Cancer Treatment Delays During the COVID-19 Pandemic

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Background/Objective: Cancer treatment is time-sensitive. Even short delays can negatively impact patient outcomes. The COVID-19 pandemic disrupted healthcare systems across the United States, causing widespread cancer care disruptions. While prior studies have examined treatment disruptions for specific cancers, nationally representative analyses covering all cancer types and socio-demographic groups remain limited. The objective of this study was to assess the national prevalence of cancer treatment disruptions during the COVID-19 pandemic and identify associated socio-demographic and health-related factors.
Methods: This study utilizes data from 928 adults with self-reported cancer diagnoses in the 2021 National Health Interview Survey (NHIS). The primary outcome was categorized into two levels: cancer treatment that was disrupted, delayed, or cancelled versus not disrupted. Weighted prevalence estimates and survey-weighted logistic regression models were used. Covariates included age, sex, race/ethnicity, educational attainment, poverty level, homeownership, self-rated health, body mass index (BMI), and smoking status. Changes, delays, and cancellations were combined into a single outcome for analysis.
Results: 17.5% of respondents reported a change, delay, or cancellation of cancer care. Prevalence was the highest among adults aged 18–34 and underweight adults, while adults over 65 years had the lowest prevalence. Males had higher odds of experiencing delays compared to females. No statistically significant differences were observed across race/ethnicity, poverty level, or self-rated health.
Conclusion: These findings indicate that nearly one in six cancer patients in the US experienced treatment disruptions during the COVID-19 pandemic. Coordinated efforts at the patient, provider, and healthcare system levels are needed to reduce future delays.

Introduction

In 2020, approximately 1.9 million individuals in the United States were diagnosed with cancer[1]. Cancer therapies, such as chemotherapy, radiation, surgery, and blood stem cell transplants, are highly time sensitive[2–5], and delays in cancer treatment, even over short intervals, have been consistently linked to worse outcomes, including increased mortality[6,7]. A 2020 analysis found that a delay in cancer treatment of even four weeks can increase patient mortality from 6% to 13% (depending on cancer type and treatment type)[7]. The COVID-19 pandemic may have led to even greater delays and barriers to cancer treatment across the country[8,9]. During the COVID-19 pandemic, several factors may have contributed to treatment delays, such as patient hesitancy due to fear of infection, limited resources in hospitals, provider shortages, and even the temporary suspension of non-urgent care[10–12]. For patients who were already immunocompromised, they may have intentionally delayed their care to avoid exposure to the virus[13].

Delayed cancer treatment can be defined as a postponement or interruption beyond clinically recommended timeframes, including delays between diagnosis to initial treatment, missed treatments, or canceled procedures. Prior studies commonly define meaningful delays as those exceeding four weeks, and although the impact varies by cancer type, stage, and treatment type, these delays can lead to further tumor progression, loss of operability, reduced survival rate, and a higher risk of recurrence[7,14,15]. Cancer care spans a variety of therapies, and each has its own challenges and time restrictions[16]. Chemotherapy and radiation therapy, for example, necessitate patients to follow up with regular cycles and appointment schedules over a span of weeks or months[17]. Surgery relies on operating room availability and preoperative clearance[18].

Although the medical harms of treatment delays are well understood, psychological tolls on patients should also be taken into consideration. Patients facing interruptions in their treatment often experience elevated stress, anxiety, and fear as they wait for treatment that could impact their survival[19,20]. While there is evidence that healthcare services were disrupted during the pandemic, national level estimates of cancer treatment delays remain limited[21]. Several large national datasets (for example, the National Cancer Database and SEER/SEER-Medicare) have been used to evaluate cancer treatment delays and to document disparities by race/ethnicity, insurance status, and other factors. However, these datasets mainly contain clinical, treatment, and survival information for diagnosed cancer patients. As a result, these datasets contain limited data on patient-reported experiences, self-rated health, and socioeconomic barriers, limiting the ability to assess pandemic-era treatment delays across all cancer types and across the full range of sociodemographic variables. A comprehensive population-based study that includes patient-reported disruptions across the full range of sociodemographic factors has not been explored.

