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ORIGINAL RESEARCH—CLINICAL

Association Between Social Vulnerability and Gastrointestinal Cancer Mortality in the United States Counties

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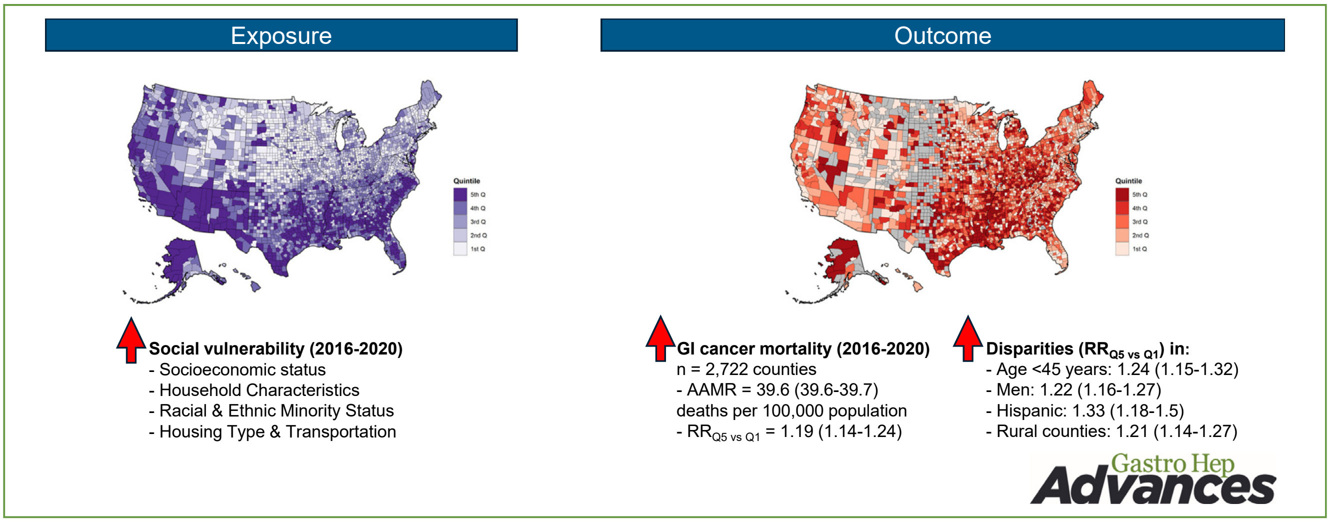

BACKGROUND AND AIMS: Social determinants of health contribute to disparities in gastrointestinal (GI) cancer mortality between individuals in the US. Their effects on count-level mortality rates remain uncertain. We aimed to assess the association between county social vulnerability and GI cancer mortality. **METHODS:** In this ecological study (2016–2020), we obtained US county Social Vulnerability Index (SVI) from the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry and age-adjusted mortality rates (AAMRs) for GI cancers from Centers for Disease Control and Prevention WONDER (Wide-Ranging Online Data for Epidemiological Research). SVI ranges from 0 to 1, with higher indices indicating greater vulnerability. We presented AAMRs by quintiles of SVIs. We used Poisson regression through generalized estimating equation to calculate rate ratios (RRs) and 95% confidence intervals (CIs) for GI cancer mortality by quintiles of SVI. **RESULTS:** There were 799,968 deaths related to GI cancers from 2016 to 2020, resulting in an AAMR (95% CI) of 39.9 (41.4–51.2) deaths per 100,000 population. The largest concentration of counties with greater SVI and GI cancer mortality was clustered in the southern US. Counties with greater SVI had higher mortality related to all GI cancers ($RR_{Q5\ vs\ Q1}$, 1.19 [95% CI, 1.14–1.24]), gastric cancer (1.58 [1.48–1.69]), liver cancer (1.54 [1.36–1.73]), and colorectal cancer ($RR_{Q5\ vs\ Q1}$, 1.23 [95% CI, 1.15–1.31]). RRs for overall GI cancers were greater among individuals <45 years (1.24 [1.15–1.32]), men (1.22 [1.16–1.27]), Hispanic individuals (1.33 [1.18–1.50]), and rural counties (1.21 [1.14–1.27]) compared with their counterparts. **CONCLUSION:** Socially disadvantaged counties face a disproportionately high burden

Abbreviations used in this paper: **AAMR, age-adjusted mortality rate; ATSDR, Agency for Toxic Substances and Disease Registry; CDC, Centers for Disease Control and Prevention; CI, confidence interval; GEE, generalized estimating equation; GI, gastrointestinal; ICD, International Classification of Disease; IQR, interquartile range; RR, rate ratio; SDOH, social determinants of health; SES, socioeconomic status; SVI, social vulnerability index; WONDER, Wide-Ranging Online Data for Epidemiological Research.**

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of GI cancer mortality in the US. Targeted public health interventions should aim to address social inequities faced by underserved communities.

