to produce a population-based dataset with the ability to inform research on cancer characteristics, diagnosis, treatment, and survival among mostly older people in the United States. These data have been widely used to examine patterns of cancer care for Medicare beneficiaries, with more than 2300 publications as of December 31, 2022 (29).

The SEER-Medicare data include people diagnosed with cancer from 1999 through 2019 and their Medicare enrollment and Medicare fee-for-service claims from 1999 through 2020 and Part D utilization data from 2007 through 2020. Though the majority of individuals enrolled in Medicare are eligible based on age due to age-eligibility at 65 years, individuals younger than 65 years of age may be eligible based on disability status or specific clinical conditions (eg, end-stage kidney disease). Individuals are included in the SEER-Medicare database if they are enrolled in Medicare at any time, which may be before, after, or at the time of their cancer diagnosis. The cancer registry data are included in the SEER Cancer file. Medicare enrollment data come from the Master Beneficiary Summary File, and Medicare fee-for-service claims data include the Medicare Provider Analysis and Review (in-patient), carrier claims (National Claims History; individual health-care professional billing), outpatient (institute provider), home health agencies, hospice, and durable medical equipment files, while Medicare Part D utilization data come from the Part D Event files. The study was determined to be not human subjects research by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board and the National Institutes of Health Office of Human Subjects Research Protection.

Overview of HUD programs
Across HUD program categories, recipients of federal housing assistance receive a subsidy that limits their household contribution to rent and utilities to approximately 30% of their income. There are 3 main forms of assistance: the Housing Choice Voucher program, public housing, and assisted multifamily programs. The Housing Choice Voucher program, the largest of the HUD program categories, allows recipients to choose housing options in the private market that meet program requirements. Public housing is owned and operated by state and local housing authorities. Multifamily housing includes a range of distinct programs in which private landlords contract for subsidies tied to specific projects. The different forms of assistance may provide differential access to place-based social support, clinical care, transportation, food access, and social networks.

HUD collects detailed administrative data on individuals and households participating in each program, including information about dates of program initiation, recertifications, and program changes. These records are reported from all states, the District of Columbia, and some US territories. HUD administrative data also include information about household composition and socioeconomic characteristics (eg, verified household income and self-reported race and ethnicity).

Linkage of individuals in the SEER-Medicare data to the HUD files
Individuals identified as having any interaction with HUD public and assisted housing programs from 2006 through 2021 were linked to the SEER data for diagnoses from 2006 through 2019 using Match*Pro probabilistic linkage software (National Cancer

Institute, Bethesda, MD) (30). Variables used for matching were Social Security number, first name, middle initial, last name, sex, date of birth, and state-county census tract (11-digit). Weights were assigned to each variable based on that variable's importance in identifying matches. Because individuals may move, census tracts were used as a secondary criterion (eg, when Social Security numbers were unavailable), and matches were considered if the census tract at diagnosis from SEER matched to any of the tracts from the HUD data. Probability scores for potential matches were assigned based on which matching variables were identical. Thresholds for probability scores to define both matches and nonmatches were determined in advance to maximize positive predictive value. Scores above the nonmatch threshold but below the match threshold (52 817 scores) were then manually reviewed. To improve consistency in this review, the research team discussed potential variable matching scenarios to establish consensus on whether they would be included or excluded (Supplementary Methods, available online). Linkages were limited to an individual's first cancer diagnosis.

Construction of housing assistance episodes with respect to cancer diagnosis

Participation "episodes" of HUD assistance define distinct time periods during which an individual received assistance from any program category and were defined using longitudinal transaction records from 2006 to 2021 (Supplementary Methods and Supplementary Figure 1, available online). Each episode of housing assistance may include multiple transaction records, and a participant may have multiple, distinct episodes of HUD assistance over time.

Episodes of housing assistance were constructed relative to the timing of an individual's cancer diagnosis (Supplementary Figure 2, available online). We defined individuals with housing assistance at the time of diagnosis as those with continuous housing assistance that started at least 6 months before the month of diagnosis and continuing for 6 months or more after diagnosis or until death, whichever occurred first. These time periods were selected to allow for sufficient exposure to housing assistance in ways that may affect cancer screening, diagnosis, or treatment.

Housing assistance is not an entitlement program: Only about one-quarter of eligible low-income families receive assistance (31). Local housing authorities use waitlists to allocate the limited supply of housing assistance. In many jurisdictions, waitlists open for short periods, and then households are randomly selected from the waitlist as housing units become available. Though there may be some preferences in the waitlist based on factors such as income and homelessness, preferences are not based on cancer diagnosis (32,33). No reliable national data source of housing assistance waitlists exists, but researchers have used the timing of housing assistance receipt to identify individuals who may have been on the waitlist at varying time points who can serve as control groups to help reduce potential confounding in analyses comparing individuals with and without housing assistance (34,35). We defined individuals with future housing assistance as those who received housing assistance that started between 6 months and 3 years after the diagnosis month and did not have assistance at the time of their diagnosis. We also constructed a group of individuals who did not have recent housing assistance, which we defined as those without housing assistance in the 3 years before and 3 years after diagnosis.

