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ORIGINAL RESEARCH

Stroke-Related Mortality in the United States–Mexico Border Area of the United States, 1999 to 2018

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BACKGROUND: The United States (US)-Mexico border is a socioeconomically underserved area. We sought to investigate whether stroke-related mortality varies between the US border and nonborder counties.

METHODS AND RESULTS: We used death certificates from the Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research database to examine stroke-related mortality in border versus nonborder counties in California, Texas, New Mexico, and Arizona. We measured average annual percent changes (AAPCs) in age-adjusted mortality rates (AAMRs) per 100 000 between 1999 and 2018. Overall, AAMRs were higher for nonborder counties, older adults, men, and non-Hispanic Black adults than their counterparts. Between 1999 and 2018, AAMRs reduced from 55.8 per 100 000 to 34.4 per 100 000 in the border counties (AAPC, –2.70) and 64.5 per 100 000 to 37.6 per 100 000 in nonborder counties (AAPC, –2.92). The annual percent change in AAMR initially decreased, followed by stagnation in both border and nonborder counties since 2012. The AAPC in AAMR decreased in all 4 states; however, AAMR increased in California's border counties since 2012 (annual percent change, 3.9). The annual percent change in AAMR decreased for older adults between 1999 and 2012 for the border (–5.10) and nonborder counties (–5.01), followed by a rise in border counties and stalling in nonborder counties. Although the AAPC in AAMR decreased for both sexes, the AAPC in AAMR differed significantly for non-Hispanic White adults in border (–2.69) and nonborder counties (–2.86). The mortality decreased consistently for all other ethnicities/races in both border and nonborder counties.

CONCLUSIONS: Stroke-related mortality varied between the border and nonborder counties. Given the substantial public health implications, targeted interventions aimed at vulnerable populations are required to improve stroke-related outcomes in the US-Mexico border area.

Key Words: epidemiology ■ mortality ■ stroke ■ US–Mexico border

The United States (US)-Mexico border region stretches ≈2000 miles and covers 62 miles north and south of the international border.[1,2] A total of 44 counties in 4 US states (Arizona, California, New Mexico, and Texas) encompass 53% of ≈15 million people residing in the border region.[1] This is a culturally diverse area where different civilizations from the US and Mexico connect across geographical borders.[3] The US border region has witnessed a significant population growth over the years, with southwest border counties exhibiting a ≈30% population increase in the 1990s.[4] Moreover, this region faces medical and socioeconomic challenges, demonstrating a wider socioeconomic gap between border counties and the rest of the US.[1,2]

Stroke remains the fifth leading cause of mortality in the US and the third leading cause of death in the

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CLINICAL PERSPECTIVE

What Is New?

- Between 1999 and 2018, residents of both border and nonborder counties in California, Texas, New Mexico, and Arizona experienced a decline in stroke-related mortality, although the decline has slowed in the past decade.
- Stroke-related mortality varied among older adults and non-Hispanic White adults in the border versus nonborder counties.

What Are the Clinical Implications?

- Overall and demographic disparities related to stroke-related mortality in border versus nonborder counties are concerning.
- Targeted interventions aimed at narrowing clinical and socioeconomic inequalities may diminish gaps in stroke-related mortality in the US–Mexico border area.

Nonstandard Abbreviations and Acronyms

AAMR	age-adjusted mortality rate
AAPC	average annual percent change

border area.[5-7] Besides cardiovascular disease burden, social disparities influence stroke-related morbidity and mortality.[8,9] Stroke has shown to correlate with social determinants of health, including but not limited to low education, socioeconomic depression, healthcare access, unemployment, and social isolation.[8,9] Because social and health inequities in the region may influence the incidence and prevalence of stroke, it is imperative to investigate stroke-related mortality trends in border counties compared with nonborder counties. A detailed assessment of the epidemiological profile of stroke-related mortality may inform policymakers and healthcare professionals to improve care for the socially disadvantaged population residing in this dynamic area. Consequently, we compared demographic and geographical trends in stroke-related mortality in the border versus nonborder counties in 4 border states (Arizona, California, New Mexico, Texas) using a national database of death certificates.

METHODS

Data Availability Statement

The Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research data sets used in this project are publicly available and are easily replicable from the methods described in the article.[10]

Data Source

We used the Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research—Multiple Cause of Death database for this analysis.[10] The Multiple Cause of Death database is composed of death certificates for US residents. Each death certificate contains data on a single underlying cause of death, up to 20 additional causes, and demographic characteristics of the decedents. We identified natural deaths attributed to stroke—defined by the World Health Organization as the disease or injury that initiated the events leading directly to death as entered by the physician on the death certificate[11]—using *International Classification of Diseases*, *Tenth Revision* (*ICD-10*) codes I60 to I69. We focused on stroke-related mortality in counties located in California, Texas, New Mexico, and Arizona further stratified into border counties (counties within 100 km [62 miles] of the US–Mexico border defined by the 1983 La Paz Agreement[12]) and nonborder counties.

This study did not require institutional review board approval because we analyzed government-issued public use data without individual identifiable information.

Data Extraction

We abstracted the data on stroke-related mortality in both border and nonborder counties in California, Texas, New Mexico, and Arizona (Table S1). We abstracted the number of stroke-related deaths and population sizes from 1999 to 2018. We abstracted the data on age, sex, ethnicity/race (non-Hispanic White, non-Hispanic Black, non-Hispanic American Indian/Alaskan Native, non-Hispanic Asian/Pacific Islander, and Hispanic), and location of death. We grouped non-Hispanic American Indian/Alaskan Native and non-Hispanic Asian/Pacific Islander adults in "other" because of the low death counts in these groups. We grouped age into young (<45 years), middle aged (45–64 years), and older (≥65 years) adults. Location of death was categorized as home, hospital (inpatient, outpatient, or emergency room), hospice, nursing home/long-term care, and others.

Statistical Analysis

We calculated crude death rates for individual years between 1999 and 2018 by dividing the number of stroke-related deaths by the total corresponding population. We applied direct standardization for age-adjustment of mortality rates using the 2000

US standard population.[13] We examined mortality trends to identify changes in a slope using Joinpoint Regression Program version 4.7.0.0, which models consecutive linear segments on a log scale connected by joinpoints where the segments meet.[14] Annual percent change (APC) with 95% CIs in age-adjusted mortality rates (AAMRs) were estimated for the line segments linking joinpoints.[14] The weighted average of the annual percent change was estimated to calculate the average annual percent change (AAPC) for the entire study period—with the weights equal to the length of the annual percent change interval.[14]

We applied the following settings to the Joinpoint Regression Program for the analyses: (1) grid search method, 2, 2, 0; (2) number of joinpoints, 0 to 3; (3) model selection method, permutation test; and (4) annual percent change/AAPC/tau 95% CI estimation, parametric method. For interpretation, slopes were considered increasing or decreasing if the estimated slope differed significantly from zero.[15,16] We applied a specific procedure-comparability test to determine whether 2 regression mean functions are parallel because of different intercepts (test of parallelism).[17] For all analyses, statistical significance was set at 5%.