Keywords: Public Health; Social Inequities; Disparity; Socioeconomic Status; Epidemiology

Introduction

Gastrointestinal (GI) cancers are significant burden on the health-care system in the United States (US), with an estimated 348,840 new cases and 172,010 deaths in 2023.[1] Although mortality rates for most GI cancers have shown downward trends over the years,[2] they remain nonuniform across the country.[3] Many regions and counties have seen disproportionally higher GI cancer incidence and mortality rates. For instance, colorectal cancer incidence and mortality rates are reportedly lowest in the West and highest in Appalachia and parts of the South and Midwest.[4] States with higher liver cancer mortality are clustered in the southern US.[5] Previous studies have identified factors associated with increased GI cancer mortality.[6,7] Among them, social determinants of health (SDOH) have been repeatedly referenced as an important contributing factor.[8,9]

SDOH have important implications for GI cancer mortality. They strongly shape health-related behaviors which then directly affect outcomes. Education, for instance, leads to higher health literacy, enabling individuals to use information and services to inform health-related decisions and actions. Higher educational attainment also leads to better, more stable jobs which allow individuals to obtain health insurance and have easier access to health care. Individuals' lifestyle choices are frequently influenced by their social backgrounds. Socially disadvantaged populations are more likely to have unhealthy lifestyle factors such as smoking, obesity, and physical inactivity.[10–12] This may in part be explained by early exposure to smoking, high social and environmental stress, low access to healthy foods and open/green space, and poor knowledge of associated adverse health effects.[13] Most studies to date examined the associations between individual-level SDOH and cancer outcomes. Nonetheless, individuals are influenced by the broader neighborhoods and communities they live in. Area-level SDOH are thus important considerations when assessing the overall GI cancer burden.[8,9]

Understanding the interplay between SDOH and GI cancer mortality may inform approaches to reduce disparity in cancer burden across US counties. In this ecological study, we evaluated social vulnerability of US counties using the Social Vulnerability Index (SVI) from the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry. This index integrates key social elements to identify communities with the least infrastructure and fewest resources that are most at risk of public health adversities.[14] The purpose of this study was to examine the association between county social vulnerability and GI cancer mortality, stratified by key demographic characteristics.

Methods

Data Source

CDC Wide-Ranging Online Data for Epidemiological Research (WONDER)'s Underlying Cause of Death database captures a single underlying cause of death and demographic data including age, sex, race/ethnicity from death certificates for US residents.[15] The underlying causes of death are classified according to the International Classification of Disease 10th revision (ICD-10) and selected from the conditions entered by the physician on the cause of death section of the death certificate. When more than one cause or condition was entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications.

We obtained county-level GI cancer-related mortality rates (ICD-10 codes C15-C26) from 2016 to 2020. Age adjustment was performed by direct standardization to the 2000 US standard population. Age-adjusted mortality rates (AAMRs) were presented in deaths per 100,000 population. We also obtained mortality rates for 5 major GI cancers: esophageal (C15), gastric (C16), liver and intrahepatic bile ducts (referred to as liver cancer in this study) (C22), pancreatic (C25), and colorectal cancer (C18-20). County-level data representing fewer than 10 persons are suppressed for confidentiality and rates are marked as unreliable when the death count is less than 20 total. These data were not presented in the current analysis.

Social Vulnerability Index

SVI is a measurement that characterizes a community's capacity to anticipate, confront, repair, and recover from the effects of a disaster.[14] The CDC/Agency for Toxic Substances and Disease Registry uses US Census data to rank each census tract on 16 social factors and groups them into 4 related themes: socioeconomic status (SES, below 150% poverty; unemployed; housing cost burden; no high school diploma; no health insurance); household characteristics (aged 65 and older; aged 17 years and older; civilian with a disability; single-parent households, English language proficiency), racial and ethnic minority status; and housing type and transportation (multiunit structures; mobile homes; crowding; no vehicle; group quarters).[14] SVI is a percentile ranking and represents the proportion of tracts (or counties) that are equal to or lower than a tract (or county) of interest in terms of social vulnerability. The index ranges from 0 to 1, with higher indices indicating greater vulnerability. SVI can be used to identify socially vulnerable populations, and prepare for and recover from public health adversities. Recent studies have associated greater SVI with adverse health outcomes including cardiovascular,[16] chronic respiratory disease,[17] and cancer mortality.[18] We utilized the 2020 SVI data for the current study.

