Ethnic Disparities in Early-Onset Gastric Cancer: A Population-Based Study in Texas and California

Anna Tavakkoli[1,2,3], Sandi L. Pruitt[2,3], Anh Q. Hoang[4], Hong Zhu[3], Amy E. Hughes[2,3], Thomas A. McKey[2], B. Joseph Elmunzer[5], Richard S. Kwon[6], Caitlin C. Murphy[7], and Amit G. Singal[1,2,3]

ABSTRACT

Background: Incidence rates of gastric cancer are increasing in young adults (age <50 years), particularly among Hispanic persons. We estimated incidence rates of early-onset gastric cancer (EOGC) among Hispanic and non-Hispanic White persons by census tract poverty level and county-level metro/nonmetro residence.

Methods: We used population-based data from the California and Texas Cancer Registries from 1995 to 2016 to estimate age-adjusted incidence rates of EOGC among Hispanic and non-Hispanic White persons by year, sex, tumor stage, census tract poverty level, metro versus nonmetro county, and state. We used logistic regression models to identify factors associated with distant stage diagnosis.

Results: Of 3,047 persons diagnosed with EOGC, 73.2% were Hispanic White. Incidence rates were 1.29 [95% confidence interval (CI), 1.24–1.35] and 0.31 (95% CI, 0.29–0.33) per 100,000 Hispanic White and non-Hispanic White persons, respectively, with consistently higher incidence rates among Hispanic persons at all levels of poverty. There were no statistically significant associations between ethnicity and distant stage diagnosis in adjusted analysis.

Conclusions: There are ethnic disparities in EOGC incidence rates that persist across poverty levels.

Impact: EOGC incidence rates vary by ethnicity and poverty; these factors should be considered when assessing disease risk and targeting prevention efforts.

Introduction

Gastric cancer is the fifth most common cancer and fourth leading cause of cancer-related deaths worldwide (1). Recently, incidence rates of noncardia gastric cancer have increased in younger (age <50 years) adults (2–8). Early-onset noncardia gastric cancer (EOGC) is clinically and morphologically distinct from noncardia gastric cancer in older adults (4, 6–9). Young adults diagnosed with gastric cancer are more likely to have tumors with signet-ring cell or diffuse histology, present with metastatic disease, and have germline mutations in *CDH1* compared with older adults (4, 6–12).

EOGC occurs more frequently in Hispanic White persons and 2 in every 5 persons diagnosed with EOGC are Hispanic. Notably, Hispanic persons account for almost 40% of the population in both California and Texas (8, 10, 13–15). Incidence rates, risk factors, and anatomic location of gastric cancer have historically differed by ethnicity (3, 16). For example, non-Hispanic White persons typically have cancer in the cardia, related to gastroesophageal reflux, whereas Hispanic White persons more often have noncardia gastric cancers related to *Helicobacter pylori (H. pylori)* infection (3–14, 16). However, few studies have evaluated whether these differences persist in those with EOGC.

Social determinants of health (SDOH), including socioeconomic status and residential neighborhood poverty, are also increasingly recognized as important factors that may play a role in cancer incidence and outcomes (15, 17, 18). Among Hispanic persons, lower neighborhood socioeconomic status is associated with increased risk of noncardia cancers, but not cardia cancers (16). The young Hispanic population is growing in the United States (19), and Hispanics are more likely than non-Hispanic White persons to live in neighborhoods of low socioeconomic status (20). Despite the alarming trend of EOGC in this population, and the impact that SDOH may have on disparities in cancer incidence, to the best of our knowledge, there have been no studies examining the relationship between SDOH and EOGC among Hispanic persons.

To address these gaps, we aimed to: (i) estimate incidence rates of EOGC by ethnicity, census tract poverty level, and county-level metro/nonmetro residence; and (ii) examine the association between ethnicity, SDOH, and tumor stage. We used population-based data from the Texas Cancer Registry (TCR) and California Cancer Registry (CCR), together representing 45% of the U.S. Hispanic population (13, 21). We hypothesized that incidence rates of EOGC are higher in Hispanic White compared with non-Hispanic White persons, and that the changing landscape of EOGC is associated with SDOHs, such as neighborhood poverty.

Materials and Methods

Study population

We used population-based data from the CCR and TCR, two of the largest cancer registries in the United States, to derive incident cases of EOGC during 1995 to 2016. Both registries collect demographic and clinical information of cancers diagnosed in their respective states and in accordance with the North American Association of Central Cancer Registries Gold Certification standards (NAACR; ref. 22). Persons were included if they were identified as Hispanic White (hereafter,

[1]Division of Digestive and Liver Diseases, Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas, Texas. [2]Department of Population and Data Sciences, University of Texas Southwestern, Dallas, Texas. [3]Simmons Comprehensive Cancer Center, University of Texas Southwestern, Dallas, Texas. [4]Natural Sciences and Mathematics, The University of Texas at Dallas, Dallas, Texas. [5]Division of Gastroenterology and Hepatology, Department of Medicine, Medical University of South Carolina, Charleston, South Carolina. [6]Division of Gastroenterology, Department of Internal Medicine, University of Michigan, Ann Arbor, Michigan. [7]School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas.

C.C. Murphy and A.G. Singal contributed equally to this article.

