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Article

Transportation barriers, emergency room use, and mortality risk among US adults by cancer history

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Abstract

Background: Lack of safe, reliable, and affordable transportation is a barrier to medical care, but little is known about its association with clinical outcomes.

Methods: We identified 28 640 adults with and 470 024 adults without a cancer history from a nationally representative cohort (2000-2018 US National Health Interview Survey) and its linked mortality files with vital status through December 31, 2019. Transportation barriers were defined as delays in care because of lack of transportation. Multivariable logistic and Cox proportional hazards models estimated the associations of transportation barriers with emergency room (ER) use and mortality risk, respectively, adjusted for age, sex, race and ethnicity, education, health insurance, comorbidities, functional limitations, and region.

Results: Of the adults, 2.8% (n = 988) and 1.7% (n = 9685) with and without a cancer history, respectively, reported transportation barriers; 7324 and 40 793 deaths occurred in adults with and without cancer history, respectively. Adults with a cancer history and transportation barriers, as compared with adults without a cancer history or transportation barriers, had the highest likelihood of ER use (adjusted odds ratio [aOR] = 2.77, 95% confidence interval [CI] = 2.34 to 3.27) and all-cause mortality risk (adjusted hazard ratio [aHR] = 2.28, 95% CI = 1.94 to 2.68), followed by adults without a cancer history with transportation barriers (ER use aOR = 1.98, 95% CI =1.87 to 2.10; all-cause mortality aHR = 1.57, 95% CI = 1.46 to 1.70) and adults with a cancer history but without transportation barriers (ER use aOR = 1.39, 95% CI = 1.34 to 1.44; all-cause mortality aHR = 1.59, 95% CI = 1.54 to 1.65).

Conclusion: Delayed care because of lack of transportation was associated with increased ER use and mortality risk among adults with and without cancer history. Cancer survivors with transportation barriers had the highest risk.

The number of cancer survivors has grown rapidly in the United States, from 10 million in 2002 to 18 million in 2022 and is projected to reach 22.1 million by 2031 (1,2). Individuals with a cancer history (hereafter, cancer survivors) are a population with high health-care needs and increased risk of developing comorbid illnesses and secondary cancers (3). Timely access to care is critical for cancer survivors to optimize their health outcomes (4).

Transportation barriers can impede timely health-care access and adherence to recommended preventive care and treatment (4-6). In 2017, nearly 6 million people in the United States delayed their care because of a lack of safe, reliable, and affordable transportation (7). Transportation barriers can be especially problematic for patients with cancer because they frequently receive multiple treatment modalities, such as radiation therapy, which often requires daily treatment for weeks (6). Moreover, patients with a cancer history may have more health-related transportation needs than the general population. They often have physical limitations and require more medical attention for their cancer, treatment complications, or other comorbid illnesses, and such high health-related transportation needs can persist through survivorship (8-10). In a recent nationally representative study, cancer survivors were more likely to report transportation barriers than adults without a cancer history (11). Factors associated with transportation barriers included younger age; being poor, uninsured, or publicly insured; unmarried; or with self-reported physical functional limitations (11). In addition, cancer survivors living in rural areas may face more transportation barriers and are at greater risk for a variety of poor health outcomes (12).

Less is known about the association of transportation barriers and care utilization and clinical outcomes; most prior research was conducted in small, single institution studies, and socioeconomically disadvantaged groups or minority groups were underrepresented (6,13-16).

In this study, we used a large, nationally representative cohort to examine the association of delays in care because of transportation barriers with emergency room (ER) use and mortality risk among cancer survivors and adults without a cancer history in the United States. Findings on clinical outcomes of

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transportation barriers may inform future social risk screening and intervention efforts to improve access to care.