The National Health Interview Survey (NHIS) COVID-19 cancer treatment data were only collected from adults who were receiving or scheduled to receive cancer treatment during the pandemic period, rather than all cancer survivors. This makes the target population for this study US adults with cancer who were actively undergoing or scheduled to undergo cancer treatment during the pandemic.

This study examines the extent to which cancer treatments were delayed during the COVID-19 pandemic and whether specific socio-demographic groups were more affected by these delays. Using nationally representative data from the 2020 and 2021 NHIS, this study examines the relationship between the COVID-19 pandemic and cancer treatment delays among US adults (18 years and older). This study hypothesized that (H1) the COVID-19 pandemic led to a substantial portion of cancer patients delaying cancer treatment and (H2) patients who did not have health insurance, were racial and ethnic minorities, or had lower income were likely to experience these delays, with these factors examined independently to assess their relative impact.

Methods

Our study analyzed data from the 2020 and 2021 National Health Interview Survey (NHIS), an annual, cross-sectional household survey conducted by the National Center for Health Statistics (NCHS) within the Centers for Disease Control and Prevention (CDC). The NHIS is the main source of information on the reported health of civilians and non-institutionalized people older than 16 years in the US[22]. It uses a stratified, multistage probability sample design to ensure the data is nationally representative across all socio-demographic groups[23].

The study population consisted of adults who reported having been diagnosed with cancer. Respondents who answered "yes" to the question were classified as having a cancer diagnosis. The sample of 928 adults was derived by only including respondents who reported a cancer diagnosis and answered "Yes" or "No" to the question: "Cancer treatments changed, delayed, or cancelled because of the coronavirus." All missing or indeterminate responses were excluded. They formed the analytic sample for this study. Since NHIS uses a complex survey design, we applied the provided sample weights so our data was nationally representative of the US adults who were receiving or scheduled to receive cancer treatment during the pandemic.

The primary outcome was whether the respondent experienced a change, delay, or cancellation of their cancer treatment due to the COVID-19 pandemic. Response answers included "Yes," "No," "Refused," "Don't know," and "N/A". For analysis, we excluded respondents with missing or indeterminate responses and coded the rest of the outcomes as binary (Yes = 1, No = 0). The delays include all modalities of cancer care (surgery, chemotherapy, radiotherapy, or other systemic treatments). We included a broad set of sociodemographic and health-related variables that may be associated with delayed cancer treatment[24,25]. These variables were drawn from NHIS survey items. The covariates included: age, sex, race/ethnicity, educational attainment, ratio of family income to poverty threshold, homeownership, self-rated health, Body Mass Index (BMI Category), and smoking status. BMI was categorized as underweight, normal weight, overweight, and obese. Self-rated health was categorized as excellent, very good, good, fair, or poor. For detailed information, refer to Appendix Table 3. All analyses were also applied with the sample weights provided by NHIS. This was to account for the unequal probabilities of selection, nonresponse, and post-stratification adjustments to align estimates with US Census population controls.

First, we generated statistics for the study sample (Table 1). Weighted proportions and 95% confidence intervals (CIs) were calculated for each covariate using the `tbl_summary` function in the `gtsummary` package applied to the survey design object using the `svyr` package.

Second, we estimated the weighted prevalence of changed, delayed, or cancelled cancer treatment across each covariate (Table 2). Prevalence estimates and 95% CIs were computed using the `survey_mean` function. Prevalence was reported overall and stratified by age, sex, race/ethnicity, educational attainment, poverty level, homeownership, self-rated health, BMI, and smoking status.

Third, we fit a survey-weighted logistic regression model with cancer treatment disruption (Yes or No) as the binary dependent variable (Table 3). Independent variables include the aforementioned variables, such as age, sex, and race/ethnicity. The model was estimated using the `svyglm` function. We report adjusted odds ratios (aORs), 95% CIs, and p-values in Table 3. All analyses applied NHIS-provided sample weights.

Variance inflation factors (VIFs) were examined for all regression covariates. Elevated VIFs were observed for indicator variables corresponding to multi-level categorical predictors (age group and BMI category), reflecting expected within-factor collinearity. VIFs for all other covariates were below commonly used thresholds ($\text{VIF} < 5$), indicating no evidence of problematic multicollinearity across substantively distinct predictors.