Corresponding Author: Anna Tavakkoli, 5959 Harry Hines Boulevard, POBI, Suite 520, Dallas, TX 75390-8887. Phone: 214-645-6355; E-mail: anna.tavakkoli@utsouthwestern.edu

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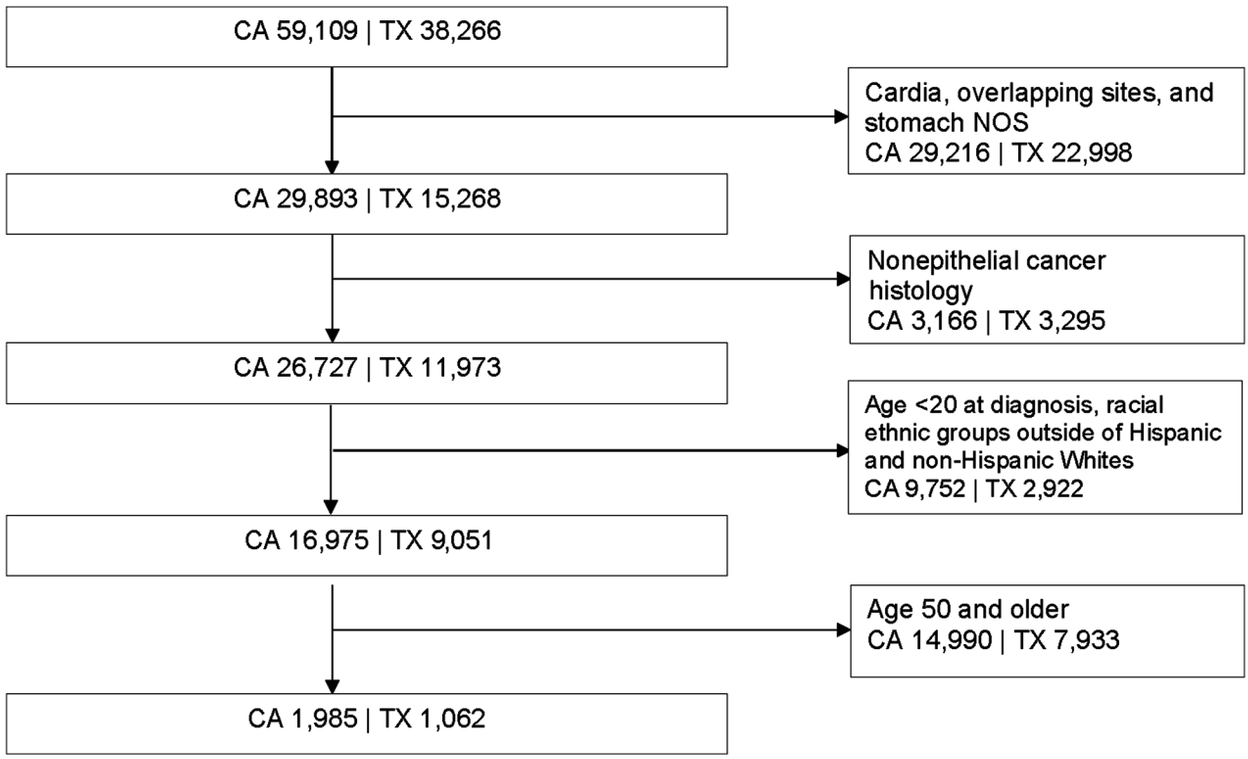

Figure 1.
Eligible patients in the TCR and CCR.

Hispanic) or non-Hispanic White (hereafter, White) based on the NAACR Hispanic Identification Algorithm (NHIA) and race variable. Persons were included if they had a noncardia gastric cancer and an International Classification of Diseases for Oncology, third edition (ICD-O-3) histology code for adenocarcinoma, linitis, intestinal, diffuse, signet, as well as those missing histology information (**Fig. 1**; ref. 16).

Covariates

We included the following covariates in our analysis: stage at diagnosis, metro versus nonmetro county, census tract poverty level, histology, grade, and insurance type. Stage at diagnosis was based on the NCI's Surveillance, Epidemiology and End Results (SEER) summary stage, defined as *in situ*/local, regional, and distant. Metro versus nonmetro county was defined using Rural-Urban Continuum Codes (RUCC), a classification scheme distinguishing counties by population size, commuting flow, and proximity to metro areas (23–25). Census tract poverty level was defined using the proportion of the population living below the federal poverty line as low (0–<10%), middle (10%–19%), and high poverty (≥20%). Tumor grade was defined as well differentiated, moderately differentiated, poorly differentiated, undifferentiated, or unknown. Insurance status was defined as uninsured, private insurance, Medicaid, Medicare, or other insurance, which includes Tricare/VA, Indian/public health, insurance not otherwise specified (NOS), unknown, and county insurance (CCR only). Insurance status at the time of diagnosis was collected in TCR after 2006 and in CCR starting in 1988.

Incidence rates of early-onset gastric cancer

For both Hispanic and White persons, we estimated age-adjusted (to the 2000 U.S. standard population) incidence rates of EOGC as rates per 100,000 persons. Corresponding 95% confidence intervals (CI) were calculated as modified gamma intervals using the Tiwari method (26). We compared incidence rates between Hispanic and White persons, overall and by 10-year age group, year of diagnosis (1995–2005 vs. 2006–2016), sex, stage at diagnosis, census tract poverty level, metro versus nonmetro county, and state (California vs. Texas).