Participants were excluded from the sample if they were diagnosed before July 2006 so that HUD assistance for the 6 months before diagnosis could be ascertained for all individuals. Other exclusions were applied for the purposes of describing the sample (eg, cancer being diagnosed at autopsy or death) (Supplementary Figure 3, available online).

We present the sociodemographic and clinical characteristics for participants in each of these different subpopulations based on HUD program episodes, recognizing that researchers will want to tailor these episode definitions to their particular research questions. We do not perform statistical tests of differences but instead describe overall trends in the samples. Descriptions of the files available for researchers are presented in Supplementary Methods (available online) and are available on the SEER-Medicare website (36).

Results

The SEER-Medicare dataset includes 5 186 369 incident cancer cases from 2006 through 2019, and HUD administrative data included 26 120 930 unique individuals who received assistance at any point from 2006 to 2021 (Supplementary Figure 3, available online). Between these 2 sources, a total of 355 490 unique individual matches were identified in the SEER-Medicare-HUD linked data, representing 6.47% of the SEER-Medicare population. After applying exclusions, 297 664 were included in the matched sample. Of those matches, we classified 156 794 as having housing assistance at diagnosis (assistance from 6 months before diagnosis until 6 months after diagnosis or death), 24 596 as having "future housing assistance" (HUD assistance 7-36 months after diagnosis), and 28 959 as not having recent housing assistance (no assistance in the 36 months before or after diagnosis). For descriptive purposes, we combined the 28 959 individuals with no HUD assistance within 3 years of diagnosis with the remaining 4 528 300 who did not match HUD records at any time point but otherwise met inclusion criteria. An additional 87 295 people did not meet our inclusion criteria based on timing of their HUD assistance relative to their cancer diagnosis; they were excluded from descriptive analyses.

Overall sample characteristics

Among individuals receiving HUD assistance at the time of their cancer diagnosis, 24.6% were younger than 65 years of age, 17.7% were aged 65 to 69 years, 33.8% were aged 70 to 79 years, and 24.0% were 80 years of age or older (Table 1 and Supplementary Table 1, available online). Approximately two-thirds (63.4%) of these individuals were women, 27.2% were racialized as non-Hispanic Black, 45.4% were non-Hispanic White, and 18.6% were Hispanic. At the time of diagnosis, half (52.3%) had Medicare fee for service (parts A, B, and D), 28.7% were enrolled in Medicare Advantage with Part D, and more than half (55.2%) had full Medicaid coverage. The most common cancer types were lung (17%), followed by breast (16.2%), colorectal (10.3%), and prostate (8.7%). Individuals were enrolled in housing assistance for a median of 61 months, including a median of 30 months before diagnosis. Their median household income was $11 900.

Individuals who received their housing assistance after diagnosis (future housing assistance) tended to be younger (47.9% <65 years of age), 57.2% were women, 27.1% were non-Hispanic Black, 48.0% were non-Hispanic White, and 16.8% were Hispanic. Among the future HUD cohort, fewer were enrolled in either Medicare fee-for-service parts A, B, and D (36.2%) or Medicare Advantage with Part D (21.1%); one-third (31.3%) had full

Table 1. Characteristics of individuals diagnosed with cancer, July 2006-2019, SEER-Medicare-HUD data linkage