RESULTS

Between 1999 and 2018, 56 019 stroke-related deaths occurred in the border counties (147 408 326 patient-years), corresponding to an overall AAMR of 39.3 (95% CI, 39.0–39.6) per 100 000 patient-years. In comparison, 516 329 stroke-related deaths occurred (1 243 119 793 patient-years) in nonborder counties, corresponding to an overall AAMR of 45.2 (95% CI, 45.0–45.3) per 100 000 patient-years. Overall, stroke-related mortality was higher in nonborder than border counties in older adults, men, and non-Hispanic Black adults versus their counterparts (Table 1).

Between 1999 and 2018, AAMR reduced from 55.8 (95% CI, 53.8–57.8) per 100 000 to 34.4 (95% CI, 33.0–35.4) per 100 000 in the border counties (AAPC, –2.70; 95% CI, –3.24 to –2.14), and 64.5 (95% CI, 63.7–65.2) per 100 000 to 37.6 (95% CI, 37.2–38.1) per 100 000 in nonborder counties (–2.92; 95% CI, –3.36 to –2.48; Table 2). The annual percent change in AAMR initially decreased, followed by stagnation in both border and nonborder counties (Figure 1).

State Stratified Analyses

Stroke-related mortality varied across states in relation to border versus nonborder counties. California's border counties had the highest mortality rates, whereas those located in Texas had the lowest mortality rates (Table S2). In contrast, Texas' nonborder counties had the highest mortality rates, and those located in Arizona had the lowest mortality rates (Table S3).

Between 1999 and 2018, AAPC in AAMR decreased in all 4 states encompassing border and nonborder areas (Tables S2 and S3). In the border area, after the initial decline, the annual percent changes in AAMRs stalled in Arizona since 2014, New Mexico since 2015, and Texas since 2004, but increased in California's counties since 2012 (3.94; 95% CI, 1.25, 6.71; Figure 2). In the nonborder areas, after the initial decrease, the annual percent change in AAMR stalled in nonborder counties in Arizona, California, and New Mexico since 2012 and Texas since 2011.

Age-Stratified Analyses

The age-specific mortality rates increased exponentially with age for both border and nonborder counties (Figure S1). The AAPCs in AAMRs for all age categories are reported in Table 2, showing a significant difference in the middle-aged group among border and nonborder counties. In border counties, the annual percent change in AAMR remained stable for young adults during the study period but decreased in middle-aged adults since 2002 (–1.24; 95% CI, –1.88 to –0.60). For nonborder counties, after the initial decrease, the annual percent change in AAMR stalled in young adults (–0.73; 95% CI, –2.57 to 1.14) and middle-aged adults (2.28; 95% CI, –0.45 to 5.09) since 2011 and 2014, respectively.

The annual percent change in AAMR decreased for older adults between 1999 and 2012 for border (–5.10; 95% CI, –5.62 to –4.57) and nonborder counties (–5.01; 95% CI, –5.44 to –4.57), followed by the increase in the border (1.99; 95% CI, 0.19–3.83) and stagnation in nonborder counties (1.02; 95% CI, –0.47 to 2.53).

Sex-Stratified Analyses

Between 1999 and 2018, the AAPC in AAMR decreased for both sexes across the border and nonborder counties (Table 2). After an initial decline, the annual percent change in AAMR increased in men (1.91; 95% CI, 0.02–3.85) and stalled in women (1.22; 95% CI, –0.53 to 3.00) since 2012 in border counties, whereas the annual percent change in AAMR showed arrest for both sexes in nonborder counties between 2012 and 2018 (Figure 3).

Ethnicity/Race-Stratified Analyses

The AAPC in AAMR decreased for all ethnicities/races; however, it differed significantly for non-Hispanic White adults in border (–2.69; 95% CI, –3.36 to –2.02) and nonborder counties (–2.86; –3.31 to

Table 1. Stroke-Related Mortality in Counties Located in the US–Mexico Border Area Versus Nonborder Area, 1999 to 2018

	Border Counties				Nonborder Counties			
	Events	Patient-Years	Crude Mortality Rate (95% CI)	AAMR (95% CI)	Events	Patient-Years	Crude Mortality Rate (95% CI)	AAMR (95% CI)
Overall	56 019	147 408 326	38.0 (37.7–38.3)	39.3 (39.0–39.6)	516 329	1 243 119 793	41.5 (41.4–41.6)	45.2 (45.0–45.3)
Age, y								
<45	1447	96 687 275	1.5 (1.4–1.6)	1.7 (1.6–1.8)	12 453	804 641 323	1.5 (1.4–1.6)	1.7 (1.6–1.8)
45–64	6757	32 549 26	20.8 (20.3–21.3)	20.0 (19.5–20.5)	64 322	294 174 671	21.9 (21.7–22.0)	21.1 (20.9–21.2)
≥65	47 815	18 171 784	263.1 (260.8–265.5)	267.2 (264.8–269.6)	439 554	144 303 799	304.6 (303.7–305.5)	311.8 (310.9–312.7)
Sex								
Female	32 010	74.239.985	43.1 (42.6–43.6)	38.5 (38.1–38.9)	304 129	625 194 548	48.6 (48.5–48.8)	44.6 (44.5–44.8)
Male	24 009	73 168 341	32.8 (32.4–33.2)	39.6 (39.1–40.1)	212 200	617 925 245	34.3 (34.2–34.5)	44.9 (44.7–45.1)
Ethnicity/race								
Non-Hispanic White	33 016	54 104 402	61.0 (60.4–61.7)	38.6 (38.2–39.0)	352 560	582 042 221	60.6 (60.4–60.8)	44.7 (44.5–44.8)
Non-Hispanic Black	1722	5 117 360	33.7 (32.1–35.2)	57.4 (54.6–60.3)	50 220	106 388 091	47.2 (46.8–47.6)	66.8 (66.2–67.5)
Hispanic	18 557	78 661 800	23.6 (23.3–23.9)	37.8 (37.3–38.4)	73 775	423 864 173	17.4 (17.3–17.5)	39.8 (39.1–39.6)
Other	2724	9 524 764	28.6 (27.5–29.7)	37.7 (36.3–39.2)	39 774	130 825 308	30.4 (30.1–30.7)	37.4 (37.1–37.8)

We grouped non-Hispanic American Indian/Alaskan Native and non-Hispanic Asian/Pacific Islander adults in "Other" because of the low death counts in these groups. AAMR indicates age-adjusted mortality rate.