Covariates

We included demographic (age, sex, race/ethnicity, rurality) and socioeconomic variables (income, educational attainment, insurance status). All variables were obtained from the 2020 American Community Survey 5-Year Estimates (2016–2020) except for rurality which was assessed using the National Center for Health Statistics 2013 Urban-Rural Classification Scheme. We classified counties into urban (large metro [≥1 million], medium/small metro [50,000–999,999]), and rural (micropolitan and noncore [nonmetropolitan counties that did not qualify as micropolitan: <50,000]) counties. All covariates were obtained at the county level and linked with county-level SVI and age-adjusted GI cancer mortality rates to form the final dataset for analysis. All data sources are presented in Table A1.

Statistical Analysis

We categorized SVI into quintiles based on the distribution among US counties (1st quintile [least vulnerable] to 5th quintile [most vulnerable]). We mapped out county SVI and age-adjusted GI cancer mortality rates and compared their distributions. All covariates were continuous variables and presented as median and interquartile ranges (IQRs) to demonstrate county characteristics across quintiles of SVI.

We presented the median age-adjusted GI cancer mortality rates and IQRs across quintiles of county SVI. We used Poisson regression through generalized estimating equation for clustered data to estimate the rate ratios (RRs) and 95% confidence intervals (CIs) for GI cancer mortality by quintiles of SVI. Tests for trend were performed by modeling SVI as a continuous variable. Stratified analysis was performed according to strata of individual-level demographic characteristics—age, sex, and race/ethnicity—and county rurality. Secondary analysis was performed for 4 SVI themes: SES, household characteristics, racial and ethnic minority status, and housing type and transportation. We also examined 5 individual GI cancers—esophageal cancer, gastric cancer, liver cancer, pancreatic cancer, and colorectal cancer. We presented the AAMRs and RRs by quintiles of SVI.

Two-sided $P < .05$ were considered statistically significant. We used the R Project for Statistical Computing (4.3.2) for all analyses and graphic creation.

Results

County Characteristics

A total of 2722 (86.6% of all US counties) US counties were included in the analysis. Table 1 shows the characteristics of US counties across quintiles of SVI. These characteristics were categorized into demographic and socioeconomic characteristics. There was a trend towards higher rates of racial and ethnic minorities including Hispanic and non-Hispanic Black or African American population with greater county SVI. Counties with greater SVI were more likely to be in rural areas. They were associated with lower SES including lower median household income and educational attainment and higher uninsured rates.

Geographic Variation in County Social Vulnerability and GI Cancer Mortality

The largest concentration of counties with greater social vulnerability was clustered across the southwestern and southeastern parts of the US (Figure). This mirrored the distribution of county-level GI cancer mortality where counties with higher mortality rates were similarly concentrated mainly in the southern US. There was significant variation in geographic distribution across the US between individual GI cancers (Figure A1). Notably, the distribution of mortality due to gastric cancer and liver cancer most closely resembled that of SVI. The distribution of esophageal cancer mortality and pancreatic cancer mortality, on the other hand, did not appear to correlate with county SVI.

Overall GI Cancer Mortality

Between 2016 and 2020, there were 799,968 GI cancer deaths with an AAMR (95% CI) of 39.6 (39.6–39.7) deaths per 100,000 population (Table 2). The AAMRs (IQRs) increased from 39.1 (35.3–43.2) in counties in the lowest SVI quintile to 46.0 [41.4–51.2] in counties in the highest SVI quintile. The RRs comparing SVI quintiles demonstrated a strong linear trend. Compared with counties in the lowest SVI quintile, RRs increased gradually from 1.04 (1.01–1.06) for counties in the second quintile to 1.19 (1.14–1.24) for counties in the highest quintile ($P_{trend} < 0.001$). The AAMRs and RRs were analyzed by quintiles of the 4 SVI themes (Table A2). SES and household characteristics had the strongest associations with GI cancer mortality (RR, 1.20 and 1.17, respectively). In a stratified analysis, GI cancer mortality rates were higher in counties with greater SVI in all strata of demographic characteristics (age, sex, race/ethnicity, county rurality) (Table 3). AAMRs (95% CIs) were higher in older adults (109.6 [109.4–109.9]), men (50.7 [50.6–50.9]), non-Hispanic Black individuals (50.2 [49.9–50.6]), and rural counties (42.8 [42.6–43.1]) compared with their respective counterparts. RRs (95% CIs) for GI cancer mortality comparing quintiles of SVI were greater in younger individuals (1.24 [1.15–1.32]), men (1.22 [1.16–1.27]), Hispanic individuals (1.33 [1.18–1.50]), and rural counties (1.21 [1.14–1.27]) compared with their counterparts.