Characteristic	HUD at diagnosis[a]	Future HUD[b]	Not recent HUD[c]
No. (%)	156 794 (100)	24 596 (100)	4 557 259 (100)
Age at diagnosis, No. (%), y			
<65	38 547 (24.6)	11 785 (47.9)	1 241 223 (27.2)
65-69	27 669 (17.7)	5191 (21.1)	976 326 (21.4)
70-79	53 003 (33.8)	5742 (23.4)	1 460 244 (32.0)
≥80	37 575 (24.0)	1878 (7.6)	879 466 (19.3)
Sex, No. (%)			
Male	57 324 (36.6)	10 531 (42.8)	2 385 263 (52.3)
Female	99 470 (63.4)	14 065 (57.2)	2 171 996 (47.7)
Race and ethnicity, No. (%)			
Non-Hispanic White	71 179 (45.4)	11 800 (48.0)	3 474 111 (76.2)
Non-Hispanic Black	42 597 (27.2)	6675 (27.1)	410 092 (9.0)
Non-Hispanic American Indian or Alaska Native	494 (0.3)	89 (0.4)	15 398 (0.3)
Non-Hispanic Asian or Pacific Islander	12 710 (8.1)	1766 (7.2)	201 571 (4.4)
Hispanic (all races)	29 111 (18.6)	4141 (16.8)	421 669 (9.3)
Non-Hispanic and unknown race	703 (0.5)	125 (0.5)	34 418 (0.8)
Medicare coverage,[d] No. (%)			
Not entitled at diagnosis	14 830 (9.5)	7610 (30.9)	983 429 (21.6)
Fee for service, Part A but not Part B	2178 (1.4)	576 (2.3)	242 393 (5.3)
Fee for service, parts A and B only	7354 (4.7)	1680 (6.8)	940 825 (20.6)
Fee for service, parts A, B, and D	81 947 (52.3)	8910 (36.2)	1 291 859 (28.4)
Medicare Advantage without Part D	663 (0.4)	128 (0.5)	55 631 (1.2)
Medicare Advantage with Part D	45 050 (28.7)	5194 (21.1)	1 016 020 (22.3)
Fee for service, Part B but not Part A	4772 (3.0)	498 (2.0)	27 102 (0.6)
Medicaid coverage,[e] No. (%)			
Not Medicare at diagnosis, unknown Medicaid	13 183 (8.4)	6977 (28.4)	901 566 (19.8)
Not Medicare	1647 (1.1)	633 (2.6)	81 863 (1.8)
Medicare, not Medicaid	35 519 (22.7)	6562 (26.7)	3 087 503 (67.8)
Medicare, full Medicaid	86 470 (55.2)	7702 (31.3)	348 381 (7.6)
Medicare, partial Medicaid	19 975 (12.7)	2722 (11.1)	137 946 (3.0)
SEER registry, No. (%)			
California	31 718 (20.2)	4241 (17.2)	1 006 873 (22.1)
Connecticut	5884 (3.8)	850 (3.5)	142 211 (3.1)
Detroit	5094 (3.3)	920 (3.7)	152 763 (3.4)
Georgia	7528 (4.8)	1593 (6.5)	338 005 (7.4)
Hawaii	1334 (0.9)	212 (0.9)	49 023 (1.1)
Idaho	737 (0.5)	202 (0.8)	56 001 (1.2)
Iowa	3050 (2.0)	727 (3.0)	130 581 (2.9)
Kentucky	5481 (3.5)	1197 (4.9)	192 175 (4.2)
Louisiana	4343 (2.8)	1092 (4.4)	175 648 (3.9)
Massachusetts	14 821 (9.5)	2105 (8.6)	242 852 (5.3)
New Jersey	14 052 (9.0)	1985 (8.1)	338 356 (7.4)
New Mexico	1172 (0.8)	298 (1.2)	66 444 (1.5)
New York	41 831 (26.7)	5037 (20.5)	715 956 (15.7)
Seattle	5016 (3.2)	734 (3.0)	172 670 (3.8)
Texas	13 684 (8.7)	3192 (13.0)	708 753 (15.6)
Utah	1049 (0.7)	211 (0.9)	68 948 (1.5)
Cancer site, No. (%)			
Bladder	5778 (3.7)	967 (3.9)	209 592 (4.6)
Female breast	25 422 (16.2)	5115 (20.8)	693 518 (15.2)
Cervix	1252 (0.8)	291 (1.2)	17 484 (0.4)
Colon/rectal	16 108 (10.3)	2721 (11.1)	398 651 (8.8)
Esophagus	1581 (1.0)	124 (0.5)	42 862 (0.9)
Kidney	4970 (3.2)	966 (3.9)	149 195 (3.3)
Lymphoma	6091 (3.9)	1024 (4.2)	193 633 (4.3)
Leukemia	3501 (2.2)	526 (2.1)	115 489 (2.5)
Liver/inflammatory bowel disease	5321 (3.4)	475 (1.9)	80 093 (1.8)
Lung	26 664 (17.0)	2201 (9.0)	552 392 (12.1)
Oral cavity	3100 (2.0)	596 (2.4)	97 469 (2.1)
Ovary	2073 (1.3)	273 (1.1)	54 644 (1.2)
Pancreas	5255 (3.4)	203 (0.8)	125 196 (2.8)
Prostate	13 639 (8.7)	3692 (15.0)	749 296 (16.4)
Uterus	6081 (3.9)	1013 (4.1)	140 119 (3.1)
Other cancers	29 958 (19.1)	4409 (17.9)	937 626 (20.6)
HUD program, No. (%)			
Not HUD matched	—	—	4 528 300 (99.4)
Housing Choice Voucher	59 930 (38.2)	8943 (36.4)	10 589 (0.2)
Public housing	34 418 (22.0)	4738 (19.3)	4636 (0.1)
Private multifamily	62 446 (39.8)	10 915 (44.4)	13 734 (0.3)
Yost Area–Level Socioeconomic Status Index quintile,[f] No. (%)			
Missing or blank	9252 (5.9)	700 (2.9)	90 584 (2.0)
First	58 918 (37.6)	8304 (33.8)	650 532 (14.3)
Second	31 226 (19.9)	5189 (21.1)	733 150 (16.1)