Table 2. Trends in Stroke-Related Mortality in Counties Located in the US–Mexico Border Area Versus Nonborder Area, 1999 to 2018

	Border Counties		Nonborder Counties		Test for Parallelism
	AAMR (1999–2018)	AAPC (95% CI)	AAMR (1999–2018)	AAPC (95% CI)	*P* Value
Overall	55.8–34.4	−2.70 (−3.24 to −2.14)	64.5–37.6	−2.92 (−3.36 to −2.48)	0.60
Age, y					
<45	1.7–1.4	−1.00 (−2.49 to 0.51)	1.8–1.4	−1.15 (−1.93 to −0.36)	0.42
45–64	24.1–19.4	−1.69 (−2.98 to −0.38)	25.5–20.2	−1.25 (−1.83 to −0.67)	0.04
≥65	390.4–230.5	−2.91 (−3.52 to −2.31)	455.9–254.9	−3.14 (−3.64 to −2.64)	0.33
Sex					
Female	53.9–33.3	−2.80 (−3.39 to −2.21)	63.3–36.3	−3.00 (−3.48 to −2.52)	0.77
Male	57.3–34.6	−2.59 (−3.23 to −1.95)	64.9–38.4	−2.99 (−3.40 to −2.57)	0.50
Ethnicity/race					
Non-Hispanic White	55.4–34.0	−2.69 (−3.36 to −2.02)	63.5–37.3	−2.86 (−3.31 to −2.40)	0.02
Non-Hispanic Black	91.7–54.6	−3.03 (−5.34 to −0.66)	91.0–54.4	−2.93 (−3.66 to −2.19)	0.20
Hispanic	51.6–33.3	−2.25 (−3.08 to −1.42)	53.8–34.7	−2.55 (−3.08 to −2.02)	0.13
Other	50.1–28.5	−3.29 (−5.20 to −1.34)	57.8–31.4	−3.16 (−3.69 to −2.62)	0.95

We grouped non-Hispanic American Indian/Alaskan Native and non-Hispanic Asian/Pacific Islander adults in "Other" because of the low death counts in these groups. AAMR indicates age-adjusted mortality rate; and AAPC, average annual percent change.

−2.40; Table 2). In border counties, the annual percent change in AAMR initially decreased for all ethnicities/races, followed by stagnation in non-Hispanic Black and Hispanic adults (Figure 4). However, after an initial decrease, the annual percent change in AAMR increased in non-Hispanic White adults in both border (2.98; 95% CI, 0.97–5.03) and nonborder counties (1.38; 95% CI, 0.04–2.74) since 2012.

Location of Death

Between 2003 and 2018, the AAPC in the proportion of deaths from stroke in the border counties increased at home (3.15; 95% CI, 1.74–4.58), but decreased at hospice facilities (−4.21; 95% CI, −6.72 to 1.64), inpatient settings (−1.11; 95% CI, −1.60 to −0.62), and nursing home/long-term care facilities (−1.90; 95% CI, −3.48 to −0.29; Figure S2).

Similarly, the AAPC in the proportion of deaths from stroke in the nonborder counties increased at home (4.39; 95% CI, 3.13–5.67), but decreased at hospice facilities (−6.22; 95% CI, −8.24 to −4.16), inpatient settings (−1.74; 95% CI, −2.39 to −1.08), and nursing home/long-term care facilities (−2.03; 95% CI, −3.43 to −0.61; Figure S3).

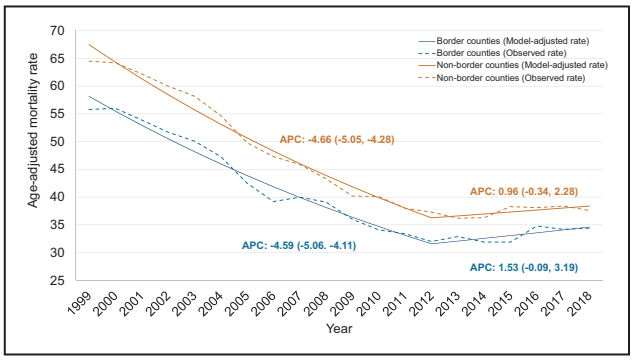

Figure 1. Age-adjusted stroke mortality rates in the border and nonborder counties in the United States, 1999 to 2018. Figure illustrates observed and model-adjusted mortality rates with APC (95% CI). APC indicates annual percent change.

DISCUSSION

Stroke-related mortality varied between the US–Mexico border and nonborder counties. Overall, nonborder counties had higher mortality rates than border counties, and demographically, older adults, men, and non-Hispanic Black adults had higher mortality rates than their counterparts. After the initial downtrend, mortality decline has stalled in both areas since 2012; however, there was considerable heterogeneity in mortality trends across border states and demographic subgroups. California's border counties demonstrated a rise in mortality since 2012, whereas mortality decline has stalled in all other states. Non-Hispanic White adults of border counties experienced a significant increase in mortality than those living in nonborder counties during the second half of the study. Finally, a higher number of individuals died at home, whereas deaths decreased at hospice facilities, hospitals, or nursing home/long-term care facilities in both border and nonborder counties.