Methods

Study participants

Adults with and without a cancer history were identified from the 2000-2018 National Health Interview Survey (NHIS) and NHIS Linked Mortality Files. The NHIS is an annual, cross-sectional, nationally representative in-person survey of the civilian, noninstitutionalized population of the United States. The annual response rate of NHIS was approximately 60% of the eligible adults during the study period (17). The NHIS Linked Mortality Files (18) were used to measure vital status for NHIS respondents through December 31, 2019, which provided 1-20 years of follow-up. Quarter and year of death were available for respondents who died during the study period. We included adults who met the following criteria: 1) reported if any delays in care due to transportation barriers; 2) reported if any ER use; 3) had valid vital status as of December 31, 2019. We only included adults aged 18-79 years because the NHIS does not provide single year of age for adults aged 80 years or older but rather groups them in a single age category, which limits survival analysis.

In the NHIS, participants were asked at the time of the survey whether a doctor or other health professional had told them that they had cancer or malignancy and, if yes, the type of cancer and diagnosis age. We excluded participants who reported only nonmelanoma skin cancer (2.0%, n = 10 429). In addition, we also dropped participants from sample if they had missing information on educational attainment (0.5%, n = 2274), health insurance coverage (0.4%, n = 1718), or functional limitations (0.1%, n = 460). (Supplementary Figure 1, available online).

Exposure

During in-person interviews, delays in care due to transportation barriers were measured by the question, "Have you delayed getting care in the past 12 months because you did not have transportation?"

Outcomes

ER use was measured by the question, "During the past 12 months, how many times have you gone to a hospital emergency room about your own health?" Participants were categorized as having "no ER use" vs "ER use" based on their responses.

All-cause and cancer deaths (International Classification of Diseases–10: C00-C97 for underlying cause of death) were identified at each year and quarter of death.

Covariates

Covariates were chosen based on previous research examining transportation barriers and existing knowledge on risk factors for poor outcomes among cancer survivors (4,11,19). Individuals reported their age, sex, race and ethnicity, educational attainment, marital status, and health insurance coverage. Functional limitations were measured from a series of questions about difficulty doing specific activities because of health issues, such as shopping, walking a quarter mile, or walking up 10 steps without resting. The number of comorbid conditions was based on a series of questions about history of hypertension, diabetes, coronary heart disease, stroke, chronic obstructive lung disease, kidney disease, liver diseases, arthritis, and morbid obesity (estimated by self-reported body mass index $\geq$40 kg/m^2 or $\geq$35 kg/m^2 with an obesity-related health condition [eg, hypertension, diabetes, heart disease, and any arthritis]). Because of the long time period included in the study, we accounted for economic and other secular trends with survey era (2000-2004, 2005-2009, 2010-2014, and 2015-2018).

Statistical analysis

Sample characteristics were compared using χ^2 tests by delays in care due to transportation barriers in cancer survivors and adults without a cancer history. Multivariable logistic regression was used to estimate the association between cancer history, transportation barriers, and ER use. After ensuring proportionality with visual inspection of log-log survival curves, we used weighted multivariable cox proportional hazards regression to examine the association of cancer history, transportation barriers, and all-cause mortality (20). Additionally, the sample was restricted to cancer survivors, and we used multivariable cox regression models to estimate the association of transportation barriers and all-cause and cancer-specific mortality. Age at survey was used as the timescale in all survival analyses, as recommended for analyses of household survey–mortality data linkages (20). This approach is equivalent to controlling for single year of age.

Covariates in multivariable models included age (in 5-year intervals), sex, race and ethnicity, educational attainment, health insurance coverage, functional limitations, number of comorbidity illnesses, and survey era. Cancer type (breast cancer, colorectal cancer, prostate cancer, and others), and time since cancer diagnosis (0-1 year, 2-5 years, 6-10 years, 11-15 years, and $\geq$16 years) were further adjusted in the models for cancer survivors' cause-specific mortalities.

To better describe the association of transportation barriers and ER visits, we conducted sensitivity analyses using frequent ER use (3 times or more in the past 12 months) as an outcome. To further minimize the potential confounding effects from various active cancer treatment, we performed additional sensitivity analysis limiting samples to long-term cancer survivors more than 5 years postdiagnosis at the survey.