Table 1. (continued)

Characteristic	HUD at diagnosis[a]	Future HUD[b]	Not recent HUD[c]
Third	22 670 (14.5)	4129 (16.8)	836 616 (18.4)
Fourth	20 333 (13.0)	3670 (14.9)	1 008 411 (22.1)
Fifth	14 395 (9.2)	2604 (10.6)	1 237 966 (27.2)
HUD assistance episode duration,[g] median (IQR), mo	61 (75)	31 (48)	26 (36)
Total annual family income[h], median (IQR)	$11 900 ($8000)	$12 600 ($8500)	$13 900 ($9000)

[a] The HUD at Diagnosis received continuous HUD assistance from 6 months before diagnosis to 6 months after diagnosis or until death if the recipient died less than 6 months after diagnosis. HUD = US Department of Housing and Urban Development; IQR = Interquartile Range; SEER, Surveillance, Epidemiology, and End Results.
[b] The Future HUD had no periods of HUD assistance from 3 years before the month of diagnosis to 6 months after diagnosis and received HUD assistance in the period between 6 months and 3 years after their cancer diagnosis.
[c] The Not Recent HUD either I) did not receive HUD assistance from 3 years before diagnosis to 3 years after diagnosis or until death or 2) did not match to any HUD data. Individuals diagnosed in July 2006 to 2009 would not have had 3 full years of HUD data to compare with but may be included in this group.
[d] Medicare coverage in the month of diagnosis. Individuals are included in the SEER-Medicare database if enrolled in Medicare at any time, regardless of enrollment at diagnosis. Individuals may be eligible for Medicare based on age, disability status, or specific clinical conditions (eg, end-stage kidney disease, amyotrophic lateral sclerosis).
[e] Medicaid coverage in the month of diagnosis.
[f] Yost Area–Level Socioeconomic Status Index quintiles are based on American Community Survey data using national cut points by diagnosis year: cases were diagnosed between 2006 and 2009 using American Community Survey 2006-2010 data, cases between 2010 and 2012 using American Community Survey 2010-2014 data, and cases from 2013 on using American Community Survey 2013-2017 data.
[g] For individuals who ever matched HUD data, the episode described is the closest to diagnosis and starts before diagnosis. Otherwise, the episode closest to diagnosis that starts after diagnosis is used.
[h] Total family income is available for individuals who ever matched HUD data and reported in dollars at the nearest available time point before diagnosis for individuals receiving HUD assistance at diagnosis, at the nearest available time point after diagnosis for individuals with future HUD assistance, and the nearest time point before or after diagnosis for the Not Recent HUD cohort.

Medicaid coverage. Their median length of housing assistance was 31 months, and their median income was $12 600.

Among individuals without recent housing assistance, approximately one-quarter (27.2%) were younger than 65 years of age at diagnosis, fewer than half (47.7%) were women, and 9.0% were non-Hispanic Black. For insurance, 28.4% were in Medicare fee for service (Parts A, B, and D), 22.3% were in Medicare Advantage, and 7.6% had full Medicaid coverage.

Sample characteristics among Medicare fee-for-service beneficiaries

Limiting the sample to individuals aged 66 years or older at diagnosis with continuous Medicare fee-for-service part A and B coverage for 12 months before diagnosis and 6 months following diagnosis (or death), there were 63 251 individuals with housing assistance at the time of their diagnosis and 5833 with future housing assistance (Table 2). Those with housing assistance at diagnosis tended to have an older age distribution and a higher proportion of women than those who went on to receive housing assistance in the future. The sample with housing assistance at diagnosis included 12 035 individuals with lung cancer (19.0%), 8866 (14.0%) with female breast cancer, 7261 (11.5%) with colorectal cancer, and 4703 (7.4%) with prostate cancer.

Table 3 stratifies individuals with continuous Medicare fee-for-service part A and B enrollment and housing assistance at the time of their diagnosis by housing assistance type. Overall, 21 074 (33.3%) individuals had housing choice vouchers, 11 840 (18.7%) had public housing, and 30 337 (48%) had multifamily housing. The characteristics across the 3 housing program categories suggest that individuals with multifamily housing had an older age distribution, and those in public housing were more likely to be non-Hispanic Black than individuals with other types of housing assistance.