Incidence rates per 100,000 persons were calculated as the number of new cancer cases divided by the size of the population. Currently, cancer registries do not provide population denominators by poverty level; therefore, in order to calculate the incidence rate of EOGC by census tract poverty level, we generated population denominators in a multi-step process. First, for each individual, we defined poverty at the time of the EOGC diagnosis defined at the census tract level as low, middle, or high. The TCR provided poverty data for all individuals; for California, we obtained the equivalent data from the U.S. Census and merged those data to the CCR. Census tracts are relatively homogenous small areas with respect to population characteristics and economic status, with an average size of 4,000 residents. Next, for each year, we calculated annual, poverty-relevant tract-level denominators using SEER county-level population denominator data and Census data on the number of census tract residents (for each county) living below the federal poverty line. The census data used include the 2000 Decennial U.S. Census and American Community Survey data (1995–2016). Denominators were calculated by multiplying the total

Table 1. Characteristics of 3,047 Hispanic and non-Hispanic Whites diagnosed with EOGC by ethnicity, TCR and CCR, 1995 to 2016.

	Hispanic White, $n = 2,233$	Non-Hispanic White, $n = 814$	P^a
	Number (percent)		
Sex			0.44
Male	1,173 (52.5)	444 (54.6)	
Female	1,058 (47.4)	370 (45.5)	
Missing	2 (0.1)	0 (0.0)	
Age at diagnosis			<0.01
20–29	162 (7.3)	22 (2.7)	
30–39	682 (30.5)	187 (23.0)	
40–49	1,389 (62.2)	605 (74.3)	
State			0.01
Texas	749 (33.5)	313 (38.5)	
California	1,484 (66.5)	501 (61.6)	
Years of diagnosis			<0.01
1995–2005	938 (42.0)	424 (52.1)	
2006–2016	1,295 (58.0)	390 (47.9)	
Charlson comorbidity index			
0	974 (43.6)	416 (51.1)	<0.01
1–2	295 (13.2)	119 (14.6)	
≥3	53 (2.4)	21 (2.6)	
Missing	911 (40.8)	258 (31.7)	
Histology			<0.01
Adenocarcinoma	718 (32.2)	302 (37.1)	
Linitis	33 (1.5)	14 (1.7)	
Intestinal	77 (3.5)	33 (4.1)	
Diffuse	188 (8.4)	41 (5.0)	
Signet	992 (44.4)	330 (40.5)	
Missing	225 (10.1%)	94 (11.6)	
Grade			<0.01
Well differentiated	30 (1.3)	25 (3.1)	
Moderately differentiated	140 (6.3)	87 (10.6)	
Poorly differentiated	1,709 (76.5)	545 (66.7)	
Undifferentiated	55 (2.4)	19 (2.3)	
Missing	299 (13.4)	138 (17.0)	
Stage			0.01
In situ/Local	281 (12.6)	136 (16.7)	
Regional	754 (33.8)	277 (34.0)	
Distant	1,108 (49.6)	355 (43.6)	
Missing	90 (4.0)	46 (5.7)	
Received chemo	1,360 (60.9)	463 (56.9)	0.05
Received surgery	1,058 (47.4)	444 (54.6)	0.01
Insurance[b]			<0.01
Uninsured	209 (17.5)	10 (2.8)	
Private	443 (37.1)	220 (60.4)	
Medicaid	372 (31.2)	54 (14.8)	
Medicare	28 (2.4)	18 (5.0)	
Other[c]	141 (11.8)	62 (4.0)	
Census tract poverty level			<0.01
0%–<10%	486 (21.8)	426 (52.3)	
10%–19%	712 (31.9)	262 (32.2)	
≥20%	1,035 (46.4)	125 (15.4)	
Missing	0	1 (0.1)	
County type			<0.01
Metro	2,115 (94.7%)	749 (92.0%)	
Nonmetro	118 (5.3%)	65 (8.0%)	
Missing	0 (0)	0 (0)	

[a]*P* values obtained using Pearson χ^2 test.
[b]Insurance collected from year 2007 and on ($n = 1,557$).
[c]Other includes Tricare/VA, Indian/public health, insurance NOS, unknown, and county.

population living in a county (SEER denominator data) by the ratio of the number of people living in low/middle/high poverty tracts to the total denominator for whom poverty data were available (Census data). This process ensured that the denominators used to calculate incidence rate for census tract poverty were comparable with those created by SEER and used to calculate incidence rate by other characteristics. All population-level poverty data were stratified by age (5-year increments), sex, ethnicity, and year.

Table 2. Characteristics of Hispanic and non-Hispanic Whites diagnosed with EOGC by ethnicity and state, TCR and CCR, 1995 to 2016.