All analyses used SAS statistical software, version 9.4 (SAS Institute Inc, Cary, NC, USA). All statistical significance testing was 2-sided at P values less than .05. All analyses used survey weights to account for the complex design of the NHIS Linked Mortality File and survey nonresponse (21). Data analyses were performed from April 1, 2022, to February 9, 2023.

The NHIS data are de-identified and publicly available. This study was exempt from institutional review board review by the Office of Research Subject Protection at the Roswell Park Comprehensive Cancer Center.

Results

Participants' characteristics and transportation barriers to care

A total of 28 640 adult cancer survivors and 470 024 adults without a cancer history aged 18-79 years were included in the study. Delays in care due to transportation barriers in the 12 months prior to the survey were reported by 2.8% (n = 988) of survivors and 1.7% (n = 9685) of adults without a cancer history. Regardless of cancer history, transportation barriers to care were statistically significantly more common among females, people who were Hispanic or non-Hispanic Black, unmarried, uninsured or public insurance beneficiaries, with functional limitations, less educational attainment, and with higher comorbidity burden. The majority (52.7%) of cancer survivors were long-term

survivors diagnosed more than 5 years before the survey. Younger cancer survivors had higher burden of transportation barriers (Table 1).

Transportation barriers to care and ER use

Of the adults, 27.5% of cancer survivors and 18.7% of those without a cancer history reported ER visits in the 12 months prior to the survey, respectively. After adjusting for covariates, cancer survivors with transportation barriers had the highest likelihood of ER use (odds ratio [OR] = 2.77, 95% confidence interval [CI] = 2.34 to 3.27), followed by adults without a cancer history with transportation barriers (OR = 1.98, 95% CI = 1.87 to 2.10), cancer survivors without transportation barriers (OR = 1.39, 95% CI = 1.34 to 1.44), and adults without a cancer history or transportation barriers (reference group) (Table 2).

Transportation barriers to care and all-cause mortality risk

During the study period, 23.9% and 7.2% of adults with and without a cancer history died, respectively. After adjusting for covariates, adults with a history of cancer and transportation barriers had the highest all-cause mortality risk (hazard ratio [HR] = 2.28, 95% CI = 1.94 to 2.68), followed by adults with a history of cancer but without transportation barriers (HR= 1.59, 95% CI = 1.54 to 1.65) and adults without a cancer history with transportation barriers (HR= 1.57, 95% CI = 1.46 to 1.70) and without transportation barriers (reference group) (Table 3).

Transportation barriers to care and cause-specific mortality risk among cancer survivors

Of the adults, 10.9% and 13.2% of those with a history of cancer died from cancer and noncancer causes, respectively. After further adjusting for covariates, including cancer type and time since diagnosis, transportation barriers were statistically significantly associated with higher all-cause (HR = 1.33, 95% CI = 1.14 to 1.54) and cancer-specific mortality risk (HR = 1.30, 95% CI = 1.03 to 1.64) (Table 4).

Sensitivity analyses

Associations between transportation barriers and frequent ER use were largely consistent with our main findings. (Supplementary Table 1, available online) Similarly, associations between transportation barriers and mortality were largely consistent in sensitivity analyses limited to long-term cancer survivors, who were diagnosed more than 5 years prior to the survey (Supplementary Table 2, available online).

Discussion

In this large, nationally representative study, we found that delays in care due to transportation barriers were statistically significantly associated with increased ER use and mortality risk in the United States. Furthermore, cancer survivors with transportation barriers had significantly higher ER use and all-cause and cancer-specific mortality risk than survivors without transportation barriers. Accumulating evidence suggests that patients with delayed medical care are more likely to have uncontrolled pain, anxiety, and poor health-related quality of life (7,14,22). Efforts to identify patients with transportation barriers to care and to address them will be an integral part of efforts to improve health-care delivery in all patients, especially in cancer patients and survivors.