Individual GI Cancer Mortality

For individual GI cancers, the AAMR (95% CI) was 3.8 (3.8–3.8) for esophageal cancer; 2.8 (2.8–2.9) for gastric cancer; 6.6 (6.6–6.7) for liver cancer; 11.1 (11.0–11.1) for pancreatic cancer; and 13.1 (13.0–13.1) for colorectal cancer (Table 4). County SVI showed strong associations with mortality related to gastric cancer ($RR_{Q5\ vs\ Q1}$, 1.58; 95%, 1.48–1.69) ($P_{trend} < 0.001$), liver cancer ($RR_{Q5\ vs\ Q1}$, 1.54; 95%, 1.36–1.73) ($P_{trend} < 0.001$), and colorectal cancer ($RR_{Q5\ vs\ Q1}$, 1.23; 95% CI, 1.15–1.31) ($P_{trend} < 0.001$). SVI was not associated with esophageal cancer ($RR_{Q5\ vs\ Q1}$, 0.95; 95%, 0.90–1.01; $P_{trend} = 0.17$) and pancreatic cancer mortality ($RR_{Q5\ vs\ Q1}$, 1.04; 95% CI, 0.98–1.09) ($P_{trend} = 0.23$).

Discussion

GI cancers are associated with substantial burden of morbidity and mortality in the US. In this ecological analysis,

Table 1. Characteristics of US Counties According to Quintiles of Social Vulnerability Index, 2016 to 2020

	Social vulnerability index				
Variable[a]	Quintile 1 (n = 545)	Quintile 2 (n = 545)	Quintile 3 (n = 544)	Quintile 4 (n = 544)	Quintile 5 (n = 544)
Median age, y	42.7 (40.4–45.3)	42.2 (39.0–45.1)	41.3 (38.6–44.4)	40.6 (38.0–43.2)	38.7 (35.8–41.5)
Male sex, %	49.8 (49.3–50.4)	49.6 (49.0–50.4)	49.6 (48.9–50.3)	49.2 (48.5–50.1)	49.4 (48.2–51.0)
Non-Hispanic White, %	92.0 (87.0–94.5)	88.3 (80.8–92.6)	84.1 (74.0–91.7)	73.0 (61.1–85.7)	53.9 (38.6–63.2)
Non-Hispanic Black or African American, %	0.9 (0.5–2.3)	2.0 (0.7–5.3)	2.4 (0.8–8.0)	5.9 (1.7–18.3)	19.8 (3.3–40.0)
Non-Hispanic Asian, %	0.7 (0.4–1.4)	0.7 (0.4–1.4)	0.7 (0.3–1.5)	0.7 (0.4–1.5)	0.7 (0.3–1.3)
Non-Hispanic American Indian and Alaska Native, %	0.2 (0.1–0.4)	0.2 (0.1–0.5)	0.2 (0.1–0.6)	0.3 (0.1–0.6)	0.3 (0.1–0.7)
Non-Hispanic Native Hawaiian and other Pacific Islander, %	0 (0-0)	0 (0–0.1)	0 (0–0.1)	0 (0–0.1)	0 (0–0.1)
Hispanic, %	3.1 (2.0–4.9)	3.6 (2.0–6.9)	4.0 (2.3–9.6)	5.8 (2.6–14.7)	7.2 (3.3–25.5)
Rural-urban continuum codes[b]	4 (1–7)	4 (2–6)	4 (2–7)	5 (2–7)	6 (3–6)
Median household income, USD	63,684 (57,727–73,741)	56,746 (51,206–65,244)	52,047 (46,443–59,312)	49,979 (43,444–55,466)	43,401 (37,558–49,368)
Population age 25 y and older with Bachelor's degree or higher, %	24.8 (19.6–34.1)	22.5 (17.7–30.3)	20.1 (15.4–27.5)	18.5 (14.9–24.2)	16.1 (13.5–20.4)
Uninsured rate, %	5.2 (4.1–6.6)	6.9 (5.2–9.1)	8.6 (6.1–11.2)	10.4 (7.5–13.5)	12.6 (9.9–16.5)

[a]All variables are continuous and presented as median and interquartile ranges.
[b]Rural-Urban Continuum Codes range from 1 to 9, with 9 indicating the highest degree of rurality.