	Texas Hispanic White, $n = 749$	Texas non-Hispanic White, $n = 313$	California Hispanic White, $n = 1{,}484$	California non-Hispanic White, $n = 501$
		Number (percent)		
Sex				
Male	387 (51.7)	166 (53.0)	786 (53.0)	278 (55.5)
Female	362 (48.3)	147 (47.0)	696 (46.9)	223 (44.5)
Missing			2 (0.1)	0 (0)
Age at diagnosis[a,b]				
20–29	59 (7.9)	8 (2.6)	103 (6.9)	14 (2.8)
30–39	215 (28.7)	68 (21.7)	467 (31.5)	119 (23.8)
40–49	475 (63.4)	237 (75.7)	914 (61.6)	368 (73.5)
Years of diagnosis[a,b]				
1995–2005	321 (42.9)	154 (49.2)	617 (41.6)	270 (53.9)
2006–2016	428 (57.1)	159 (50.8)	867 (58.4)	231 (46.1)
Charlson comorbidity index[b]				
0	179 (23.9)	75 (24.0)	795 (53.6)	341 (86.1)
1–2	43 (5.7)	13 (4.2)	252 (17.0)	106 (21.2)
≥3	4 (0.5)	0 (0)	49 (3.3)	21 (4.2)
Missing	523 (69.8)	225 (71.9)	388 (26.2)	33 (6.6)
Histology[b]				
Adenocarcinoma	296 (39.5)	123 (39.3)	422 (28.4)	179 (35.7)
Linitis	5 (0.7)	4 (1.3)	28 (1.9)	10 (2.0)
Intestinal	16 (2.1)	12 (3.8)	61 (4.1)	21 (4.2)
Diffuse	36 (4.8)	16 (5.1)	152 (10.2)	25 (5.0)
Signet	321 (42.9)	121 (38.7)	671 (45.2)	209 (41.7)
Missing	75 (10.0)	37 (11.8)	150 (10.1)	57 (11.4)
Grade[a,b]				
Well differentiated	14 (1.9)	5 (1.6)	16 (1.1)	20 (4.0)
Moderately differentiated	61 (8.1)	39 (12.5)	79 (5.3)	48 (9.6)
Poorly differentiated	546 (72.9)	191 (61.0)	1,163 (78.4)	354 (70.7)
Undifferentiated	14 (1.9)	10 (3.2)	41 (2.8)	9 (1.8)
Missing	114 (15.2)	68 (21.7)	185 (12.5)	70 (14.0)
Stage[a]				
In situ/Local	103 (13.8)	59 (18.9)	178 (12.0)	77 (15.4)
Regional	270 (36.1)	110 (35.1)	484 (32.6)	167 (33.3)
Distant	332 (44.3)	114 (36.4)	776 (52.3)	241 (48.1)
Missing	44 (5.9)	30 (9.6)	46 (3.1)	16 (3.2)
Received chemo[a]	410 (54.7)	148 (47.3)	950 (64.0)	315 (32.9)
Received surgery[a,b]	325 (43.4)	149 (47.6)	733 (49.4)	295 (58.9)
Insurance[a,b,c]				
Uninsured	130 (33.7)	9 (6.1)	141 (9.5)	10 (2.0)
Private	124 (32.1)	87 (58.8)	577 (38.9)	294 (58.7)
Medicaid	56 (14.5)	9 (6.1)	509 (32.3)	95 (19.0)
Medicare	14 (3.6)	10 (6.8)	33 (2.2)	22 (4.4)
Other[d]	62 (16.1)	33 (22.3)	224 (15.1)	80 (16.0)
Census tract poverty level[a,b]				
0%–<10%	119 (15.9)	164 (52.4)	367 (24.7)	262 (52.3)
10%–<20%	234 (31.2)	102 (32.6)	478 (32.2)	160 (31.9)
≥20%	396 (52.9)	46 (14.7)	639 (43.1)	79 (15.8)
Missing	0 (0)	1 (0.3)	0 (0)	0 (0)
County type[b]				
Metro	654 (87.3)	271 (86.6)	1,461 (98.5)	478 (95.4)
Nonmetro	95 (12.7)	42 (13.4)	23 (1.6)	23 (4.6)
Missing	0 (0)	0 (0)	0 (0)	0 (0)

[a]*P* values obtained using Pearson χ^2 test are <0.05, Texas Cancer Registry.
[b]*P* values obtained using Pearson χ^2 test are <0.05, CCR.
[c]Insurance collected starting year 2007 ($n = 534$).
[d]Other includes Tricare/VA, Indian/public health, insurance NOS, unknown, and county.

To illustrate changes in incidence rates over time, we plotted age-adjusted incidence rates by ethnicity and census tract poverty level, county type, and stage at diagnosis in two different time periods (1995–2005 and 2006–2016) between Hispanic and Whites persons. A cut-off of 2005 was selected *a priori* to create two equal 10-year time periods.

We also conducted a joinpoint analysis to estimate annual percent change (APC) in incidence rates by ethnicity, census tract poverty level, and county-level metro/nonmetro residence. The joinpoint model uses permutation analysis to fit a series of joined straight lines on a logarithmic scale to observed rates, whereby the slope of the line segment between joinpoints is equivalent to the APC. Two-sided P values < 0.05 were considered to indicate statistical significance, whereby the APC is significantly different from 0.

Factors associated with distant stage at diagnosis

We used logistic regression models to estimate associations of stage at diagnosis (distant stage vs. *in-situ*/local or regional stage) and ethnicity, age at diagnosis, county type, state, and census tract poverty level. We report crude and adjusted ORs and 95% CIs; the adjusted model included sex, age at diagnosis, year of diagnosis, and tumor histology.

Statistical analysis

Baseline characteristics between Hispanic and White persons were compared using Pearson χ^2 test for categorical variables. We used SEER*Prep Version 2.6.0 to prepare data for use in SEER*Stat Version 8.3.9.2 (Surveillance Research Program, NCI). We used STATA Version 15.0 (Stata Corp) to calculate incidence rates and fit regression models. We used SAS (Cary) to prepare the poverty level denominators.

Data availability

Cancer data have been provided by the TCR, Cancer Epidemiology and Surveillance Branch, Texas Department of State Health Services (www.dshs.texas.gov/tcr), and the CCR, California Department of Public Health (https://www.ccrcal.org/learn-about-ccr/).