Transportation barriers have direct implications for patient care. Our study showed greater likelihood of ER visits among cancer survivors with transportation barriers, consistent with previous results in the general population (7). When cancer survivors cannot address their health needs in the clinic because of a lack of safe, reliable, and affordable transportation options, no-shows to clinic appointments may result in ER visits with unbearable symptoms or even life-threatening conditions. This is dangerous for patients, and these ER visits result in higher costs to patients, families, and the health-care system.

Unfortunately, the adverse effects of transportation barriers do not end in ERs or clinics. In our study, cancer survivors with transportation barriers had the highest mortality risk across all patient groups. Among cancer survivors, the excess mortality risks were from cancer and other causes. Prior research showed cancer survivors have a higher comorbidity burden and increased risk of developing other comorbid illnesses and second malignancies (3,23). Without equitable access to related specialty services such as cardio-oncology service, heart disease and other conditions may be uncontrolled, and survivors may later succumb to these otherwise manageable chronic diseases. In addition, patients with transportation difficulties may be less likely to receive preventative services such as cancer screening, which is particularly important for survivors given their elevated risks of developing subsequent primary cancers (24). Additionally, transportation barriers prevent patients, especially those who are socioeconomically vulnerable and medically underserved, from participating in clinical trials (25).

Improving options for comprehensive insurance coverage can be a potential solution for transportation barriers to health care at the policy level, as health insurance coverage has been shown to be associated with reduced transportation barriers (11). The Centers for Medicare & Medicaid Service's Innovation Center's new Enhancing Oncology Model (26) and the Accountable Communities Model focus on addressing patient social needs, including transportation barriers to care (27). The Medicaid program is required to ensure its beneficiaries' access to health-care services and to provide specialized transportation options (ie, Medicaid's nonemergency medical transportation [NEMT]). This is critical for cancer survivors, as public health insurance coverage (primarily Medicaid) is common because of work limitations and financial hardship (28). Although previous research demonstrated that Medicaid expansion under the Affordable Care Act was associated with improved insurance coverage and care affordability among cancer survivors (29), future studies are warranted to explore its effects on transportation barriers and related outcomes.

Nonetheless, transportation options through health insurance are not a perfect solution to transportation barriers to health care. According to the Mandated Report on NEMT by the Medicaid and Children's Health Insurance Program Payment and Access Commission, less than 5% of Medicaid beneficiaries used NEMT benefits in 2018 despite its mandated coverage (30). Among those using NEMT programs, concerns about reliability were reported, such as no-shows, late pickups, ill-equipped vehicles, and long call center wait times. Furthermore, many NEMT programs cover only limited on-demand transportation, if at all, and require patients to schedule rides with a considerable lead time.

In recent years, ride-sharing companies such as Uber and Lyft have joined the NEMT markets. Although the use of ride sharing as a NEMT service decreased wait times and average per-ride costs, with a high patient satisfaction rate (31), simply offering

Table 1. Sample size and characteristics of US adults with and without a history of cancer, by delay in care due to transportation barriers within 12 months[a]