Discussion

As the affordable housing crisis in the United States continues to grow (13), data for research examining associations among housing, cancer care, and patient outcomes have been limited. For most American families, housing represents a household's largest monthly expense and may contribute to the unequal burden

of cancer through a wide range of pathways (19,24,25). This novel SEER-Medicare-HUD data linkage provides research resources for examining the role of safe, affordable housing, focusing on the receipt of federal housing assistance and its timing to a first cancer diagnosis.

The linked dataset has multiple strengths for research, including its objective data on cancer characteristics, health-care use, and housing assistance and its large sample size, allowing researchers to explore overall associations along with heterogeneity between cancer sites. Researchers may wish to compare those with housing assistance at the time of diagnosis with those who receive it at a future date as 1 way to reduce potential unobserved confounding. This approach, however, has potential limitations, including that it assumes that subsequent receipt of housing assistance was unaffected by a cancer diagnosis and treatment, and it requires that individuals survive long enough to observe them coming off the waitlist after their cancer diagnosis. These and other methodological questions will require careful exploration.

There exist long-standing inequities in housing status across racialized and ethnic groups. Households racialized as Black are significantly less likely to be homeowners and more likely to be cost burdened by their housing, experience eviction, and have other forms of housing insecurity (13,37). These inequities reflect a long history of systemic racism in housing policies, including redlining in mortgage lending, racial covenants, and exclusionary zoning (15). Latino individuals, Native American individuals, people with disabilities, and other groups have also experienced systemic discrimination and inequities in housing that may contribute to poorer cancer outcomes (38). The presented data linkage creates opportunities to explore the extent to which the receipt of federal housing assistance may contribute to or help ameliorate inequities in cancer across the continuum. The fact that more than one-quarter of the sample with current housing assistance is racialized as Black compared with less than 10% of those without recent housing assistance underscores the potential importance of housing and housing assistance when investigating root causes of inequities.

Researchers may use the SEER-Medicare-HUD linked data to investigate how associations differ across forms of housing assistance. Each housing assistance program category is designed to

Table 2. Timing of HUD assistance and cancer diagnosis among individuals continuously enrolled in Medicare fee for service parts A and B and aged 66 years or older at diagnosis, SEER-Medicare-HUD linkage, July 2006-2019[a]

Characteristic	HUD at diagnosis[b]	Future HUD[c]
No. (%)	63 251 (100.0)	5833 (100.0)
Age at diagnosis, No. (%), y		
66-69	11 071 (17.5)	1847 (31.7)
70-79	28 776 (45.5)	2881 (49.4)
≥80	23 404 (37.0)	1105 (18.9)
Sex, No. (%)		
Male	22 442 (35.5)	2457 (42.1)
Female	40 809 (64.5)	3376 (57.9)
Race and ethnicity, No. (%)		
Non-Hispanic White	35 792 (56.6)	3451 (59.2)
Non-Hispanic Black	11 889 (18.8)	1093 (18.7)
Non-Hispanic American Indian or Alaska Native	170 (0.3)	12 (0.2)
Non-Hispanic Asian or Pacific Islander	6351 (10.0)	519 (8.9)
Hispanic (all races)	8768 (13.9)	733 (12.6)
Non-Hispanic and unknown race	281 (0.4)	25 (0.4)
Medicare coverage, No. (%)		
Fee for service, part A and B only	5714 (9.0)	1101 (18.9)
Fee for service, parts A, B, D	57 537 (91.0)	4732 (81.1)
Medicaid coverage, No. (%)		
Medicare, not Medicaid	15 787 (25.0)	2489 (42.7)
Medicare, full Medicaid	40 190 (63.5)	2605 (44.7)
Medicare, partial Medicaid	7274 (11.5)	739 (12.7)
Cancer site, No. (%)		
Bladder	2836 (4.5)	341 (5.9)
Female breast	8866 (14.0)	1162 (19.9)
Cervix	372 (0.6)	31 (0.5)
Colon/rectal	7261 (11.5)	744 (12.8)
Esophagus	617 (1.0)	33 (0.6)
Kidney	1809 (2.9)	204 (3.5)
Lymphoma	2506 (4.0)	237 (4.1)
Leukemia	1539 (2.4)	114 (2.0)
Liver/inflammatory bowel disease	1892 (3.0)	79 (1.4)
Lung	12 035 (19.0)	604 (10.4)
Oral cavity	1079 (1.7)	96 (1.7)
Ovary	884 (1.4)	61 (1.1)
Pancreas	2421 (3.8)	44 (0.8)
Prostate	4703 (7.4)	913 (15.7)
Uterus	2024 (3.2)	181 (3.1)
Other cancers	12 407 (19.6)	989 (17.0)
HUD program, No. (%)		
Housing Choice Voucher	21 074 (33.3)	1768 (30.3)
Public housing	11 840 (18.7)	1022 (17.5)
Private multifamily	30 337 (48.0)	3043 (52.2)
HUD episode duration,[d] median (IQR), mo	69 (73)	33 (48)
Total annual family income,[e] median (IQR)	$11 900 ($7500)	$13 900 ($9000)
Disability, No. (%)		
Yes	474 (0. 8)	40 (0.7)
Household structure,[f] No. (%)		
Elderly, no children	61 173 (96.7)	5640 (96.7)
Disabled, no children	375 (0.6)	33 (0.6)
Not disabled, no children	187 (0.3)	33 (0.6)
Elderly, with children	1105 (1.8)	91 (1.6)
Disabled, with children	99 (0.2)	—
Have children	255 (0.4)	24 (0.4)
Missing	57 (0.1)	—
Yost Area–Level Socioeconomic Status Index quintile,[g] No. (%)		
Missing or blank	2914 (4.6)	144 (2.5)
First	20 972 (33.2)	1672 (28.7)
Second	13 139 (20.8)	1221 (20.9)
Third	9874 (15.6)	1050 (18.0)
Fourth	9148 (14.5)	952 (16.3)
Fifth	7204 (11.4)	794 (13.6)
High poverty in census tract, No. (%)		
≥30.1%	15 436 (24.4)	1313 (22.5)