Results

Characteristics of the study population

We identified 1,985 and 1,062 Hispanic and White persons diagnosed with EOGC in California and Texas, respectively, during 1995 to 2016 (**Fig. 1**). Most persons diagnosed with EOGC were Hispanic (73.2%), with several notable differences in characteristics by ethnicity (**Table 1**). For example, a higher proportion of Hispanic persons were uninsured (17.5% vs. 2.8%) or had Medicaid (31.2% vs. 14.8%) and lived in high poverty neighborhoods (46.4% vs. 15.4%) or metro countries (94.7% vs. 92.0%) compared with White persons (**Table 1**). Hispanic persons were also more likely to have signet ring cell histology (44.4% vs. 40.5%) and poorly differentiated grade (76.5% vs. 66.7%) than White persons (**Table 1**).

Characteristics by state

We identified 749 Hispanic and 313 White persons with EOGC in Texas from 1995 to 2016. The majority of EOGC was diagnosed among the 40- to 49-year age group (**Table 2**). A greater proportion of Hispanic persons were uninsured (33.7% vs. 6.1%, $P < 0.01$), lived in a high poverty census tract (52.9 vs. 14.7%, $P < 0.01$), and diagnosed with distant disease (44.3% vs. 36.4%, $P < 0.01$; **Table 2**).

We identified 1,484 Hispanic and 501 White persons with EOGC in California. Similar to Texas, the majority of EOGC was diagnosed among the 40- to 49-year age group (**Table 2**). Compared with White

Table 3. Age-adjusted incidence rates of EOGC by ethnicity, TCR and CCR, 1995 to 2016.

	Hispanic White		Non-Hispanic White	
	Rate per 100,000	95% CI	Rate per 100,000	95% CI
Overall	1.29	1.24–1.35	0.31	0.29–0.33
Age at diagnosis				
20–29	0.21	0.18–0.24	0.03	0.02–0.04
30–39	0.99	0.91–1.06	0.22	0.19–0.26
40–49	2.52	2.39–2.66	0.63	0.58–0.69
Year of diagnosis				
1995–2005	1.35	1.27–1.44	0.31	0.28–0.34
2006–2016	1.34	1.27–1.41	0.33	0.29–0.36
Sex				
Male	1.34	1.27–1.42	0.33	0.30–0.37
Female	1.24	1.17–1.32	0.29	0.26–0.32
Stage at diagnosis				
Local	0.17	0.15–0.19	0.05	0.04–0.06
Regional	0.44	0.41–0.48	0.11	0.09–0.12
Distant	0.63	0.59–0.67	0.14	0.12–0.15
County type				
Metro	1.22	1.17–1.28	0.28	0.26–0.31
Nonmetro	0.07	0.06–0.08	0.03	0.02–0.03
Census tract poverty level				
<10%	1.10	1.00–1.20	0.28	0.26–0.31
10%–19%	1.36	1.26–1.47	0.35	0.31–0.39
≥20%	1.49	1.40–1.59	0.40	0.34–0.48
State				
California	1.48	1.41–1.56	0.33	0.30–0.36
Texas	1.14	1.05–1.22	0.29	0.26–0.33

persons, a greater proportion of Hispanic persons in California were on Medicaid (32.3% vs. 19.0%, $P < 0.01$), and lived in a high poverty census tract (43.1% vs. 15.8%, $P < 0.01$; **Table 2**). There was no statistically significant difference in stage of disease between Hispanic and White persons. Notably, a smaller proportion of Hispanic persons in California were uninsured as compared with Texas (9.5% vs. 33.7%).

Incidence rates of EOCG

Overall, incidence rates of EOGC were 1.29 per 100,000 Hispanic persons (95% CI, 1.24–1.35) and 0.31 per 100,000 White persons (95% CI, 0.29–0.33; **Table 3**). Incidence rates were consistently higher among Hispanic persons compared with White persons by age, year, sex, stage at diagnosis, county type, census tract poverty level, and state. For example, incidence rates of EOGC within high poverty neighborhoods (≥20%) were 1.49 per 100,000 Hispanics persons (95% CI, 1.40–1.59) versus 0.40 per 100,000 Whites persons (95% CI, 0.34–0.48; **Table 3**). The incidence rate of distant disease was 0.63 per 100,000 Hispanic persons (0.59, 0.67) and 0.14 per 100,000 White persons (95% CI, 0.12–0.15).

We evaluated the change in incidence rates over two time periods: 1995 to 2005 to 2006 to 2016 by stage at diagnosis, census tract poverty level, and metro versus nonmetro county. Incidence confidence intervals overlapped for most groups, which suggests a lack of statistical significance. From 1995 to 2005 to 2006 to 2016, incidence rates of EOGC increased in low (<10%) poverty neighborhoods from 1.00 (95% CI, 0.87–1.20) per 100,000 Hispanic persons to 1.20 (95% CI, 1.01–1.30) per 100,000 Hispanic persons (**Table 4**). For both middle (10%–19%) and high (≥20%) poverty neighborhoods, incidence rates of EOGC decreased for Hispanic persons (**Table 4**). Among White persons, incidence rates of EOGC increased for middle (10%–19%) poverty neighborhoods but decreased among high (≥20%) poverty neighborhoods (**Table 4**). There were no changes in incidence rates of EOGC among both Hispanic and White persons by county type (**Table 4**). Incidence rates of distant stage disease increased from 1995 to 2005 to 2006 to 2016 for both Hispanic and White persons. The incidence rate of distant disease from 1995 to 2005 was 0.60 per 100,00 Hispanic persons (95% CI, 0.55–0.66) and 0.69 per 100,000 Hispanic persons (95% CI, 0.64–0.75) from 2006 to 2016. In contrast, the incidence rate of distant disease from 1995 to 2005 was 0.13 per 100,000 White persons (95% CI, 0.11–0.15) and 0.15 per 100,000 White persons (95% CI, 0.13–0.17) from 2006 to2016 (**Table 4**).