Participants characteristics	Adults with a cancer history Delays in care due to lack of transportation			Adults without a cancer history Delays in care due to lack of transportation		
Total (weighted %)	Yes n = 988 (2.8)	No n = 27 652 (97.2%)	P[b]	Yes n = 9685 (1.7%)	No n = 460 339 (98.3%)	P[b]
Age, y			<.001			.04
18-44	25.0	16.3		52.3	54.1	
45-54	20.0	16.7		20.3	19.6	
55-64	26.1	25.8		15.6	14.8	
65-74	21.0	28.6		8.7	8.7	
75-79	7.9	12.6		3.1	2.8	
Sex			<.001			<.001
Male	25.0	39.1		37.2	49.3	
Female	75.0	60.9		62.8	50.7	
Race			<.001			<.001
Asian and other	3.5	3.2		5.8	5.9	
Hispanic	10.0	6.3		20.1	14.7	
Non-Hispanic Black	17.0	8.2		24.1	12.1	
Non-Hispanic White	69.5	82.3		50.0	67.2	
Educational attainment			<.001			<.001
Less than high school	27.4	13.8		33.6	14.0	
High school graduate	30.8	28.5		30.7	27.0	
More than high school	41.7	57.7		35.7	59.0	
Married			<.001			<.001
Yes	27.0	62.0		25.7	55.7	
No or missing	73.0	38.0		74.3	44.3	
Health insurance[c]			<.001			<.001
64 years and younger: private insurance	13.4	40.9		20.8	61.4	
64 years and younger: public insurance	44.1	11.4		42.7	11.1	
64 years and younger: uninsured	13.6	6.4		24.7	16.0	
65 years and older: Medicare and Private	8.0	22.7		3.0	5.9	
65 years and older: Medicare Advantage or HMO	1.8	5.3		1.2	1.4	
65 years and older: Medicare and Medicaid	8.9	2.5		3.3	0.9	
65 years and older: Medicare only or other	10.3	10.7		4.2	3.4	
Region			.35			<.001
Midwest	24.9	24.1		24.0	23.5	
Northeast	15.8	18.8		14.0	17.9	
South	38.8	37.1		39.4	36.6	
West	20.6	20.0		22.7	22.0	
Survey era			.05			<.001
2000-2004	18.6	21.1		18.7	24.6	
2005-2009	23.6	24.8		26.5	25.9	
2010-2014	27.1	28.4		29.7	27.1	
2015-2018	30.7	25.7		25.1	22.5	
Any functional limitations[d]			<.001			<.001
No	9.1	41.5		31.9	70.5	
Yes	90.9	58.5		68.1	29.5	
Number of comorbid illnesses[e]			<.001			<.001
0	10.9	27.3		35.1	59.2	
1	16.7	26.2		20.0	20.9	
2	19.5	21.4		15.5	10.9	
≥3	52.9	25.1		29.4	9.0	
Time since cancer diagnosis,y			<.001			
<2	27.0	20.4				
2-5	18.5	26.9				
6-10	16.6	20.3				
11-15	11.2	12.2				
≥16	26.7	20.1				
Cancer type						
Breast cancer	18.1	21.9	.03			
Prostate cancer	6.0	13.5	<.001			
Colorectal cancer	8.8	7.8	.26			
Other[f]	68.3	57.4	<.001			

[a] Data source: 2000-2018 National Health Interview Survey (NHIS) and 2019 NHIS linked Mortality Files. HMO = Health Maintenance Organization.
[b] P values were derived from χ^2 tests.
[c] Public insurance included Medicare, Medicaid, State Children's Health Insurance Program, and/or other public hospital or physician coverage. Age 64 years or younger with public insurance comprised people younger than 65 years who had 1 or more types of public coverage and did not have private coverage. Age 65 years or older Medicare with private, comprised people aged 65 years and older who had Medicare and private insurance coverage and did not have Medicare Advantage/HMO. Age 65 years and older with Medicare Advantage/HMO comprised people aged 65 years and older who had Medicare Advantage or HMO and did not have Medicaid coverage. Age 65 years and older with Medicare only or other comprised people aged 65 years and older who had Medicare only and/or 1 or more other types of public coverage except for Medicaid or no coverage.
[d] Functional limitations included any self-reported limitation in walking a quarter of a mile, walking up 10 steps without resting, standing or sitting for 2 hours, stooping, reaching up over head, carrying 10 pounds, pushing large objects such as a living room chair, shopping, or visiting friends.
[e] Comorbid Illnesses included hypertension, diabetes, coronary artery diseases, stroke, chronic obstructive lung diseases, kidney disease, liver diseases, arthritis, and morbid obesity.
[f] Other includes cancers of all sites except for breast, prostate, colorectal cancer, and nonmelanoma skin cancer.