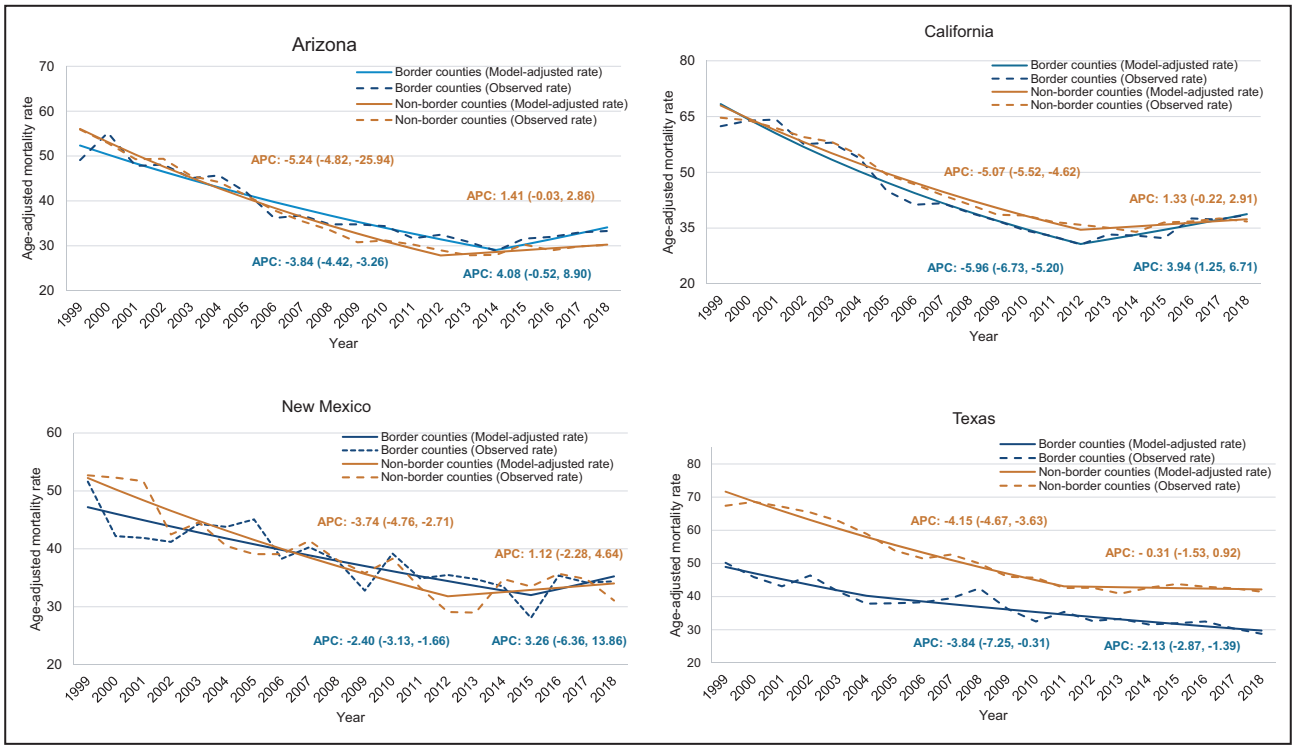

Figure 2. Age-adjusted stroke-related mortality rates in the border and nonborder counties, stratified by states in the United States, 1999 to 2018.
Figure illustrates observed and model-adjusted mortality rates with APC (95% CI). APC indicates annual percent change.

Contrasting mortality trends between the border and nonborder counties can be elucidated based on the heterogeneities related to demographic characteristics, cardiovascular risk burden, socioeconomic challenges, and limited access care among residents of border areas.[18] In 2008, nearly 1 in 2 residents in border counties were non-Hispanic individuals.[18-20] The border population is aging, and individuals aged ≥65 years may increase by 18% in the 4 border states by 2030.[19,20] Hence, a rise in stroke-related deaths in older adults may predict a concerning upsurge in total mortality burden in the future. From a

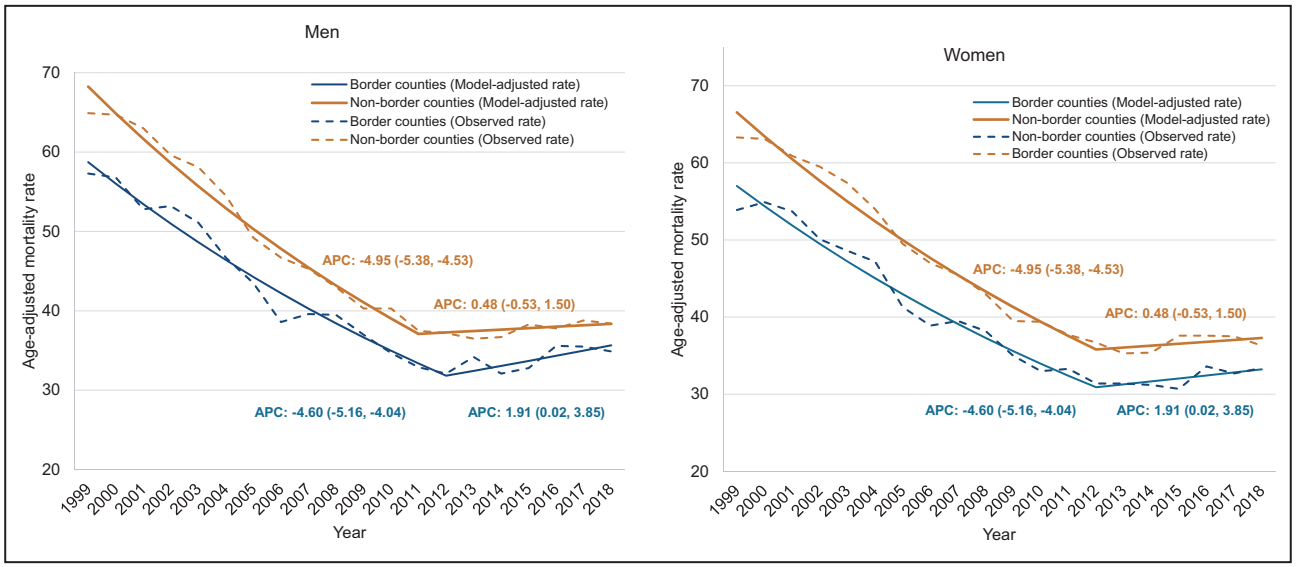

Figure 3. Age-adjusted stroke-related mortality rates in the border and nonborder counties, stratified by sex in the United States, 1999 to 2018.
Figure illustrates observed and model-adjusted mortality rates with APC (95% CI). APC indicates annual percent change.