[a] Continuous enrollment in Medicare fee for service parts A and B was required for the 12 months before diagnosis until 6 months after diagnosis or death, whichever occurred first. HUD = US Department of Housing and Urban Development. IQR = Interquartile Range; SEER = Surveillance, Epidemiology, and End Results.

[b] The HUD at Diagnosis received continuous HUD assistance from 6 months before diagnosis to 6 months after diagnosis or until death if the recipient died less than 6 months after diagnosis.

[c] The Future HUD had no periods of HUD assistance from 3 years before the month of diagnosis to 6 months after diagnosis and received HUD assistance in the period between 6 months and 3 years after their cancer diagnosis.

[d] For individuals receiving HUD assistance at diagnosis, the episode described is the closest to diagnosis and starts before diagnosis. For the future HUD cohort, the episode closest to diagnosis that starts after diagnosis is described.

[e] Total annual family income is reported in dollars at the nearest available time point before diagnosis for individuals receiving HUD assistance at diagnosis and at the nearest available time point after diagnosis for individuals with future HUD assistance.

[f] "—" denotes a cell suppressed for privacy concerns because HUD does not allow reporting cell sizes where n < 11. HUD is aware that the term *elderly* is being phased out in favor of the preferred term *older adults*; however, the term *elderly* continues to be used for HUD programs because the term is used to define a key programmatic population in extant legislation and regulations, including the Housing Act of 1937.

[g] Yost Area–Level Socioeconomic Status Index quintiles are based on American Community Survey data using national cut points by diagnosis year: cases diagnosed between 2006 and 2009 using American Community Survey 2006-2010 data, cases between 2010 and 2012 using American Community Survey 2010-2014 data, and cases from 2013 on using American Community Survey 2013-2017 data.

Table 3. Type of HUD assistance at cancer diagnosis among individuals continuously enrolled in Medicare fee for service parts A and B and aged 66 years or older at diagnosis, SEER-Medicare-HUD linkage, July 2006-2019[a]