APC was evaluated by ethnicity, stage at diagnosis, census tract poverty level, and metro versus nonmetro county. Although not statistically significant, the APC suggested -0.1 for White persons and 0.08 for Hispanic persons (**Fig. 2**). Among Hispanic persons, distant disease increased by 1.91% per year but decreased by 1.35% per year among White persons ($P < 0.05$; **Fig. 2**). Changes in APC by census tract poverty level and metro versus nonmetro county were similar to our findings over two time periods. For example, the APC for White persons living among high (≥20%) poverty neighborhoods decreased by 2.28% per year ($P < 0.05$) and the APC for Hispanic persons living in low (<10%) poverty neighborhoods increase by 2.04% per year ($P < 0.05$).

Stage at diagnosis

In unadjusted analyses, a higher proportion of Hispanic persons were diagnosed with distant disease compared with White persons (49.6% vs. 43.6%, $P = 0.01$; **Table 1**). However, in the multivariable logistic regression model, distant stage was associated with living in

Table 4. Point estimates and confidence intervals for EOGC for 1995 to 2005 and 2006 to 2016 among Hispanic White and non-Hispanic White persons.

	1995–2005		2006–2016		
	Age-adjusted incidence rate	95% CI	Age-adjusted incidence rate	95% CI	*P*[a]
Low poverty (<10%)					
Hispanic	1.00	0.87–1.20	1.20	1.00–1.30	0.021
White	0.26	0.23–0.30	0.30	0.26–0.35	0.167
Medium poverty (10%–19%)					
Hispanic	1.40	1.20–1.60	1.30	1.20–1.50	0.376
White	0.34	0.28–0.40	0.36	0.30–0.43	0.922
High poverty (≥20%)					
Hispanic	1.60	1.40–1.70	1.40	1.30–1.60	0.654
White	0.47	0.36–0.60	0.34	0.26–0.45	0.056
Metro county					
Hispanic	1.26	1.18–1.35	1.28	1.21–1.35	0.824
White	0.28	0.26–0.31	0.30	0.27–0.33	0.571
Nonmetro county					
Hispanic	0.09	0.07–0.11	0.06	0.05–0.08	0.051
White	0.02	0.02–0.03	0.03	0.02–0.04	0.397
In situ stage					
Hispanic	0.15	0.12–0.19	0.19	0.16–0.22	0.140
White	0.04	0.03–0.05	0.07	0.06–0.09	0.003
Local/regional					
Hispanic	0.54	0.48–0.59	0.41	0.37–0.45	0.003
White	0.13	0.11–0.15	0.08	0.07–0.10	0.007
Distant stage					
Hispanic	0.60	0.55–0.66	0.69	0.64–0.75	0.029
White	0.13	0.11–0.15	0.15	0.13–0.17	0.137

[a]*P* comparing incidence rates from 1995–2005 to 2006–2016.