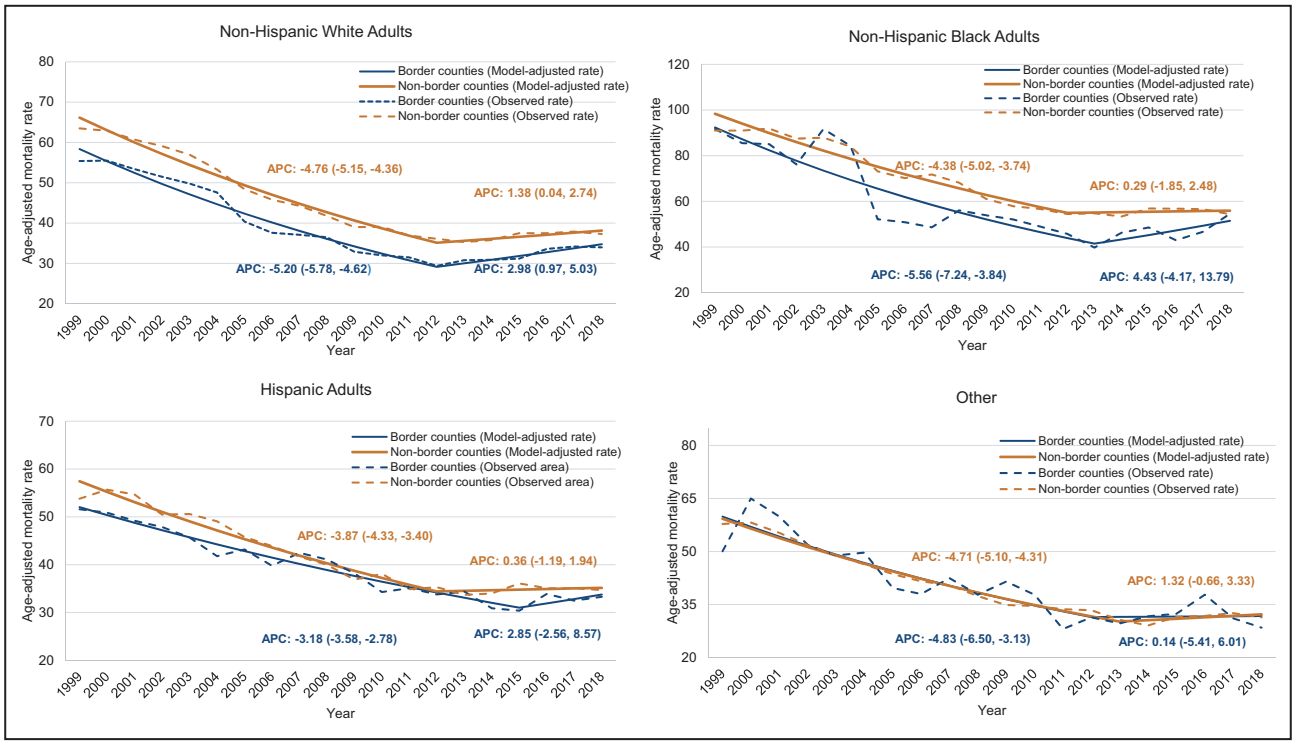

Figure 4. Age-adjusted stroke-related mortality rates in the border and nonborder counties, stratified by ethnicity/race in the United States, 1999 to 2018.
Figure illustrates observed and model-adjusted mortality rates with APC (95% CI). APC indicates annual percent change.

socioeconomic perspective, as per 2007 estimates, the annual income per capita was $26 842 in the border counties compared with $39 013 in the border states and $38 839 in the United States, translating into more than twice the poverty rate (25%) in the border area than the national level (13%).[20,21] Of the 10 most impoverished counties in the US, 3 (Starr, Maverick, and Hudspeth) belonged to Texas.[20] Of a total of 44 border counties, 48% were designated as economically distressed counties.[20] Between 2000 and 2003, about 23% of the border residents lacked health insurance coverage compared with 15% health insurance coverage nationally.[22] In 2008, the unemployment rate was 11.5% in the border region and 5.6% in the US.[23]

On the same note, the disproportionate burden of cardiometabolic risk factors in the border counties may further contribute to stroke-related mortality. For instance, the prevalence of diabetes mellitus in the border area was ≈9.5% compared with 8.0% in the overall US in 2007.[22] The hospital discharge rates of diabetes mellitus among border county residents were higher than their nonborder counties (16.6 per 10 000 versus 14.9 per 10 000).[24] A county-level survey (1999–2008) showed suboptimal blood pressure control among men in counties along the US–Mexico border in Texas, New Mexico, and Arizona.[25] A significantly higher age-adjusted prevalence of obesity (22%) and physical inactivity (43%) was reported among border residents.[22] The combination of suboptimal cardiometabolic profile and less favorable social determinants of health in the border population contribute to health disparities.

As per the US–Mexico Border Health Commission 2010 update, the hospital discharge rate for stroke was significantly lower for border residents than for nonborder residents (28.0 per 10 000 versus 34.0 per 10 000).[22] The lower hospital discharge rate may be attributed to a greater likelihood of border residents to die from stroke without being hospitalized, or a higher likelihood to die during or following hospitalization, thus eliminating rehospitalization for future treatment of the same condition.[26] Moreover, certain ethnic/racial minorities might prefer to die at home. Our findings complement these observations demonstrating a more significant number of individuals dying at home than in the hospital setting in the border area.[27]

Several limitations of this study need to be acknowledged. Because vital statistics and census population data rely on death certificates, potential coding errors can exist.[28] Inaccurate ascertainment of demographic data is also subject to misclassification. We could not generate subgroup analyses based on stroke subtypes. We lacked data on stroke incidence and pertinent clinical and socioeconomic variables; therefore,

we could not examine the association of clinical or social determinants of health with stroke-related mortality. Finally, vital statistics records deaths to the state of residence at the time of death and does not factor in migration across the US–Mexico border. For instance, according to Pew Hispanic Center estimates, a total of 3 million Mexican citizens immigrated to the United States between 1995 and 2000, followed by a decline to 1.4 million between 2005 and 2010.[29] Meanwhile, nearly 1.4 million Mexican citizens moved from the United States to Mexico between 2005 and 2010.

Moreover, recent changing patterns of border enforcement and characteristics of return migrants can further influence this area's population composition.[30] Because migration is strongly implicated in the intertwined demographic and health transitions, these aspects of demographic transition influence socioeconomic indicators, comorbidity burden, and subsequent mortality.

In summary, in the US–Mexico border counties, the initial decline in stroke-related mortality has stalled during the past decade. Our findings illustrate the demographic and state-level disparities regarding stroke-related mortality across the border and nonborder counties. The Million Hearts initiative targets to prevent 1 million heart attacks and strokes by 2022.[31] Future policy efforts should advocate for integrating social determinants of health into existing cardiovascular care paradigms to identify vulnerable populations that could benefit from targeted interventions and mitigate the burden of stroke-related mortality in the unique US–Mexico border region.

ARTICLE INFORMATION

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Disclosures

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Supplementary Material

Tables S1–S3
Figures S1–S3

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Supplemental Material

Table S1. List of counties included in the analysis with age-adjusted stroke-related mortality, 1999-2018.