Results

Characteristics of the Sample

Our study consisted of 928 US adults with a history of cancer who were receiving or scheduled to receive cancer treatment in 2020 and 2021. Two-thirds of the respondents, 66%, were aged 65 years or older, while 24% were aged 50–64 years, 8.1% were aged 35–49 years, and 2.2% were aged 18–34 years. The sample was almost evenly split in half by sex, with 51% female and 49% male participants.

In terms of race/ethnicity, most respondents identified themselves as non-Hispanic White, followed by non-Hispanic Black, Hispanic and non-Hispanic Other. By educational attainment, 72% had at least some college education, 23% were high school graduates or equivalent, and 5.7% had less than a high school education.

About one-third of respondents had family incomes that were more than five times the federal poverty threshold, while 6.1% were living at or below the poverty level. The majority of respondents reported owning a house.

In terms of self-rated health, 6.8% rated their health as excellent, 24% as very good, 31% as good, 23% as fair, and 16% as poor. One-third of respondents were obese, overweight, and normal weight with 2.5% of the respondents being underweight. Nearly half of the respondents had never smoked, 40% were former smokers, and 10% smoke currently.

Weighted Prevalence of Changed, Delayed, or Cancelled Cancer Treatment by Characteristic

Overall, 17.5% of adult cancer patients nationally experienced a change, delay, or cancellation of cancer treatment during the COVID-19 pandemic (Table 2). We observed a general decrease in the proportion by age group: the prevalence was highest among adults aged 18 to 34 years, followed by respondents aged 50–64 years, then 35–49 years, and the lowest being among adults aged 65 years or older. Females had a lower chance of delayed or changed cancer treatment compared to males. Detailed percentages and confidence intervals are presented in Table 2.

Across race/ethnicity, prevalence estimates were similar across groups, with overlapping confidence intervals. By educational attainment, adults with at least some college education reported a higher prevalence of treatment disruption compared to those with lower educational attainment. We observed an inverted U-shaped pattern when analyzing the prevalence by poverty level. The highest prevalence occurred among those with income between >2 and ≤ 3 times the poverty threshold and lower prevalence at both the lowest ≤ 1 and highest >5 income categories.

Adults who did not own their home reported a higher prevalence compared to homeowners. For self-rated health, prevalence ranged from 15.4% among those reporting good health to 21.0% among those reporting excellent health. For BMI, the underweight adults had the highest prevalence, followed by overweight, obese, and normal weight. By smoking status, prevalence was highest among current smokers, followed by former smokers and individuals who have never smoked.

Regression Results

Patterns observed in the descriptive analyses were consistent with results from the adjusted regression models. For detailed statistics, refer to Table 3.

After adjusting for socio-demographic and health-related characteristics, the odds of experiencing changed, delayed, or cancelled treatment because of COVID-19 were lower among adults aged 65 years and older compared to those aged 50–64 years (adjusted odds ratio [aOR] = 0.58, 95% CI: 0.37–0.93). Consistent with descriptive findings, the odds were higher for males compared to females (aOR = 1.64, 95% CI: 1.05–2.55).

We did not observe any statistically significant differences across race/ethnicity categories, indicating that unadjusted differences did not remain once covariates were accounted for. The odds were also higher for adults with at least some college education compared to high school graduates (aOR = 1.76, 95% CI: 1.05–2.96). Respondents with less than a high school education had equivalent odds compared to high school graduates. Underweight adults had significantly higher odds compared to normal weight adults (aOR = 4.74, 95% CI: 1.70–13.2). No statistically significant differences were found for overweight or obese categories compared to normal weight.

We also did not observe statistically significant associations with poverty level, homeownership status, smoking status, or self-rated health and the odds of cancer treatment delays.

Discussion

In this nationally representative study of cancer treatment delays during the COVID-19 pandemic, we identified three main findings. First, we found that nearly one in six adult patients (17.5%) reported that their cancer treatment was changed, delayed, or cancelled because of the COVID-19 pandemic. Second, our data shows that treatment disruptions were not evenly distributed. Younger patients and underweight adults were more likely to experience delays, while older adults (≥ 65 years) were less likely to report any delays. Males also had higher odds of delayed cancer treatment compared to females. Third, despite concerns about inequalities in cancer treatment during the pandemic, we did not observe any statistically significant differences in disruptions by race/ethnicity, poverty level, or self-rated health.