Characteristic	Housing Choice Voucher	Public housing	Private multifamily
No. (%)	21 074 (100.0)	11 840 (100.0)	30 337 (100.0)
Age at diagnosis, No. (%), y			
66-69	4485 (21.3)	2451 (20.7)	4135 (13.6)
70-79	9785 (46.4)	5609 (47.4)	13 382 (44.1)
≥80	6804 (32.3)	3780 (31.9)	12 820 (42.3)
Sex, No. (%)			
Male	7386 (35.1)	4498 (38.0)	10 558 (34.8)
Female	13 688 (65.0)	7342 (62.0)	19 779 (65.2)
Race and ethnicity, No. (%)			
Non-Hispanic White	12 168 (57.7)	5480 (46.3)	18 144 (59.8)
Non-Hispanic Black	3994 (19.0)	3311 (28.0)	4584 (15.1)
Non-Hispanic American Indian or Alaska Native	71 (0.3)	24 (0.2)	75 (0.3)
Non-Hispanic Asian or Pacific Islander	1665 (7.9)	657 (5.6)	4029 (13.3)
Hispanic (all races)	3060 (14.5)	2335 (19.7)	3373 (11.1)
Non-Hispanic and unknown race	116 (0.6)	33 (0.3)	132 (0.4)
Medicare coverage, No. (%)			
Fee for service, parts A and B only	1112 (5.3)	1492 (12.6)	3110 (10.3)
Fee for service, parts A, B, and D	19 962 (94.7)	10 348 (87.4)	27 227 (89.8)
Medicaid coverage, No. (%)			
Medicare, not Medicaid	3471 (16.5)	3483 (29.4)	8833 (29.1)
Medicare, full Medicaid	15 473 (73.4)	6862 (58.0)	17 855 (58.9)
Medicare, partial Medicaid	2130 (10.1)	1495 (12.6)	3649 (12.0)
Cancer site, No. (%)			
Bladder	919 (4.4)	485 (4.1)	1432 (4.7)
Female breast	2978 (14.1)	1626 (13.7)	4262 (14.1)
Cervix	131 (0.6)	72 (0.6)	169 (0.6)
Colon/rectal	2341 (11.1)	1364 (11.5)	3556 (11.7)
Esophagus	180 (0.9)	144 (1.2)	293 (1.0)
Kidney	624 (3.0)	302 (2.6)	883 (2.9)
Lymphoma	843 (4.0)	432 (3.7)	1231 (4.1)
Leukemia	510 (2.4)	273 (2.3)	756 (2.5)
Liver/inflammatory bowel disease	714 (3.4)	356 (3.0)	822 (2.7)
Lung	4015 (19.1)	2419 (20.4)	5601 (18.5)
Oral cavity	334 (1.6)	194 (1.6)	551 (1.8)
Ovary	306 (1.5)	149 (1.3)	429 (1.4)
Pancreas	845 (4.0)	445 (3.8)	1131 (3.7)
Prostate	1474 (7.0)	1018 (8.6)	2211 (7.3)
Uterus	736 (3.5)	389 (3.3)	899 (3.0)
Other cancers	4124 (19.6)	2172 (18.3)	6111 (20.1)
HUD episode duration,[b] median (IQR), mo	62 (69)	64.5 (72)	73 (81)
Total annual family income,[c] median (IQR)	$11 650 ($7200)	$11 800 ($8600)	$12 100 ($7300)
Disability, No. (%)			
Yes	356 (1.7)	79 (0.7)	39 (0.1)
Household structure,[d] No. (%)			
Elderly, no children	19 786 (93.9)	11 357 (95.9)	30 030 (99.0)
Disabled, no children	277 (1.3)	65 (0.6)	33 (0.1)
Not disabled, no children	116 (0.6)	50 (0.4)	21 (0.1)
Elderly, with children	596 (2.8)	313 (2.6)	196 (0.7)
Disabled, with children	79 (0.4)	14 (0.1)	—
Have children	201 (1.0)	41 (0.4)	—
Missing	19 (0.1)	0 (0.0)	38 (0.1)
Yost Area–Level Socioeconomic Status Index quintile,[e] No. (%)			
Missing or blank	615 (2.9)	1083 (9.2)	1216 (4.0)
First	5879 (27.9)	5291 (44.7)	9802 (32.3)
Second	5002 (23.7)	2168 (18.3)	5969 (19.7)
Third	3999 (19.0)	1293 (10.9)	4582 (15.1)
Fourth	3254 (15.4)	1125 (9.5)	4769 (15.7)
Fifth	2325 (11.0)	880 (7.4)	3999 (13.2)
High poverty in census tract, No. (%)			
≥30.1%	4073 (19.3)	4410 (37.3)	6953 (22.9)

[a] Continuous enrollment in Medicare fee-for-service parts A and B was required for the 12 months before diagnosis until 6 months after diagnosis or death, whichever occurred first. HUD, US Department of Housing and Urban Development; IQR = Interquartile Range; SEER = Surveillance, Epidemiology, and End Results.

[b] The episode described is the closest to diagnosis and starts before diagnosis.

[c] Total family income is reported in dollars at the nearest available time point before diagnosis.

[d] "—" denotes a cell suppressed for privacy concerns because HUD does not allow reporting cell sizes where n < 11. In the case that only 1 cell had n < 11, the cells with the 2 lowest counts were suppressed. HUD is aware that the term *elderly* is being phased out in favor of the preferred term *older adults*; however, the term *elderly* continues to be used for HUD programs because the term is used to define a key programmatic population in extant legislation and regulations, including the Housing Act of 1937.