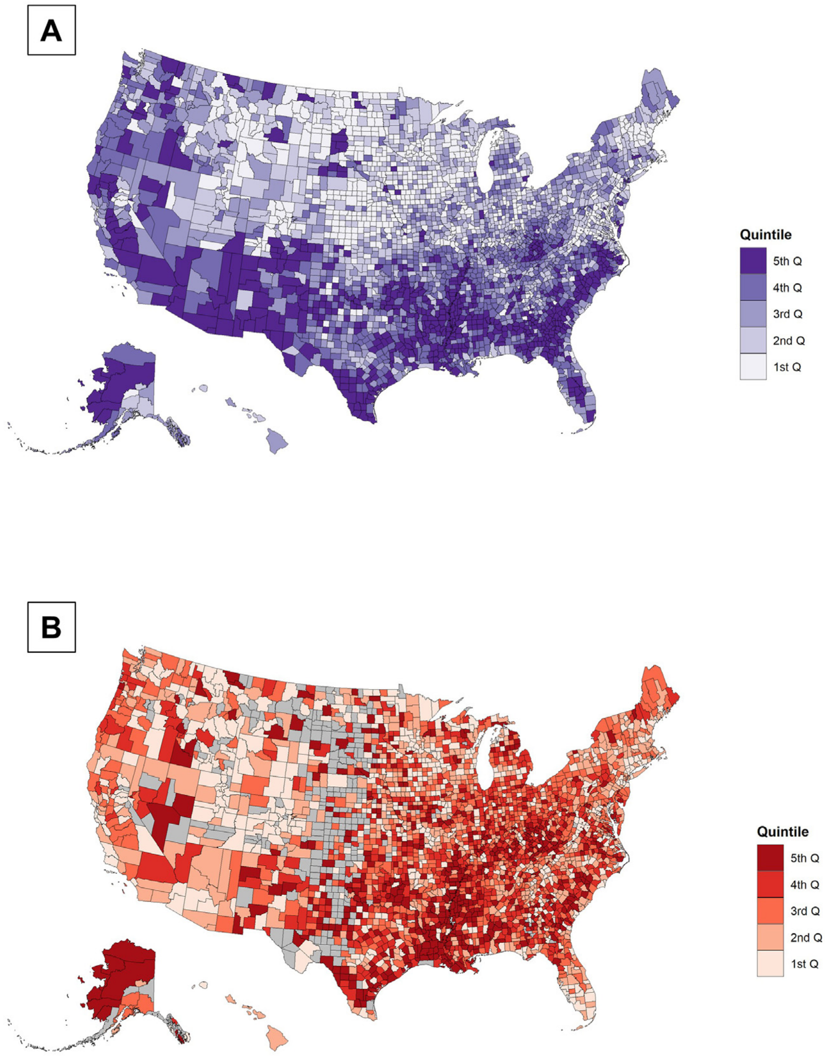

Figure. Geographic variation in social vulnerability and GI cancer mortality in the US, 2016–2020. (A) Counties by Social Vulnerability Index; (B) by age-adjusted GI cancer mortality rates. Q indicates quintile.

we demonstrate significant geographic variability in GI cancer mortality across the country. Counties with greater social vulnerability experienced higher GI cancer mortality. Mortality disparities were more prominent in younger individuals, men, Hispanic individuals, and rural communities compared with their counterparts. Among 5 individual GI cancers, mortality due to gastric cancer, liver cancer, and colorectal cancer demonstrated the strongest correlation with social vulnerability. Our analysis offers a more granular understanding of disparities in GI cancer mortality and serves to inform a focused approach to decrease GI cancer burden.

Health disparities in the US have been well documented for numerous diseases and malignancies. GI cancers are of particular concern as they account for significant health-

Table 2. Association Between Social Vulnerability Index and Age-adjusted GI Cancer Mortality Rates in US Counties, 2016 to 2020

		Social vulnerability index					
	Overall	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P_{trend}
No. of counties	2722	545	545	544	544	544	
AAMR, median (IQR)[a]	39.6 (39.6–39.7)	39.1 (35.3–43.2)	40.8 (36.5–44.8)	41.4 (37.4–46.0)	42.9 (39.4–47.5)	46.0 (41.4–51.2)	
RR (95% CI)[b]	N/A	1 (reference)	1.04 (1.01–1.06)	1.06 (1.04–1.09)	1.11 (1.08–1.15)	1.19 (1.14–1.24)	<.001

AAMR, age-adjusted mortality rate; CI, confidence interval; GI, gastrointestinal; IQR, interquartile range; N/A, not applicable; RR, rate ratio.
[a]Presented in median number of deaths per 100,000 population and IQR.
[b]Univariable model.

Table 3. Association Between Social Vulnerability Index and Age-adjusted GI Cancer Mortality Rates in US Counties, 2016–2020