US-Mexico Non-Border region				US-Mexico Border region			
County	**Deaths**	**Population**	**Age-adjusted mortality rate**	**County**	**Deaths**	**Population**	**Age-adjusted mortality rate**
Apache County, AZ	393	1407929	34.6	Cochise County, AZ	1209	2514506	39.1
Coconino County, AZ	622	2613508	36.4	Pima County, AZ	8795	19005257	37.6
Gila County, AZ	704	1052445	42	Santa Cruz County, AZ	326	884422	38.1
Graham County, AZ	305	713065	47.5	Yuma County, AZ	1348	3750385	31.5
Greenlee County, AZ	57	171532	36.6	Imperial County, CA	1150	3305085	40.9
La Paz County, AZ	204	404395	27.2	San Diego County, CA	25628	61348334	42.5
Maricopa County, AZ	25746	74588439	35.2	Dona Ana County, NM	1365	3983539	36.7
Mohave County, AZ	2277	3808477	39	Grant County, NM	358	588685	39.2
Navajo County, AZ	763	2102845	39.9	Hidalgo County, NM	65	99106	50.4
Pinal County, AZ	1950	6303557	29.4	Luna County, NM	272	496813	39.7
Yavapai County, AZ	2740	4058545	38.3	Otero County, NM	465	1271473	35.7
Alameda County, CA	13431	30420360	46.5	Sierra County, NM	215	240155	41.4
Alpine County, CA	17	23593		Brewster County, TX	87	181243	39.6
Amador County, CA	513	747023	44	Brooks County, TX	67	148552	37.5
Butte County, CA	2984	4353129	50.9	Cameron County, TX	2330	7781556	34.1
Calaveras County, CA	495	888078	37.8	Crockett County, TX	28	75906	31.8
Colusa County, CA	146	414000	36.1	Culberson County, TX	17	50333	
Contra Costa County, CA	10635	20846589	48.4	Dimmit County, TX	112	205225	50.7
Del Norte County, CA	285	558109	48.1	Duval County, TX	117	241380	41.5
El Dorado County, CA	1321	3523158	33.3	Edwards County, TX	14	40232	
Fresno County, CA	8188	18104122	52.6	El Paso County, TX	4970	15413356	39.2
Glenn County, CA	283	551343	47.3	Frio County, TX	148	348605	49.5
Humboldt County, CA	1848	2650955	62.8	Hidalgo County, TX	3393	14636886	30.5
Inyo County, CA	237	366544	40.4	Hudspeth County, TX	21	70694	30.9
Kern County, CA	5553	15978315	47.3	Jeff Davis County, TX	16	45001	
Kings County, CA	875	2916248	45.2	Jim Hogg County, TX	53	104336	45.1
Lake County, CA	969	1262112	55.1	Kinney County, TX	40	70597	35.8

Lassen County, CA	209	668966	37.9	La Salle County, TX	64	135606	52.4
Los Angeles County, CA	74568	196977672	41.6	Maverick County, TX	322	1057151	38.4
Madera County, CA	1150	2883583	45.2	Pecos County, TX	124	316209	45.1
Marin County, CA	2572	5035883	36	Presidio County, TX	56	148277	27.8
Mariposa County, CA	204	354935	38.9	Real County, TX	42	64998	37.5
Mendocino County, CA	1000	1748676	45.4	Reeves County, TX	99	273665	38.4
Merced County, CA	1999	4961784	52.8	Starr County, TX	313	1194212	33.8
Modoc County, CA	138	186776	50.9	Sutton County, TX	34	81321	42.1
Mono County, CA	43	274785	23.1	Terrell County, TX	12	18713	
Monterey County, CA	3263	8324693	42.5	Uvalde County, TX	280	530096	45.2
Napa County, CA	1788	2687791	48	Val Verde County, TX	371	952085	41.3
Nevada County, CA	1412	1943051	46	Webb County, TX	1374	4778680	44.2
Orange County, CA	24553	60210389	42.4	Willacy County, TX	135	426279	34.5
Placer County, CA	3580	6610005	43.7	Zapata County, TX	74	269854	31.2
Plumas County, CA	231	399624	40.6	Zavala County, TX	101	235659	46.4
Riverside County, CA	17462	41203666	43.7				
Sacramento County, CA	13499	27926092	50.5				
San Benito County, CA	388	1120139	43.4				
San Bernardino County, CA	13662	39604783	47.4				
San Francisco County, CA	8349	16173141	42.9				
San Joaquin County, CA	6453	13385258	54.5				
San Luis Obispo County, CA	3716	5326247	53.1				
San Mateo County, CA	6648	14451528	39.4				
Santa Barbara County, CA	4097	8426314	42.2				
Santa Clara County, CA	11602	35521209	35.8				
Santa Cruz County, CA	1931	5231698	37.5				
Shasta County, CA	2207	3504265	48.1				
Sierra County, CA	37	65108	37				
Siskiyou County, CA	623	884162	46.5				
Solano County, CA	3813	8331290	50.4				
Sonoma County, CA	5603	9595491	47.1				

Stanislaus County, CA	4417	10129730	49				
Sutter County, CA	947	1814101	50.6				
Tehama County, CA	772	1224615	51.1				
Trinity County, CA	141	265252	40.3				
Tulare County, CA	3523	8490142	52.3				
Tuolumne County, CA	707	1102879	41.4				
Ventura County, CA	6541	16221018	40.8				
Yolo County, CA	1563	3912498	46.6				
Yuba County, CA	649	1389426	58.9				
Bernalillo County, NM	5260	12688915	40.8				
Catron County, NM	34	71233	26.6				
Chaves County, NM	607	1275210	40.2				
Cibola County, NM	174	539448	33.9				
Colfax County, NM	134	269528	32.6				
Curry County, NM	376	954430	43				
DeBaca County, NM	31	40008	40.9				
Eddy County, NM	468	1072422	38.2				
Guadalupe County, NM	46	92249	40.1				
Lea County, NM	520	1257739	47.9				
Lincoln County, NM	181	398553	32.1				
Los Alamos County, NM	110	363759	25.7				
McKinley County, NM	378	1452888	37.7				
Mora County, NM	47	97338	34.5				
Quay County, NM	114	181227	42.1				
Rio Arriba County, NM	305	803722	36.9				
Roosevelt County, NM	141	382628	37.7				
Sandoval County, NM	854	2410777	36.9				
San Juan County, NM	714	2461378	33.8				
San Miguel County, NM	213	581075	33.6				
Santa Fe County, NM	913	2822912	29.6				
Socorro County, NM	163	353727	46.4				

Taos County, NM	232	641652	29.2				
Torrance County, NM	126	325205	40				
Union County, NM	54	85158	42.5				
Valencia County, NM	555	1457395	41.3				
Anderson County, TX	635	1141436	55.7				
Andrews County, TX	173	298852	69.2				
Angelina County, TX	2188	1694439	118.7				
Aransas County, TX	330	472484	45.2				
Archer County, TX	103	177611	49.5				
Armstrong County, TX	37	39532	57.2				
Atascosa County, TX	455	886435	54.6				
Austin County, TX	284	546801	41.7				
Bailey County, TX	57	139224	36.9				
Bandera County, TX	188	401233	35.3				
Bastrop County, TX	582	1439193	45.3				
Baylor County, TX	88	75827	60				
Bee County, TX	254	645645	46.2				
Bell County, TX	1766	5886631	40.6				
Bexar County, TX	13745	33364854	48.5				
Blanco County, TX	180	201365	62.5				
Bosque County, TX	355	357908	58.1				
Bowie County, TX	1296	1828413	61.6				
Brazoria County, TX	2059	6034105	46.3				
Brazos County, TX	1137	3738652	49.7				
Briscoe County, TX	26	32940	49				
Brown County, TX	863	758793	82.4				
Burleson County, TX	181	342812	37.2				
Burnet County, TX	480	828651	41.6				
Caldwell County, TX	327	750457	44.1				
Calhoun County, TX	221	424017	48.1				
Callahan County, TX	139	267224	39.1				