[e] Yost Area–Level Socioeconomic Status Index quintiles are based on American Community Survey data using national cut points by diagnosis year: cases diagnosed between 2006 and 2009 using American Community Survey 2006-2010 data, cases between 2010 and 2012 using American Community Survey 2010-2014 data, and cases from 2013 on using American Community Survey 2013-2017 data.

limit out-of-pocket spending on rent and utilities to 30% of household income; however, each program category has unique features that may be differently associated with cancer care and outcomes. For example, recipients of housing choice vouchers can rent units from landlords in the private market, which, in an ideal scenario, enables greater choice of housing units. In practice, this choice is often constrained by a variety of factors, including difficulties finding affordable units where landlords are willing to rent to voucher holders (39). The novel data linkage gives researchers opportunities to explore variation across HUD program categories, which may have particular relevance for policy makers.

One mechanism that previously been identified in the association between housing assistance status and health outcomes is that of neighborhood context (40-42). By matching the linked data with information on tract-level characteristics obtained from the American Community Survey, researchers can explore how associations for cancer across the continuum vary across different neighborhood contexts and over time.

Researchers can also use the data to examine how housing assistance, including different types of housing assistance, heterogeneity across populations, and neighborhood context, affect a range of cancer care and outcomes. For example, a recent systematic review identified few studies examining the association between housing and the quality of cancer care and end-of-life care (19).

This data linkage has several potential limitations that researchers should consider. First, there is the potential for incomplete or inaccurate data linkage, including undercounting of individuals receiving HUD assistance who are diagnosed with cancer within a SEER geographic region but who do not match. Second, HUD administrative data do not consistently document when a participant exits a program; episode end dates were defined using all transaction types, and they assume that participants retain assistance until the end of the recertification window. This approach may lead to misclassified HUD assistance episodes as longer than they were if participants left the program before the end of the recertification window. Third, generalizability is limited to SEER registry locations and Medicare fee-for-service beneficiaries. Medicare Advantage utilization data are not currently available within SEER-Medicare, although the NCI is investigating their release in the future. The proportion of older adults enrolled in Medicare Advantage has increased to more than half of Medicare beneficiaries, albeit with market variation by state and county (43). Recently, Medicare Advantage enrollees have been disproportionately lower-income, Black, or Latino, individuals; dually enrolled in Medicaid; and living in urban areas compared with Medicare fee-for-service beneficiaries (43,44). Fourth, the current linkage includes only an individual's first cancer diagnosis. Finally, there is a delay between cancer diagnoses and services provided and data availability for research. As such, it may be difficult to investigate recent events, including, for example, the intersection between housing policies put in place during the COVID-19 pandemic; federal rental assistance; and cancer diagnoses, treatment, and outcomes.

In summary, the novel SEER-Medicare-HUD data linkage offers an important linked data resource with which to explore the ways in which housing assistance is associated with cancer diagnosis and patient outcomes across the cancer care continuum, including the role of housing assistance status in potentially reducing or contributing to inequities across racialized and ethnic groups. These data will be made available to researchers through the NCI's SEER-Medicare data request process.

Data availability

Researchers can apply to use the new data linkage using the SEER-Medicare data request process at https://healthcaredelivery.cancer.gov/seermedicare/obtain/requests.html.

Author contributions

Craig Evan Pollack, MD, MHS (Conceptualization; Funding acquisition; Investigation; Methodology; Supervision; Writing—original draft); Veronica Garrison, MPH (Conceptualization; Investigation; Methodology; Supervision; Writing—review & editing); Taylor Johnson, MHS (Conceptualization; Investigation; Methodology; Project administration; Visualization; Writing—review & editing); Amanda L. Blackford, ScM (Investigation; Methodology; Visualization; Writing—review & editing); Bob Banks, BS (Data curation; Formal analysis; Investigation; Methodology; Project administration; Validation; Writing—review & editing); William Howe, BS, BA (Data curation; Formal analysis; Investigation; Methodology; Project administration; Validation; Writing—review & editing); K. Robin Yabroff, PhD (Conceptualization; Funding acquisition; Investigation; Methodology; Supervision; Writing—review & editing); Lindsey Enewold, MPH, PhD (Conceptualization; Investigation; Methodology; Supervision; Writing—review & editing).

Conflicts of interest

C.E.P. reports stock ownership in Gilead Pharmaceuticals. From September 2019 to July 2022, Johns Hopkins entered into a contract with HUD for C.E.P. to work part time on a temporary assignment, assisting the agency on housing and health issues. K.R.Y. has served on the Flatiron Health Equity Advisory Board; all honoraria are donated to her employer, the American Cancer Society. K.R.Y. also has received honoraria from the National Comprehensive Cancer Network for workgroup participation.

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