Pre-pandemic evidence demonstrates that delays in cancer treatment are associated with worse clinical outcomes. A sys-

Table 1 Characteristics of Sample

Characteristic	**Categories**	**N = 928**[1]
Age (Years)	18–34	20 (2.2%)
	35–49	75 (8.1%)
	50–64	221 (24%)
	65+	606 (66%)
	Unknown	6
Sex	Female	476 (51%)
	Male	452 (49%)
Race/Ethnicity	Hispanic	40 (4.3%)
	Non-Hispanic Black	64 (6.9%)
	Non-Hispanic Other	38 (4.1%)
	Non-Hispanic White	786 (85%)
Education	High School Graduate or Equivalent	209 (23%)
	At Least Some College	663 (72%)
	Less Than High School Graduate	53 (5.7%)
	Unknown	3
Ratio of Family Income to Poverty Threshold	≤ 1	57 (6.1%)
	>1 and ≤ 2	165 (18%)
	>2 and ≤ 3	166 (18%)
	>3 and ≤ 4	124 (13%)
	>4 and ≤ 5	104 (11%)
	>5	312 (34%)
Homeownership		717 (79%)
	Unknown	26
Self Rated Health	Poor	149 (16%)
	Fair	211 (23%)
	Good	284 (31%)
	Very Good	219 (24%)
	Excellent	63 (6.8%)
	Unknown	2
BMI	Underweight	23 (2.5%)
	Normal weight	288 (32%)
	Overweight	296 (32%)
	Obese	305 (33%)
	Unknown	16
Smoking Status	Never	451 (49%)
	Former	368 (40%)
	Current	94 (10%)
	Unknown	15

[1] n (%)

tematic review and meta-analysis published showed that for surgery, systemic therapy, and radiotherapy, a four-week delay was associated with increased mortality across multiple cancer types[7]. Similarly, in breast cancer, analyses also documented that a longer period before surgery was linked to significantly worse survival outcomes[26]. Furthermore, in lung cancer, de-

Table 2 Prevalence of Delayed Cancer Treatment by Characteristic

Group	Proportion	Lower 95% CI	Upper 95% CI
Overall			
	17.5%	14.7%	20.3%
Age (years)			
18–34	33.7%	11.3%	56.1%
35–49	19.7%	8.7%	30.6%
50–64	21.9%	15.7%	28.2%
65+	14.4%	11.4%	17.4%
Sex			
Female	15.2%	11.7%	18.7%
Male	19.9%	15.5%	24.3%
Race/Ethnicity			
Hispanic	18.7%	4.3%	33.1%
Non-Hispanic Black	17.7%	7.3%	28.1%
Non-Hispanic Other	21.9%	3.9%	39.9%
Non-Hispanic White	17.2%	14.2%	20.1%
Educational Attainment			
High School Graduate or Equivalent	14.0%	8.9%	19.2%
At Least Some College	20.2%	16.6%	23.8%
Less Than High School Graduate	5.6%	0.0%	12.0%
Poverty Level			
≤ 1	18.2%	5.4%	31.0%
>1 and ≤ 2	15.5%	9.1%	21.9%
>2 and ≤ 3	23.2%	16.2%	30.2%
>3 and ≤ 4	17.7%	9.5%	26.0%
>4 and ≤ 5	16.5%	8.7%	24.4%
>5	16.3%	11.6%	20.9%
Homeownership			
No	21.3%	13.7%	28.9%
Yes	17.1%	14.0%	20.9%
Self Rated Health			
Poor	18.5%	11.6%	25.5%
Fair	18.2%	12.3%	24.1%
Good	15.4%	10.5%	20.4%
Very Good	17.9%	11.9%	23.8%
Excellent	21.0%	9.9%	32.2%
BMI			
Underweight	37.3%	14.7%	59.8%
Normal weight	14.6%	10.1%	19.2%
Overweight	19.2%	13.9%	24.5%
Obese	16.9%	12.2%	21.7%
Smoking Status			
Never	16.7%	12.7%	20.7%
Former	18.2%	13.8%	22.6%
Current	22.6%	12.5%	32.8%