Camp County, TX	185	243904	61.3				
Carson County, TX	78	125111	47.5				
Cass County, TX	625	604396	70				
Castro County, TX	67	158973	40.3				
Chambers County, TX	239	663006	49.3				
Cherokee County, TX	780	994310	65.3				
Childress County, TX	114	144547	62.9				
Clay County, TX	146	216131	52.6				
Cochran County, TX	31	64259	44.8				
Coke County, TX	52	69071	42.8				
Coleman County, TX	174	175305	60.1				
Collin County, TX	3303	14815894	38.6				
Collingsworth County, TX	50	60926	50.8				
Colorado County, TX	267	413701	41.5				
Comal County, TX	1110	2116351	44.9				
Comanche County, TX	252	274426	57.5				
Concho County, TX	65	79571	72.7				
Cooke County, TX	576	764878	61				
Coryell County, TX	401	1487934	46.9				
Cottle County, TX	33	31488	56.4				
Crane County, TX	59	86233	70.8				
Crosby County, TX	123	126640	74.8				
Dallam County, TX	67	132392	70.9				
Dallas County, TX	17890	47506558	52				
Dawson County, TX	153	277723	48.7				
Deaf Smith County, TX	155	377798	42.3				
Delta County, TX	94	105585	58				
Denton County, TX	2779	12688035	41.5				
DeWitt County, TX	349	404776	54				
Dickens County, TX	39	49054	49.8				
Donley County, TX	50	73407	42.5				

Eastland County, TX	356	367549	60.9				
Ector County, TX	1226	2747740	56.7				
Ellis County, TX	1252	2855727	56				
Erath County, TX	441	747061	54.2				
Falls County, TX	234	355866	50.6				
Fannin County, TX	464	664844	52.2				
Fayette County, TX	417	478812	45.7				
Fisher County, TX	70	80706	47				
Floyd County, TX	102	133323	55.2				
Foard County, TX	41	27692	72.1				
Fort Bend County, TX	2633	11081222	40.6				
Franklin County, TX	163	206615	56.5				
Freestone County, TX	253	382805	49.4				
Gaines County, TX	106	343010	42.6				
Galveston County, TX	2763	5795628	53				
Garza County, TX	63	120164	56.3				
Gillespie County, TX	445	479410	42.3				
Goliad County, TX	70	144662	32.7				
Gonzales County, TX	252	394907	51				
Gray County, TX	293	449775	49.9				
Grayson County, TX	1388	2393781	47.5				
Gregg County, TX	1549	2375835	59.1				
Grimes County, TX	277	521749	48.9				
Guadalupe County, TX	809	2477083	35.6				
Hale County, TX	417	712649	57.5				
Hall County, TX	56	68556	47.2				
Hamilton County, TX	163	166297	48.4				
Hansford County, TX	57	108554	44.7				
Hardeman County, TX	70	85009	50.4				
Hardin County, TX	583	1058269	53.9				
Harris County, TX	26529	80095425	50.4				

Harrison County, TX	752	1292736	54.6				
Hartley County, TX	59	116726	45.2				
Haskell County, TX	130	117608	58.9				
Hays County, TX	904	3029116	44.8				
Hemphill County, TX	48	74714	54.9				
Henderson County, TX	1225	1556060	58.3				
Hill County, TX	584	688334	60.4				
Hockley County, TX	262	460590	57.4				
Hood County, TX	687	993754	46.1				
Hopkins County, TX	494	688036	58.1				
Houston County, TX	325	465308	46.2				
Howard County, TX	323	695571	43.8				
Hunt County, TX	991	1701610	56.2				
Hutchinson County, TX	267	445670	50.6				
Irion County, TX	17	32347					
Jack County, TX	130	178621	66.5				
Jackson County, TX	146	286050	39.6				
Jasper County, TX	561	711115	65.3				
Jefferson County, TX	3173	5032413	58.8				
Jim Wells County, TX	376	812139	46.1				
Johnson County, TX	1541	2948083	62.9				
Jones County, TX	223	403353	50.3				
Karnes County, TX	159	302240	45.6				
Kaufman County, TX	908	1954080	57.1				
Kendall County, TX	333	653766	38.5				
Kent County, TX	18	15956					
Kerr County, TX	844	964983	44.4				
Kimble County, TX	54	90116	34.3				
Kleberg County, TX	259	632004	46				
Knox County, TX	107	77121	75.9				
Lamar County, TX	696	986609	53.9				

Lamb County, TX	185	281488	49.3				
Lampasas County, TX	201	391007	41.1				
Lavaca County, TX	348	387922	47.9				
Lee County, TX	178	329429	43.7				
Leon County, TX	250	328707	52.9				
Liberty County, TX	684	1519619	54.5				
Limestone County, TX	401	460864	68.3				
Lipscomb County, TX	59	65055	67.7				
Live Oak County, TX	104	236815	32.1				
Llano County, TX	287	378904	33.8				
Lubbock County, TX	2346	5462714	47.6				
Lynn County, TX	86	120913	62				
McCulloch County, TX	166	163492	63				
McLennan County, TX	2649	4628105	54.5				
Madison County, TX	161	270310	52.7				
Marion County, TX	167	212462	52.8				
Martin County, TX	47	98784	50				
Mason County, TX	58	78762	37.9				
Matagorda County, TX	397	740532	49.7				
Medina County, TX	421	898017	44.4				
Menard County, TX	49	44567	57.3				
Midland County, TX	1022	2745883	41.6				
Milam County, TX	360	494420	50.8				
Mills County, TX	93	98462	48.8				
Mitchell County, TX	125	184829	60.5				
Montague County, TX	453	389873	76.3				
Montgomery County, TX	2861	8653388	43.3				
Moore County, TX	143	423545	42.5				
Morris County, TX	214	258077	56.9				
Motley County, TX	27	24939	59.8				
Nacogdoches County, TX	831	1258763	67.9				

