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County Rurality and Socioeconomic Deprivation is Associated with Reduced Survival from Gastric Cancer in the United States

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INTRODUCTION

Gastric cancer (GC) is responsible for approximately 780,000 deaths annually and remains the third most common cause of cancer-related mortality worldwide.[1] While the absolute burden of GC in the United States (US) is low compared to some developing and recently developed countries, 5-year survival from GC remains poor (~27%).[2] Because GC screening and early detection programs are not routine in the US, GC is most often diagnosed at advanced stages where therapeutic options are limited and cure is unlikely. By contrast, when GC is diagnosed at an early stage, resection is often curative and five-year survival exceeds 95%.[2]

Apart from non-modifiable tumor-specific factors such as stage and histology, determinants associated with survival following GC diagnosis are largely undefined. An improved understanding of theoretically modifiable factors, such as local community and geographic factors, may lead to more efficient resource allocation to improve outcomes from this deadly disease. County-level characteristics such as urbanization, poverty, and unemployment are known determinants of health outcomes. Defining community-related factors which impact GC survival may provide critical insight for resource allocation and for targeted interventions. We leveraged a large sample of the US population with linkage to county-level

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RJH, SCS, MCC, LP, and JHH contributed to analysis and interpretation of data.
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characteristics in order to test the hypothesis that county-level factors—specifically, rurality, educational attainment, poverty, and unemployment– are independently associated with survival following GC diagnosis.

METHODS

We conducted a retrospective cohort analysis of survival following an incident GC diagnosis identified from the Surveillance, Epidemiology, and End Results (SEER) Program between 1992 and 2016.[3] All regional registries which reported county-level data during the study period were included in the analytic cohort. A flow diagram demonstrating cohort selection is depicted in Supplementary Figure 1. Patient-level covariates recorded at time of diagnosis were age, sex, race, ethnicity, and health insurance coverage. Tumor-level covariates recorded were anatomic location (cardia or non-cardia), histology (diffuse, intestinal, or not specified), summary stage (local or advanced), and performance of surgical resection. For each incident case, the county of residence was recorded and linked to county-level factors derived from the American Community Survey. Counties were classified as urban or rural based on a dichotomized system utilized by the US Department of Agriculture. Educational attainment, poverty, and unemployment were ascertained for each county. Further details are provided in the Supplementary Methods.

For the analysis, educational attainment, poverty, and unemployment by county were categorized into tertiles. The primary endpoint was cancer-specific survival, and the secondary endpoint was overall survival. The association between the exposure variables (county-level factors) and survival were assessed utilizing proportional hazards (PH) regression. Effect estimates were presented as the hazard ratio (HR) with 95% confidence intervals (CIs). HRs >1 represented decreased survival. Factors previously identified or believed to be associated with survival were evaluated as potential confounders. These included age, gender, race, ethnicity, insurance status, tumor stage, tumor histology, performance of tumor resection, and county-level attributes. Relevant patient-, tumor-, and county-level covariates were included in the respective multivariable model if variable inclusion resulted in a change-in-estimate between adjusted and unadjusted HRs of ≥10%.

RESULTS

A total of 107,562 incident GC diagnoses from 612 unique counties were included in the analytic cohort. The association between county-level factors and GC-specific survival are detailed in Table 1, which includes stratification by stage of diagnosis (local vs advanced stage). Rural county residency was associated with modestly decreased GC-specific survival (HR 1.06; CI 1.03–1.10), but this difference was more pronounced for localized-stage cancers (HR 1.27, CI 1.16–1.39) compared to advanced-stage cancers (HR 1.03, CI 0.99–1.06). Counties in the highest tertile of educational attainment demonstrated better survival (HR 0.91, CI 0.89–0.93) compared to counties in the lowest tertile. Increasing county poverty was associated with reduced survival. This association was particularly robust among localized-stage cancers, where counties in the highest tertile of poverty had markedly reduced survival (HR 1.30, CI 1.20–1.42) compared to counties in the lowest tertile of poverty. There was no clear pattern of association between county-level unemployment and GC-specific survival, irrespective of tumor stage.

The magnitude and directionality of the associations between county-level factors and *overall* survival were generally similar to those for GC-specific survival (Supplementary Table 1). The association between rural county residency and reduced survival was maintained (HR 1.09, CI 1.06–1.17), and was likewise more pronounced among localized-stage cancers (HR 1.19, CI 1.13–1.26). Increasing educational attainment was associated with improved overall survival, whereas increasing poverty was associated with reduced overall survival.