Table 3 Regression Results (Cancer Treatments Changed, Delayed, or Cancelled Because of the Coronavirus/COVID-19 Pandemic)
Survey-Weighted Logistic Regression: Odds of Cancer Treatments Changed, Delayed, or Cancelled Because of the Coronavirus/COVID-19 Pandemic

Variable		**OR**	**95% CI**	***p*-value**
Age (years)	50–64	—	—	
	18–34	1.99	0.69, 5.70	0.2
	35–49	0.98	0.46, 2.08	>0.9
	65+	0.58	0.37, 0.93	0.023
Sex	Female	—	—	
	Male	1.64	1.05, 2.55	0.029
Race/Ethnicity	Hispanic	—	—	
	Non-Hispanic Black	0.85	0.24, 2.98	0.8
	Non-Hispanic Other	1.08	0.28, 4.14	>0.9
	Non-Hispanic White	0.80	0.30, 2.10	0.6
Education	High School Graduate or Equivalent	—	—	
	At Least Some College	1.76	1.05, 2.96	0.032
	Less Than High School Graduate	0.30	0.08, 1.08	0.066
Ratio of Family Income to Poverty Threshold	≤1	—	—	
	>1 and ≤2	1.27	0.42, 3.82	0.7
	>2 and ≤3	1.88	0.64, 5.51	0.2
	>3 and ≤4	1.21	0.38, 3.86	0.7
	>4 and ≤5	1.27	0.39, 4.11	0.7
	>5	1.00	0.34, 2.91	>0.9
Homeownership	No	—	—	
	Yes	0.87	0.51, 1.48	>0.9
Self Rated Health	Poor	—	—	
	Fair	1.21	0.63, 2.32	0.6
	Good	1.00	0.52, 1.91	>0.9
	Very Good	1.20	0.60, 2.37	0.6
	Excellent	1.60	0.64, 4.01	0.3
BMI	Normal weight	—	—	
	Underweight	4.74	1.70, 13.2	0.003
	Overweight	1.39	0.82, 2.35	0.2
	Obese	1.22	0.70, 2.12	0.5
Smoking Status	Never	—	—	
	Former	1.28	0.82, 2.00	0.3
	Current	1.69	0.83, 3.47	0.2

Abbreviations: CI = Confidence Interval, OR = Odds Ratio

lays were also associated with higher mortality[27].

During the early phases of the COVID-19 pandemic, cancer patients faced substantially higher risks of severe COVID-19 and death than the general population. This led to temporary protective measures to reduce exposure in clinics and in hospitals. Large meta-analyses documented the elevated mortality among cancer patients with COVID-19, especially with active disease and certain treatments[28,29]. These findings suggest that minimizing delays is crucial after safe workflows are established. Balancing infection risk with known harms of delayed cancer care became a central challenge for health care providers and patients.

Cancer treatment disruptions observed in this study mirrored other healthcare challenges during the pandemic. To reduce transmission, many systems reduced "elective" procedures in 2020. Analyses show state-mandated and hospital-level temporary suspensions with the goal of freeing beds, staff, and PPE (Personal Protective Equipment)[30]. In the US, the use of general health services declined significantly, with things such as office visits, vaccinations, and chronic care management all reducing in 2020[31]. Systematic reviews of global data also similarly showed reductions in screening, delayed initiation of needed therapy, and postponed surgeries[7,21]. Analyses of US electronic health record data further showed significant declines in oncology visits, chemotherapy treatments, and cancer-related procedures in 2020[32]. Population studies subsequently showed effects on cancer treatments: sharp drops in new cancer diagnoses during this time period, which aligns with deferred evaluation[33,34].

These findings are consistent with previous literature on cancer treatment delays during the COVID-19 pandemic, confirming that a significant number of US cancer patients experienced treatment changes or delays. However, while some studies focused on single cancers reported racial and socioeconomic inequalities in delayed cancer care[35], we did not observe any significant inequalities by race/ethnicity after adjustment. This suggests that these delays may have been shared by all demographic groups.