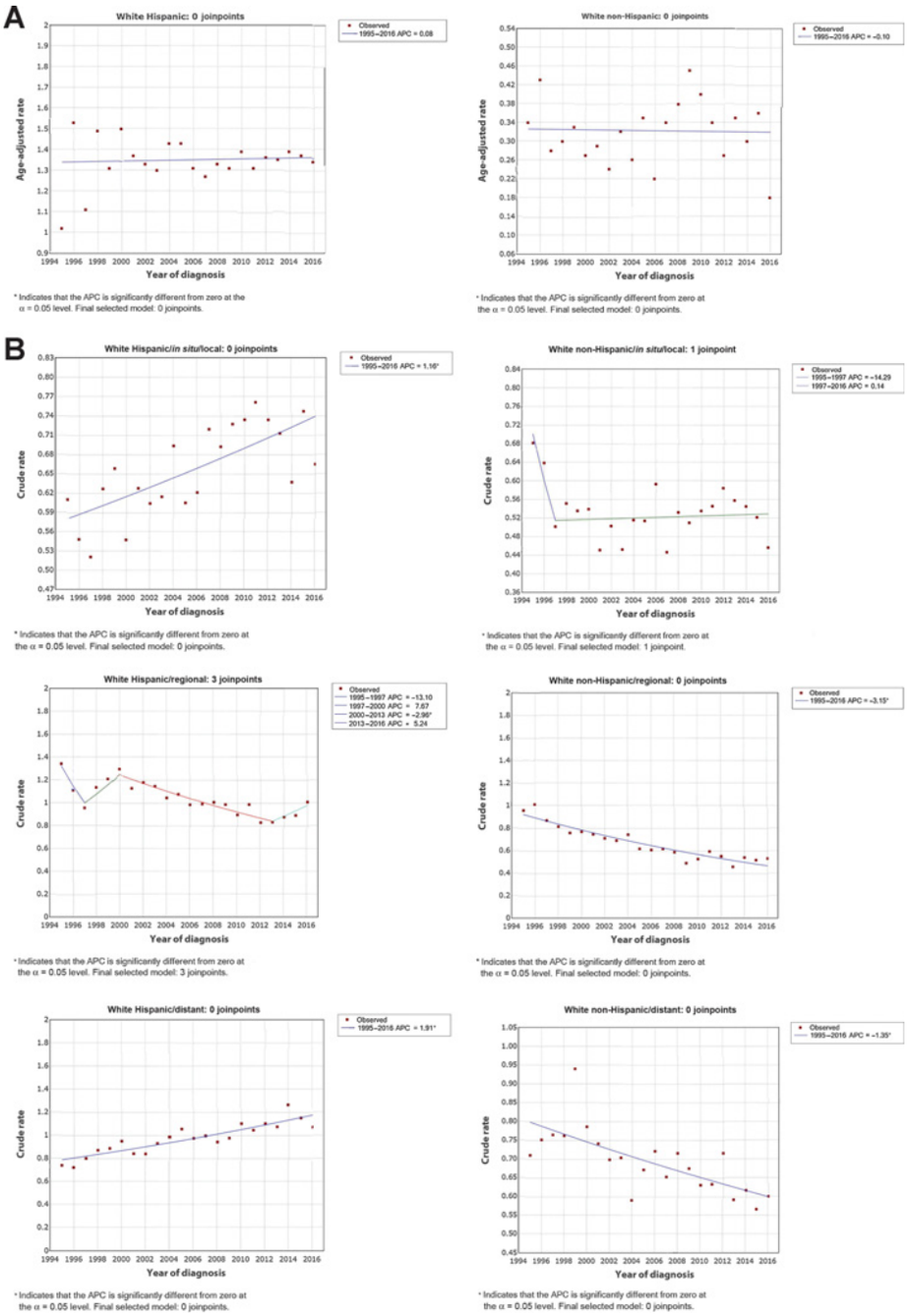

Figure 2.
APC among Hispanic and non-Hispanic Whites with EOGC. **A,** APC of EOGC from 1995 to 2016 by ethnicity. **B,** APC of EOGC from 1995 to 2016 by ethnicity and stage of disease.

California [adjusted OR (aOR): 1.47; 95% CI, 1.24–1.75] but not with ethnicity (aOR: 1.06; 95% CI, 0.87–1.29) or census tract poverty level (aOR: 1.13; 95% CI, 0.93–1.39 for middle poverty and aOR: 1.06; 95% CI, 0.86–1.30 for high poverty; **Table 5**).

We conducted a sensitivity of persons diagnosed with EOGC from 2007 to 2016 to estimate the association of payer type and stage of diagnosis. Distant stage remained associated with residence in California (aOR: 1.68; 95% CI, 1.26–2.24) and having either no insurance (aOR: 2.15; 95% CI, 1.48–3.14) or Medicaid (aOR: 1.90; 95% CI, 1.42–2.55) as compared with private insurance. The association between Hispanic ethnicity and tumor stage was unchanged and was not statistically significant.

Discussion

In this population-based study in Texas and California, we observed differences in the burden of EOGC among Hispanic and non-Hispanic White persons. 3 out of every 4 patients diagnosed with EOGC were Hispanic, who were more likely to live in high poverty neighborhoods, metro counties, and be either uninsured or have

Table 5. Crude and adjusted ORs assessing association of distant (vs. local or regional) stage at diagnosis by ethnicity, county type, state, and census tract poverty level, TCR and CCR, 1995 to 2016.

	Crude ($n = 3,047$) OR (95% CI)	Adjusted ($n = 2,615$)[a] OR (95% CI)
Ethnicity		
Non-Hispanic White	Ref	Ref
Hispanic White	1.25 (1.06–1.47)	1.06 (0.87–1.29)
County type		
Metro	Ref	Ref
Nonmetro	1.11 (0.82–1.51)	1.13 (0.80–1.59)
State		
Texas	Ref	Ref
California	1.36 (1.17–1.59)	1.47 (1.24–1.75)
Census tract poverty level		
0%–<10%	Ref	Ref
10%–<20%	1.16 (0.97–1.40)	1.13 (0.93–1.39)
≥20%	1.16 (0.97–1.40)	1.06 (0.86–1.30)

[a]The adjusted multivariable model adjusted from sex, histology, age at diagnosis (continuous), and year of diagnosis (continuous) and excluded those with missing data [stage ($n = 111$), histology ($n = 294$), stage and histology ($n = 24$), histology and poverty ($n = 1$), and sex ($n = 2$)].

Medicaid compared with non-Hispanic White persons with EOGC. Differences in incidence rates between the two groups persisted across multiple domains, including age, year, sex, stage, county type, census tract poverty level, and state.

We observed in bivariate analyses that a higher proportion of Hispanic persons were diagnosed with distant disease and had signet ring cell histology, although our adjusted regression model showed no statistically significant association between ethnicity and stage of disease. Prior population-based gastric cancer studies have demonstrated that signet ring cell carcinoma occurs more commonly in Hispanic persons (27, 28). While signet ring cell carcinoma is not associated with worse survival, it often presents at higher tumor stage than adenocarcinoma (27, 28). Future studies should compare the proportion of signet ring cell histology in Hispanic persons from all-age groups to evaluate whether signet-ring cell carcinoma occurs more commonly in younger Hispanics.