DISCUSSION

In this US population-based analysis, we identified specific county-level factors that are independently associated with survival following GC diagnosis. Our finding of a rural ‘survival gap’ for GC warrants particular emphasis. The reasons underlying this observed survival difference between rural and urban dwellers are undoubtedly multifactorial, but may include modifiable factors such as limited availability of diagnostic testing, limited access to physicians qualified to perform endoscopic or surgical GC resection, and a relative dearth of oncology centers for specialized cancer care. The relevance of these factors is further supported by our finding that the rural survival gap was accentuated among localized-stage disease, where timely surgical or endoscopic resection is potentially curative.[4] These findings highlight the need for effective, practical strategies to improve access for patients diagnosed with GC in rural areas.

We specifically demonstrated that increasing levels of county poverty and low educational attainment are associated with decreased survival, irrespective of tumor stage. These findings are consistent with prior research showing ongoing disparities in cancer survival among patients with lower income[5, 6] and educational attainment.[7] Future community-based intervention programs—for example, patient navigator systems focused on GC diagnosis and treatment—may help to narrow the observed survival gap. The success stories of patient navigators with respect to both breast and colon cancer provide precedent for the benefit of such programs in reducing barriers to cancer care faced by those with lower incomes.[8]

In conclusion, county rurality and socioeconomic deprivation are associated with worse survival following GC diagnosis in the US. These findings have clinical and public health implications with respect to appropriate resource allocation and targeted interventions to attenuate county-level disparities in cancer outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Abbreviations

GC	Gastric Cancer

U.S.	United States
SEER	Surveillance Epidemiology, and End Results
FIPS	Federal Information Processing Standard
PH	proportional hazards
HR	hazard ratio
CI	confidence interval

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Table 1:

Association Between County-Level Factors and Gastric Cancer-Specific Survival

County-Level Factor	All Stages (N=107,562)		Localized Stage (N=27,078)		Advanced Stage (N=80,484)	
	HR (95% CI)	**P value**	**HR (95% CI)**	**P value**	**HR (95% CI)**	**P value**
Rurality						
Rural (vs urban)	1.06 (1.03–1.10)	**<0.001**	1.27 (1.16–1.39)	**<0.001**	1.03 (0.99–1.06)	0.2
Educational Attainment (% of population ≥25 years old with at least a high-school degree)						
Lowest tertile (< 80.0%)	1.00	Ref.	1.00	Ref.	1.00	Ref.
Middle (80.0 to 88.2%)	0.99 (0.97–1.02)	0.6	1.11 (1.05–1.20)	**0.001**	0.97 (0.95–1.01)	0.2
Highest (> 88.2%)	0.91 (0.89–0.93)	**<0.001**	0.91 (0.85–0.98)	**0.01**	0.92 (0.90–0.94)	**<0.001**
p for trend		**<0.001**		**0.006**		**<0.001**
Poverty (% of households below the federal poverty limit)						
Lowest tertile (< 10.3%)	1.00	Ref.	1.00	Ref.	1.00	Ref.
Middle (10.3% to 16.5%)	1.06 (1.04–1.08)	**<0.001**	1.07 (1.00–1.13)	**0.04**	1.06 (1.04–1.08)	**<0.001**
Highest (> 16.5%)	1.15 (1.11–1.18)	**<0.001**	1.30 (1.20–1.42)	**<0.001**	1.09 (1.05–1.12)	**<0.001**
p for trend		**<0.001**		**<0.001**		**<0.001**
Unemployment (% of unemployed persons ≥16 years old)						
Lowest tertile (< 6.9%)	1.00	Ref.	1.00	Ref.	1.00	Ref.
Middle (6.9 to 9.7%)	0.98 (0.96–1.01)	0.2	1.06 (0.98–1.15)	0.1	0.98 (0.95–1.00)	0.07
Highest (> 9.7%)	1.02 (0.99–1.04)	0.2	1.01 (0.93–1.10)	0.8	1.01 (0.98–1.04)	0.6
p for trend		0.2		0.9		0.6

County rurality based on rural-urban continuum coding from US Department of Agriculture. County factors derived from the American Community Survey of the US Census. All presented hazard ratios (HRs) are adjusted for patient-, tumor-, and county-level covariates. Adjusted HRs >1 represented decreased survival.