Characteristics	Overall	Social vulnerability index					
		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P_{trend}
Age							
<45 y							
AAMR, median (IQR)[a]	2.2 (2.2–2.3)	1.9 (1.8–2.2)	2.1 (1.9–2.3)	2.2 (1.9–2.5)	2.4 (2.2–2.6)	2.4 (2.2–2.7)	
RR (95% CI)[b]	N/A	1 (reference)	1.1 (1.02–1.19)	1.15 (1.05–1.25)	1.23 (1.15–1.31)	1.24 (1.15–1.32)	<.001
≥45 y							
AAMR, median (IQR)[a]	109.6 (109.4–109.9)	108.3 (96.9–120.3)	112.5 (100.3–122.9)	114.2 (103.4–125.4)	119.1 (108.3–130.5)	126.0 (114.2–141.6)	
RR (95% CI)[b]	N/A	1 (reference)	1.03 (1.01–1.06)	1.06 (1.03–1.08)	1.11 (1.08–1.14)	1.18 (1.13–1.23)	<.001
Sex							
Men							
AAMR, median (IQR)[a]	50.7 (50.6–50.9)	49.2 (43.7–55.8)	52.2 (46.2–58.1)	53.0 (48.0–60.0)	55.7 (50.0–62.3)	59.2 (53.2–68.3)	
RR (95% CI)[b]	N/A	1 (reference)	1.05 (1.02–1.07)	1.08 (1.05–1.11)	1.13 (1.09–1.16)	1.22 (1.16–1.27)	<.001
Women							
AAMR, median (IQR)[a]	30.3 (30.2–30.5)	29.6 (26.5–33.2)	31.0 (27.7–34.6)	31.5 (28.4–35.1)	32.5 (29.2–36.3)	33.9 (30.4–38.6)	
RR (95% CI)[b]	N/A	1 (reference)	1.03 (1.01–1.05)	1.07 (1.04–1.10)	1.10 (1.06–1.13)	1.15 (1.10–1.19)	<.001
Race/ethnicity							
Non-Hispanic White							
AAMR, median (IQR)[a]	38.9 (38.8–39.0)	39.3 (35.2–43.3)	40.6 (36.1–45.0)	41.5 (37.1–45.9)	42.2 (38.5–46.9)	43.5 (39.6–48.8)	
RR (95% CI)[b]	N/A	1 (reference)	1.03 (1.01–1.06)	1.06 (1.04–1.09)	1.09 (1.05–1.12)	1.12 (1.09–1.15)	<.001
Non-Hispanic Black							
AAMR, median (IQR)[a]	50.2 (49.9–50.6)	48.5 (43.2–56.9)	51.5 (46.1–58.6)	52.2 (47.2–57.5)	55.2 (48.2–65.6)	56.2 (48.0–64.8)	
RR (95% CI)[b]	N/A	1 (reference)	1.06 (1.01–1.10)	1.05 (0.98–1.13)	1.13 (1.07–1.20)	1.11 (1.03–1.19)	.006
Hispanic							
AAMR, median (IQR)[a]	37.2 (36.9–37.5)	33.5 (29.1–38.5)	37.4 (32.5–41.1)	35.0 (29.8–42.2)	39.0 (33.5–46.0)	43.5 (38.1–51.2)	
RR (95% CI)[b]	N/A	1 (reference)	1.1 (1.03–1.18)	1.09 (0.95–1.25)	1.25 (1.03–1.52)	1.33 (1.18–1.50)	.006
Rurality[c]							
Urban							
AAMR, median (IQR)[a]	39.1 (39.0–39.2)	37.9 (34.4–41.7)	38.8 (35.7–42.1)	40.1 (37.0–43.7)	41.2 (38.2–44.4)	42.9 (39.5–46.8)	
RR (95% CI)[b]	N/A	1 (reference)	1.02 (1.00–1.05)	1.06 (1.03–1.10)	1.09 (1.05–1.13)	1.13 (1.08–1.17)	<.001
Rural							
AAMR, median (IQR)[a]	42.8 (42.6–43.1)	40.5 (36.0–45.3)	42.0 (37.7–46.5)	43.2 (38.7–48.0)	44.5 (40.4–50.0)	47.1 (42.3–53.7)	
RR (95% CI)[b]	N/A	1 (reference)	1.05 (1.01–1.09)	1.08 (1.04–1.12)	1.13 (1.09–1.17)	1.21 (1.14–1.27)	<.001

AAMR, age-adjusted mortality rate; CI, confidence interval; GI, gastrointestinal; IQR, interquartile range; N/A, not applicable; RR, rate ratio.
[a]Presented in median number of deaths per 100,000 population and IQR.
[b]Univariable model.
[c]Rurality was assessed using the National Center for Health Statistics 2013 Urban-Rural Classification Scheme. Counties were classified into urban (large metro [≥1 million], medium/small metro [50,000–999,999]), and rural (micropolitan and noncore [nonmetropolitan counties that did not qualify as micropolitan: <50,000]) counties.