Table 2. Association of transportation barriers with ER use among US adults with and without a history of cancer[a]

Cancer history	Delay in care due to lack of transportation[b]	ER use/No.	Weighted %	Odds ratio (95% CI)	P[c]
Yes	Yes	577/988	60.1	2.77 (2.34 to 3.27)	<.0001
	No	7831/27652	27.5	1.39 (1.34 to 1.44)	<.0001
No	Yes	4654/9685	48.1	1.98 (1.87 to 2.10)	<.0001
	No	89018/460339	18.7	Referent	

[a] Data source: 2000-2018 National Health Interview Survey (NHIS) and 2019 NHIS linked Mortality Files. CI = confidence interval; ER = emergency room.
[b] Delays in care due to transportation barriers were measured by the question, "Have you delayed getting care in the past 12 months because you did not have transportation?"
[c] Multivariable logistic regression model was adjusted for age (in 5-year intervals), sex, race and ethnicity, educational attainment, health insurance, comorbidities, region, survey year era, and functional limitations.

Table 3. Association of transportation barriers with all-cause mortality risk among US adults with and without a history of cancer[a]

Cancer history	Delay in care due to lack of transportation[b]	Event/No.	Weighted %	Hazard ratio (95% CI)	P[c]
Yes	Yes	322/988	32.5	2.28 (1.94 to 2.68)	<.0001
	No	7002/27652	23.9	1.59 (1.54 to 1.65)	<.0001
No	Yes	1611/9685	14.5	1.57 (1.46 to 1.70)	<.0001
	No	39182/460339	7.2	Referent	

[a] Data source: 2000-2018 National Health Interview Survey (NHIS) and 2019 NHIS linked Mortality Files. CI = confidence interval.
[b] Delays in care due to transportation barriers were measured by the question, "Have you delayed getting care in the past 12 months because you did not have transportation?"
[c] Multivariable Cox proportional hazards regression model used age as the timescale and adjusted for sex, race and ethnicity, educational attainment, health insurance, comorbidities, region, survey year era, and functional limitations.

Table 4. Association of transportation barriers with cause-specific mortality risk among US adults with a history of cancer[a]

Cause of death	Delay in care due to lack of transportation[b]	Event/No.	Weighted %	Hazard ratio (95% CI)	P[c]
All-cause	Yes	322/988	32.5	1.33 (1.14 to 1.54)	.0002
	No	7002/27652	23.9	Referent	
Cancer	Yes	125/988	13.2	1.30 (1.03 to 1.64)	.03
	No	3109/27652	10.9	Referent	

[a] Data source: 2000-2018 National Health Interview Survey (NHIS) and 2019 NHIS linked Mortality Files. Cancer deaths identified as International Classification of Diseases–10 C00-C97 as underlying cause of death. CI = confidence interval.
[b] Delays in care due to transportation barriers were measured by the question, "Have you delayed getting care in the past 12 months because you did not have transportation?"
[c] Multivariable Cox proportional hazards regression model used age as the timescale and adjusted for sex, race and ethnicity, educational attainment, health insurance, comorbidities, region, survey year era, functional limitations, time since cancer diagnosis, and cancer type (breast, colorectal, prostate, and others).

the service did not decrease missed primary care appointments in a randomized control trial (32). More comprehensive approaches may be needed to target transportation barriers to care. For example, the PROgram for Non-emergency TranspOrtation at the University of Illinois Health System effectively prevented cancer treatment nonadherence and readmission by working with all stakeholders including social workers, nurses, and the management team (33). Similarly, in addition to providing travel support, the Navigation for Disparities and Untimely Radiation ThErapy program at the Medical University of South Carolina helps patients navigate available resources and targets other systematic barriers to timely radiation therapy. Preliminary data showed that it largely decreased the treatment delay in patients with head and neck squamous cell carcinoma (34,35).