The higher likelihood of treatment disruptions among younger adults requires further consideration. Younger cancer patients are more likely to receive multimodal and time-intensive treatments, which may increase vulnerability to disruptions[36–38]. Studies have also shown that younger adults were also more likely to experience employment instability, caregiving responsibilities, and insurance changes during the pandemic, all of which may have interfered with timely cancer treatment[39].

Similarly, the elevated odds of treatment disruption among underweight individuals may reflect underlying conditions. Low BMI in cancer patients is often associated with advanced disease, cancer related cachexia, or frailty, which can complicate treatment[40]. Additionally, studies have shown that underweight individuals tend to have a higher risk of severe outcomes and secondary infections than those with normal BMI, which may reflect compromised immune defense or reduced nutritional reserves[41–43]. All of these factors suggest that both patients and healthcare providers may have been more cautious in proceeding with treatment during periods of high COVID-19 risk, choosing to delay treatment until the perceived risk was lower. This interpretation highlights how underlying health conditions and patient risk perception can influence treatment decisions in times of a public health emergency.

The lasting implications of these disruptions highlight the urgent need for recovery-focused policies. Delays in care can produce care gaps, such as reduced imaging and clinic volumes, which can lead to further delays in the future, if not addressed. Radiology and health services analyses documented substantial declines in US imaging and outpatient care volumes during 2020[44–46]. US studies also report decreases in incident cancer detection during these periods. This led to more diagnoses that only happened at an advanced stage, underscoring the need for recovery policies[47,48]. Given the heightened COVID-19 vulnerability in cancer patients and the mortality cost of delayed oncologic care, policies should preserve continuous access to time-sensitive cancer treatments[49].

Strengths and Limitations

The use of a large, nationally representative data set allows findings to be generalized to the population of cancer patients. Unlike prior studies that focused on single cancer types, this study includes all cancers, allowing for a better understanding of how COVID-19 affected cancer treatment across the nation. The study examines not only delayed treatment but also the related aspects of care disruption, such as delays in follow-up meetings, surgeries, and treatment cycles. By including a large range of socio-demographic, behavioral, and health-related variables, the study explores cancer treatment delays and identifies groups at highest risk for delays.

The reliance on self-reported outcomes introduces potential biases and misclassifications, as participants may inaccurately describe their health or remember delays in care. The data set also does not include cancer type, stage, or recency, which limits the ability to assess whether the severity or type of cancer influenced the likelihood or impact of specific treatment delays. For example, delays in chemotherapy for aggressive cancers have different clinical consequences than delays in routine screening for cancers in remission. Furthermore, the study combines multiple forms of disruption, such as delayed diagnostic testing, postponed or canceled procedures, and interrupted treatment cycles, into a single measure of treatment delay. As a result, this study cannot isolate the independent impact of specific delay types, which may obscure the impact of individual delay types.

Conclusion

Overall, more than 1 in 6 US adults who were receiving or scheduled to receive cancer treatment during the COVID-19 pandemic reported a treatment disruption, change, or cancellation. The absence of statistically significant differences by race/ethnicity, poverty level, or self-rated health suggests that treatment disruptions during the pandemic were caused by system-wide constraints. These results highlight a gap in emergency preparedness for maintaining regular cancer treatment during public health emergencies. For healthcare providers and systems, these findings show the need for protocols that protect patients with ongoing cancer treatment when resources are limited. For policymakers, the findings suggest taking into consideration continuity of ongoing treatment when planning public health emergency responses. Future studies could evaluate which system-level strategies most effectively prevent or minimize treatment disruption during future crises and how delayed care during the COVID-19 pandemic will affect long term cancer outcomes.

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Appendix A

Appendix Table 1: Unweighted Missingness Table for Regression Covariates (uses IHIS)

Missingness in Regression Covariates (Unweighted)
Counts are based on IHIS (analytic sample after excluding missing outcome)

Covariate	Included	Missing	Missing (%)
Age (years)	922	6	0.6%
Sex	928	0	0.0%
Race/Ethnicity	928	0	0.0%
Education	925	3	0.3%
Ratio of Family Income to Poverty Threshold	928	0	0.0%
Homeownership	902	26	2.8%
Self Rated Health	926	2	0.2%
BMI	912	16	1.7%
Smoking Status	913	15	1.6%
Complete-case (all covariates)	879	49	5.3%