Table 4. Association Between Social Vulnerability Index and Age-adjusted GI Cancer Mortality Rates in US Counties, 2016 to 2020

	Social vulnerability index						
Cancer type	Overall	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P_{trend}
Esophageal cancer							
No. of counties	862	173	173	172	172	172	
AAMR, median (IQR)[a]	3.8 (3.8–3.8)	4.4 (3.7–5.1)	4.5 (3.7–5.6)	4.5 (3.8–5.4)	4.3 (3.5–5.1)	4.2 (3.4–4.8)	
RR (95% CI)[b]	N/A	1 (reference)	1.04 (0.98–1.11)	1.05 (0.99–1.12)	0.98 (0.92–1.05)	0.95 (0.90–1.01)	.17
Gastric cancer							
No. of counties	505	101	101	101	101	101	
AAMR, median (IQR)[a]	2.8 (2.8–2.9)	2.3 (2.0–2.6)	2.5 (2.2–2.9)	2.6 (2.3–3.1)	3.0 (2.5–3.4)	3.7 (3.0–4.2)	
RR (95% CI)[b]	N/A	1 (reference)	1.12 (1.06–1.19)	1.15 (1.08–1.23)	1.29 (1.22–1.35)	1.58 (1.48–1.69)	<.001
Liver cancer							
No. of counties	1135	227	227	227	227	227	
AAMR, median (IQR)[a]	6.6 (6.6–6.7)	5.6 (5.1–6.3)	6.4 (5.5–7.0)	6.7 (5.8–7.9)	7.2 (6.2–8.5)	8.4 (7.2–10.1)	
RR (95% CI)[b]	N/A	1 (reference)	1.1 (1.06–1.15)	1.20 (1.13–1.28)	1.30 (1.22–1.38)	1.54 (1.36–1.73)	<.001
Pancreatic cancer							
No. of counties	1634	327	327	327	327	326	
AAMR, median (IQR)[a]	11.1 (11.0–11.1)	11.4 (10.3–12.6)	11.5 (10.4–12.7)	11.5 (10.4–12.8)	11.4 (10.4–12.9)	11.7 (10.3–13.6)	
RR (95% CI)[b]	N/A	1 (reference)	1.00 (0.98–1.03)	1.00 (0.97–1.03)	1.01 (0.98–1.05)	1.04 (0.98–1.09)	0.23
Colorectal cancer							
No. of counties	1933	387	387	387	386	386	
AAMR, median (IQR)[a]	13.1 (13.0–13.1)	13.2 (11.4–15.8)	14.0 (12.1–16.5)	14.2 (12.4–17.1)	15.0 (13.3–17.8)	16.1 (13.8–19.2)	
RR (95% CI)[b]	N/A	1 (reference)	1.06 (1.02–1.10)	1.10 (1.05–1.16)	1.16 (1.10–1.23)	1.23 (1.15–1.31)	<.001

AAMR, age-adjusted mortality rate; CI, confidence interval; GI, gastrointestinal; IQR, interquartile range; N/A, not applicable; RR, rate ratio.
[a]Presented in median number of deaths per 100,000 population and IQR.
[b]Univariable model.

care burden.[2] Using 3 national databases,[19] Singh et al discovered disparities in incidence and mortality of gastric, liver, esophageal, and colorectal cancer across levels of income and educational attainment. In a study by Fabregas et al,[20] individuals with higher income and insurance had lower odds of advanced pancreatic cancer and better overall survival. Most studies to date utilize individual-level data to assess disparities between sociodemographic groups. Nonetheless, individuals are exposed to the communities and neighborhoods that shape the conditions of their daily lives. Negative health outcomes may be the result of the socioeconomic environment in which they live. As such, studies that explore area-level disparities are warranted. Wagle et al[8] found that racial disparities in overall survival of hepatocellular carcinoma may be moderated by neighborhood SES and are particularly evident among those living in high-poverty neighborhoods. In a study by Song et al,[9] the authors demonstrated significant county-level socioeconomic inequalities in GI cancer mortality. In line with their findings, we show that counties with greater social vulnerability are associated with higher GI cancer mortality rates. The largest concentration of counties with greater social vulnerability were clustered across the southwestern and southeastern parts of the US, which coincided with the geographic variation in GI cancer mortality.

Despite the decline in GI cancer mortality rates in recent decades,[2] some US counties continued to show increases in mortality.[3] These counties are often underserved communities that lack adequate public health infrastructure. First, the residents are more likely to have unfavorable cancer risk profiles such as smoking, obesity, and physical inactivity.[10–12] Doubeni et al[21] found that a substantial proportion of the socioeconomic disparity in colorectal cancer risk may be attributable to the higher prevalence of unhealthy lifestyle behaviors in low-SES populations. Poor neighborhood quality often presents environmental adversity to the population and may accentuate their tendency to unhealthy lifestyle behaviors.[22] These individuals often have easy access to tobacco and alcohol, strong peer influence and poor social support, and reduced access to open/green space to promote physical activity.[13] Immigrants may experience greater burden of liver cancer and gastric cancer due to higher rates of viral hepatitis and higher salt intake related to their country of origin.[23,24] We found that the associations between social vulnerability and gastric cancer and liver cancer mortality were stronger compared with the other cancers. Second, socially disadvantaged populations often lack access to quality health care. They face challenges related to cost and marginalization, including lack of access to housing, insurance, funds and credit for out-of-pocket costs and needed services.[25–27] Due to low educational attainment, they often have poor health awareness and health literacy.[28] They also face longer travel distances to cancer screening sites,[29] as evidenced by lower screening rates in African Americans and individuals with lower household income.[30] Similarly, counties with higher SVI have lower colorectal cancer screening rates,[31] which may in part explain the significant association between county social vulnerability and colorectal cancer mortality in our analysis. Immigrants additionally may experience language barriers associated with confusion when seeking care.[32]