More efforts are needed to screen and identify cancer survivors with transportation difficulties and help them navigate available transportation services. Although the National Comprehensive Cancer Network recommends screening patients with cancer for transportation barriers as part of practical problems in its distress screening tool (18), there is wide variability across cancer centers in when and how often the tool is administrated and how distress, once identified, is addressed. Moreover, it remains unclear if long-term cancer survivors would benefit from these recommendations after the care transition from oncology to primary care teams.

Telehealth may also mitigate some of the transportation burdens among cancer survivors, especially for people living in rural areas with limited health-care facilities (36). Telehealth has been shown equally effective for certain purposes, such as symptom control, and more convenient and cost effective in care delivery (37). However, telehealth access may be limited for people living in areas without adequate broadband and for people with low digital literacy (38).

Our study had several limitations. First, our results likely underestimated the prevalence of transportation barriers as well as the magnitude of associations between transportation barriers and mortality because the NHIS asked only 1 question about delays in care due to transportation barriers in the past 12 months, thus, we could not quantify how many times people delayed care or fully capture the people who forgo care, nor could we assess longer-term transportation barriers to care Second, our

study may underestimate the burden from transportation barriers, as people experiencing them may be less likely to participate in the NHIS. The NHIS response rate was approximately 60% throughout the study period, and nonresponders may have been different from responders. We used NHIS survey weights, which help correct for nonresponse, however (17). In addition, we could not adjust for detailed geographic location (eg, urban and rural areas, distance to care facilities) because of the lack of information in the publicly available NHIS. Third, the NHIS did not interview Native Americans living on reservations or people living in institutions (eg, nursing homes), who may also face transportations barriers to care. Fourth, the NHIS survey did not capture cancer stage, treatment(s), treatment response, and timing of treatment, which may confound the association between transportation barriers and mortality. However, our sensitivity analysis of long-term survivors 5 or more years postdiagnosis, who are less likely to be receiving active treatment, was largely consistent with the main findings. Moreover, survey participants who were not cancer survivors at the time of survey but developed cancer later may bias the comparison between cancer survivors and individuals without a cancer history toward a null association. Furthermore, even though we used multiple years of NHIS survey data spanning nearly 2 decades, the number of participants reporting transportation barriers was still too small to conduct meaningful analyses stratified by sociodemographic factors and cancer type. Lastly, our study is subject to survival bias, because our sample is a selected group of cancer survivors by virtue of having cancer and surviving long enough to be sampled by the NHIS and completing the survey. Patients with poor prognosis cancers and/or later stages of disease (or early cancer deaths) are less likely to be included in household surveys, despite more medical needs.

Transportation barriers to care were associated with increased ER visits and increased all-cause and cancer-specific mortality. Efforts to screen for and reduce transportation barriers are warranted for cancer survivors.

Data availability

The datasets were derived from sources in the public domain: National Center for Health Statistics, National Health Interview Survey at https://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm.

Author contributions

Changchuan Jiang, MD, MPH (Conceptualization; Data curation; Formal analysis; Methodology; Supervision; Visualization; Writing—original draft; Writing—review & editing), K. Robin Yabroff, PhD, MBA (Conceptualization; Writing—original draft; Writing—review & editing), Lei Deng, MD (Writing—original draft; Writing—review & editing), Qian Wang, MD, MPH (Writing—original draft; Writing—review & editing), Stuthi Perimbeti, MD, MPH (Writing—original draft; Writing—review & editing), Charles L Shapiro, MD (Writing—original draft; Writing—review & editing), and Xuesong Han, PhD (Conceptualization; Formal analysis; Methodology; Supervision; Writing—original draft; Writing—review & editing).

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Conflicts of interest

XH has received grant from AstraZeneca for research outside of the current study. KRY serves on the Flatiron Health Equity Advisory Board.

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