Incidence rates were higher in Hispanic persons compared with non-Hispanic White persons across all levels of poverty. Higher poverty and lower socioeconomic status among Hispanic persons (of all ages) have been linked to higher incidence rates of certain cancers, including gastric cancer. Specifically, prior studies have found higher overall and histology-specific incidence rates among Hispanic persons who are foreign-born, lower socioeconomic status, and reside in ethnic enclaves (5, 16). These higher incidence rates have been at least partially attributed to the higher prevalence of *H. pylori* infection, which increases the risk of developing both diffuse and intestinal-type gastric cancer (5, 29). For example, higher household crowding, lower education level, and lower socioeconomic status, which are common features of Hispanic enclaves in the United States, are associated with *H. pylori* infection (5, 30, 31). Other potential explanations include the increasing incidence of obesity among young Hispanics, which is often associated with lower socioeconomic status (32, 33). Our findings underscore the need to identify drivers of ethnic disparities that persist even within similar-poverty neighborhoods. These drivers may be due to both structural and cultural factors and can be used to develop interventions to prevent EOGC in higher risk communities (34, 35).

We observed geographic disparities in tumor stage. Persons living in California were more likely to be diagnosed with distant stage disease EOGC as compared with Texas, although reasons for this finding are not clear. The composition of ethnic populations in Texas and California are similar, with approximately 39% of the population of Hispanic ethnicity, and most Hispanic persons are of Mexican origin. While Texans with EOGC are more likely to be uninsured (Texas 25.9% vs. California 7.6%), a higher proportion of patients with EOGC in California are on Medicaid (California 30.4% vs. Texas 12.2%); sensitivity analyses demonstrated both insurance types were associated with distant disease. The association between distant disease and living in California may also be due to an unmeasured confounder, such as nativity. A larger share of the population in California is foreign-born (27%) compared with Texas (17%; refs. 36, 37) and tumor etiology or aggressiveness may differ by birthplace. For example, a California study found that foreign-born persons, ages 25 to 39 years had a higher incidence rate of noncardia gastric cancer as compared with those born in the United States (5). Unfortunately, analyses evaluating nativity are often limited due to high proportions of missing data and misclassification of birthplace in cancer registries (38). In addition, there may be differences in degree of urbanicity that we could not capture using county-level RUCC codes, or differences in ethnic enclaves, which could be associated with a higher or lower risk of metastatic EOGC (22). Future studies should evaluate the role that birthplace, census tract degree of urbanicity, ethnic enclaves, and other environmental or lifestyle factors may play in EOGC incidence and tumor stage.

To our knowledge, this is the first study to combine population-based cancer registry data from California and Texas to examine ethnic disparities in EOGC. The combined data represent nearly 50% of the U.S. Hispanic population. In addition, our study is the first to estimate incidence rates of EOGC by poverty level, and we observed higher incidence rates among Hispanic persons living across all poverty levels. Poverty is consistently associated with worse cancer incidence and mortality for many cancer types (39, 40). However, estimating cancer incidence rates by poverty level at the census tract level can be difficult and labor intensive because cancer registries do not typically provide the denominator data necessary for this calculation to researchers. A strength of our study is not only the incorporation of population denominator data by ethnicity, age, and census tract poverty, but also highlighting the need for this denominator data to be more readily available to researchers interested in SDOH (41).

Our study has some limitations that should be noted. First, although we combined cancer registry data from Texas and California, some of our analyses may have been limited by the small number of cases. For example, only 6% of the EOGC population in California and Texas lived in nonmetro areas. This likely decreased our ability to detect a difference in incidence rates by nonmetro/metro areas. Second, our study did not assess factors such as ethnic enclaves or nativity. Understanding the role of neighborhood enclaves or nativity could potentially clarify some of our findings and inform interventions to improve observed ethnic disparities in EOGC. Third, since most Texans and Californians are of Mexican origin, our results may not be generalizable to other Hispanic populations. For example, 86% of Hispanic persons in Florida are non-Mexican origin, and their risk of EOGC may differ from Hispanic persons in California and Texas (41). Fourth, we evaluated incidence rates over two time periods (1995–2005 and 2006–2016). However, for most of our covariates of interest, the CIs overlapped among the two time periods. As a result, we cannot definitively conclude that the incidence rates are statistically different in the two time periods except for stage of disease. However, these results are consistent with our APC results and likely is a reflection of the small number of cases. Finally, the extent of missing data differed between the states and this may introduce bias into our analyses. For example, there was more missing stage data in Texas as compared with California, and these differences in missing data may contribute to the lack of an association between stage and ethnicity.

In conclusion, our study found marked ethnic disparities in incidence rates of EOGC, with the highest incidence rates among Hispanic persons, particularly those in metro areas and higher poverty neighborhoods. Future studies are needed to identify risk factors that may be unique to Hispanic populations to guide interventions that can decrease incidence, morbidity, and mortality of this deadly disease.

Authors' Disclosures

C.C. Murphy reports personal fees from Freenome outside the submitted work. No disclosures were reported by the other authors.

Authors' Contributions

A. Tavakkoli: Conceptualization, data curation, software, formal analysis, funding acquisition, writing–original draft. **S.L. Pruitt:** Resources, supervision, methodology, writing–review and editing. **A.Q. Hoang:** Data curation, software, methodology, writing–review and editing. **H. Zhu:** Software, methodology, writing–review and editing. **A.E. Hughes:** Data curation, software, methodology, writing–review and editing. **T.A. McKey:** Software, formal analysis, methodology. **B.J. Elmunzer:** Conceptualization, writing–review and editing. **R.S. Kwon:** Conceptualization, writing–review and editing. **C.C. Murphy:** Conceptualization, resources, formal analysis, supervision, methodology, writing–review and editing. **A.G. Singal:** Conceptualization, resources, supervision, funding acquisition, methodology, writing–review and editing.

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