Certain populations notably saw more significant social disparities in GI cancer mortality between counties. Among individuals younger than age 45 years, despite having an overall low GI cancer mortality, those who live in more socially vulnerable counties experienced higher GI cancer mortality. a prior study showed that compared with late-onset colorectal cancers, early-onset colorectal cancers are more likely to affect racial minorities and present with advanced or metastatic disease or with aggressive histology.[33] Lack of health-care access may cause young individuals in these underserved counties to bear disproportionately high GI cancer burden. Cancer mortality is known to be higher in men than in women.[34] We show that the differences in county-level GI cancer mortality across social gradients were more significant in men compared with women. Among all racial/ethnic groups, Hispanic individuals saw greater social disparities in mortality compared with their NHW and NHB counterparts. Hispanics are more likely to be uninsured and have poor health literacy which, on top of poor lifestyle, lead to worsened cancer outcomes.[35,36] Rural-urban disparities are often seen in GI cancer mortality.[37] We showed that GI cancer mortality in rural counties was more strongly associated with social vulnerability than in urban counties. These underserved counties suffer from unequal access to quality care related to limited health-care–seeking behaviors, higher uninsured rates, and longer travel distances.[38] Urban counties have more equal access to health care across gradients of social vulnerability, thus minimizing the impact of social vulnerability.

Our study has several strengths. Our data were obtained from a nationally representative database. We included a wide range of detailed variables to characterize counties' social attributes. We were able to map counties based on the level of social vulnerability and GI cancer mortality, providing direct visualization of the distribution of these variables. We performed a series of comprehensive analyses to explore the relationship between social vulnerability and GI cancer mortality.

We also recognize some important limitations. First, SVI is a broad measure of social disadvantage and does not allow assessment of individual social elements, though the 4 themes comprising SVI can be studied.[6] Second, miscoding issues may exist for data of administrative sources. The cause of death, in particular, is subject to coding errors due to the inability to determine the precise cause. Third, we excluded counties with less than 20 death counts in accordance with CDC recommendations which aimed to address concerns for reliability and confidentiality. We recognize that these censored counties are more likely to be rural, hence leading to selection bias. The exclusion also resulted in low sample sizes for a few strata and individual GI cancers. Fourth, county-level variables were collected cross-sectionally and precluded modeling changes in variables over time. Lastly, our unit of analysis was county. There may be loss of nuance given the potential heterogeneity within counties. Our findings should be interpreted with caution to avoid ecological fallacy.

In conclusion, disparities in GI cancer mortality exist across gradients of social vulnerability. Counties with greater social vulnerability are associated with higher GI cancer mortality rates, especially among younger individuals, men, Hispanic individuals, and rural communities. Our findings demonstrate the fragility of the underserved communities and underscore the need for an improved strategy for resource allocation and targeted public health interventions to address social inequities in GI cancer mortality in the US.

Supplementary Materials

Material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.gastha.2024.05.007.

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Study concept and design: Chun-Han Lo, N. Jewel Samadder; acquisition of data: Chun-Han Lo; statistical analysis: Chun-Han Lo; interpretation of data: all authors; drafting of the manuscript: Chun-Han Lo, Harminder Singh, N. Jewel Samadder; critical revision of the manuscript for important intellectual content: all authors.

Conflicts of Interest:
These authors disclose the following: N. Jewel Samadder is a consultant for Jansen Research and Development and Recursion Pharmaceuticals. Harminder Singh has been on advisory boards or a consultant to Pendopharm, Amgen Canada, Roche Canada, Sandoz Canada, Takeda Canada, and Guardant Health, Inc and has received research funding for an investigator-initiated grant from Pfizer. None of this is related to the current work. The remaining authors disclose no conflicts.

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This study did not require institutional review board approval per institutional policy at the University of Nevada, Las Vegas (UNLV) as the analysis used publicly available aggregated data without individually identifiable information.

Data Transparency Statement:
All data used in this study were from a publicly available source. Data used specifically for analysis may be requested by contacting the corresponding author.

Reporting Guidelines:
Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).