Appendix Table 2: Multicollinearity Diagnostics

Variance Inflation Factors from multiColl::VIF (Unweighted)

Covariate (Indicator Level)	VIF	Collinearity Assessment
AGECATEGORY 35–49	4.28	Low
AGECATEGORY 50–64	9.25	Moderate
AGECATEGORY 65+	10.99	High (within-category)
SEX Male	1.12	Low
RACEETHNICITY Non-Hispanic Black	2.50	Low
RACEETHNICITY Non-Hispanic Other	2.00	Low
RACEETHNICITY Non-Hispanic White	3.53	Low
EDUC At Least Some College	1.36	Low
EDUC Less Than High School Graduate	1.25	Low
POVERTYCATEGORY >1 and ≤ 2	3.43	Low
POVERTYCATEGORY >2 and ≤ 3	3.74	Low
POVERTYCATEGORY >3 and ≤ 4	3.28	Low
POVERTYCATEGORY >4 and ≤ 5	2.93	Low
POVERTYCATEGORY >5	5.74	Moderate
OWNERSHIP Yes	1.33	Low
SELFRATEDHEALTH Fair	1.95	Low
SELFRATEDHEALTH Good	2.23	Low
SELFRATEDHEALTH Very Good	2.17	Low
SELFRATEDHEALTH Excellent	1.48	Low
BMICAT Normal weight	9.98	Moderate
BMICAT Overweight	10.19	High (within-category)
BMICAT Obese	10.40	High (within-category)
SMOKESTATUS2 Former	1.18	Low
SMOKESTATUS2 Current	1.24	Low

Notes: VIFs are reported for indicator variables resulting from multi-level categorical covariates. Elevated VIFs for age group and BMI category reflect expected within-factor collinearity and do not indicate problematic correlation across substantively distinct predictors. Thresholds: VIF ≥ 5 (moderate), VIF ≥ 10 (high).

Appendix Table 3: NHIS Survey Questions and Analytic Coding of Outcome and Covariates

Variable	**NHIS Survey Question**	**Original Response Levels**	**Levels Used in Analysis**
Cancer Treatment Changed, Delayed, or Cancelled (Outcome)	Because of the Coronavirus/COVID-19 pandemic, were any of your cancer treatments changed, delayed or cancelled?	1 = Yes; 2 = No; 7 = Refused; 8 = Not ascertained; 9 = Don't know	Binary: Yes = 1; No = 0 (Refused, Not ascertained, Don't know set to missing)
Age Category	What is your age at last birthday?	Continuous age in years	18–34; 35–49; 50–64; ≥ 65
Sex	Are you male or female?	1 = Male; 2 = Female	Male; Female
Race/Ethnicity	What race do you consider yourself to be? Are you of Hispanic origin?	Race and Hispanic origin reported separately	Hispanic; Non-Hispanic White; Non-Hispanic Black; Non-Hispanic Other
Educational Attainment	What is the highest level of school you have completed or the highest degree you have received?	Detailed education codes (less than high school through advanced degree)	Less than high school graduate; High school graduate or equivalent; At least some college
Family Income/ Poverty Ratio	Derived from reported family income and federal poverty thresholds	Continuous ratio of family income to federal poverty threshold	≤ 1; >1–≤ 2; >2–≤ 3; >3–≤ 4; >4–≤ 5; >5
Homeownership	Do you own or rent your home?	Own; Rent; Other arrangement	Yes (own); Unknown (other)
Self-Rated Health	Would you say your health in general is excellent, very good, good, fair, or poor?	1 = Excellent; 2 = Very good; 3 = Good; 4 = Fair; 5 = Poor	Poor; Fair; Good; Very good; Excellent
Body Mass Index (BMI)	Derived from self-reported height and weight	Continuous BMI calculated from self-reported height and weight	Underweight; Normal weight; Overweight; Obese
Smoking Status	Have you smoked at least 100 cigarettes in your life? Do you now smoke every day, some days, or not at all?	Detailed smoking history and current smoking frequency	Never; Former; Current

Source: 2020, 2021 National Health Interview Survey (NHIS), accessed via IPUMS Health Surveys.