Navarro County, TX	726	945270	66				
Newton County, TX	167	288791	50.6				
Nolan County, TX	199	302174	50.3				
Nueces County, TX	3075	6738595	47.5				
Ochiltree County, TX	84	197461	51.8				
Oldham County, TX	12	41453					
Orange County, TX	994	1668077	56.4				
Palo Pinto County, TX	411	555084	60.7				
Panola County, TX	283	467484	49.1				
Parker County, TX	1112	2229008	56				
Parmer County, TX	98	200422	48.1				
Polk County, TX	676	909530	60.7				
Potter County, TX	1314	2380615	57.7				
Rains County, TX	189	214258	65.8				
Randall County, TX	944	2367232	41.8				
Reagan County, TX	57	68187	109.2				
Red River County, TX	251	261751	59.1				
Refugio County, TX	98	149094	46.4				
Robertson County, TX	171	330040	39.1				
Rockwall County, TX	535	1436479	48.4				
Runnels County, TX	157	213198	44.3				
Rusk County, TX	564	1026539	46.1				
Sabine County, TX	246	210165	67.1				
San Augustine County, TX	190	176209	60.2				
San Jacinto County, TX	259	513317	42.2				
San Patricio County, TX	657	1331710	53.4				
San Saba County, TX	85	120177	43.7				
Schleicher County, TX	39	62405	56.5				
Scurry County, TX	191	333488	49.6				
Shackelford County, TX	42	66603	43.2				
Shelby County, TX	436	508537	70.5				

Sherman County, TX	28	61358	40.6				
Smith County, TX	2031	4054786	43.7				
Somervell County, TX	122	161080	61.5				
Stephens County, TX	133	189985	48.9				
Sterling County, TX	13	25216					
Stonewall County, TX	19	29338					
Swisher County, TX	119	157155	57.4				
Tarrant County, TX	13991	35062294	54.4				
Taylor County, TX	1674	2613223	60.2				
Terry County, TX	134	252038	47.7				
Throckmorton County, TX	16	33180					
Titus County, TX	309	616052	50.4				
Tom Green County, TX	1095	2198836	44.6				
Travis County, TX	5265	20086290	42.6				
Trinity County, TX	243	286131	54.7				
Tyler County, TX	268	425219	45.6				
Upshur County, TX	512	773195	57.5				
Upton County, TX	35	67179	45.2				
Van Zandt County, TX	683	1038915	49.8				
Victoria County, TX	865	1746851	47.1				
Walker County, TX	577	1335182	54.8				
Waller County, TX	302	831184	46.6				
Ward County, TX	118	217090	48.3				
Washington County, TX	406	656830	40.9				
Wharton County, TX	478	824050	48.8				
Wheeler County, TX	61	106216	40.5				
Wichita County, TX	1758	2627275	63.4				
Wilbarger County, TX	269	272128	71.4				
Williamson County, TX	2160	7970607	38.6				
Wilson County, TX	360	823210	42.5				
Winkler County, TX	81	144435	58.5				

Wise County, TX	606	1157861	60.8				
Wood County, TX	634	820728	47.7				
Yoakum County, TX	42	156576	29.9				
Young County, TX	315	362296	56.1				

Table S2. Trends in Age-Adjusted Stroke Mortality in Counties located in the U.S. Mexican Border Area, 1999-2018.

Year	Arizona	California	New Mexico	Texas
1999	49.1	62.4	51.6	50.2
2000	55.2	63.9	42.2	45.9
2001	47.8	64.2	41.9	43.1
2002	48.1	57.6	41.2	46.4
2003	45.1	58.0	44.3	41.5
2004	45.7	53.9	43.8	37.9
2005	41.9	45.0	45.1	38.0
2006	36.2	41.3	38.3	38.3
2007	36.8	41.7	40.3	39.5
2008	34.8	39.1	38	42.5
2009	34.8	36.9	32.8	36.3
2010	34.4	34.4	39.2	32.5
2011	31.7	32.8	34.9	35.4
2012	32.5	30.6	35.5	32.7
2013	30.9	33.3	34.8	33.3
2014	28.9	33	33.5	31.6
2015	31.6	32.3	28.1	32
2016	32	37.6	35.4	32.5
2017	33	37.3	34.2	30.4
2018	33.3	38.6	34.4	28.8
APC [95% CI], Segment 1	**-3.84 [-4.42, -3.26]**	**-5.96 [-6.73, -5.20]**	**-2.40 [-3.13, -1.66]**	**-3.84 [-7.25, -0.31]**
APC [95% CI], Segment 2	4.08 [-0.52, 8.9]	**3.94 [1.25, 6.71]**	3.26 [-6.36, 13.86]	**-2.13 [-2.87, -1.39]**
Joinpoint year	2014	2012	2015	2004
AAPC [95% CI]	**-2.23 [-3.18, -1.26]**	**-2.94 [-3.83, -2.05]**	**-1.53 [-3.02, -0.00]**	**-2.58 [-3.57, -1.59]**

Observed age-adjusted mortality rates are reported per 100,000 persons. APC stands for Annual Percentage Change and AAPC stands for Average Annual Percent Change. Segments 1 and 2 are APCs before and after joinpoint year. Bold indicates that annual percent change is significantly different from zero at the alpha = 0.05

Table S3. Trends in Age-Adjusted Stroke Mortality in Counties located in the Non-Border Area, 1999-2018.

Year	Arizona	California	New Mexico	Texas
1999	55.9	64.7	52.7	67.4
2000	52.9	64.0	52.3	68.6
2001	49.3	61.9	51.7	67.1
2002	49.4	59.5	42.5	65.4
2003	45.6	58.2	44.6	62.8
2004	44.2	54.7	40.5	58.9
2005	41.2	49.4	39.1	53.9
2006	37.9	46.8	39.1	51.5
2007	35.5	43.9	41.4	52.7
2008	33.5	41.3	38.1	50.0
2009	30.8	38.6	35.8	46.0
2010	31.2	38.4	38.3	45.7
2011	30.3	36.7	33.3	42.6
2012	29.0	35.9	29.1	42.7
2013	27.9	35.1	29.0	40.9
2014	28.0	34.0	34.8	42.7
2015	30.3	36.5	33.5	43.8
2016	29.0	36.8	35.7	43.0
2017	29.9	37.6	34.8	42.5
2018	30.2	36.8	31.1	41.5
APC [95% CI], Segment 1	**-5.24 [-4.82, -25.94]**	**-5.07 [-5.52, -4.62]**	**-3.74 [-4.76, -2.71]**	**-4.15 [-4.67, -3.63]**
APC [95% CI], Segment 2	1.41 [-0.03, 2.86]	1.33 [-0.22, 2.91]	1.12 [-2.28, 4.64]	**-0.31 [-1.53, 0.92]**
Joinpoint year	2012	2012	2012	2011
AAPC [95% CI]	**-3.19 [-3.67, -2.70]**	**-3.09 [-3.62, -2.57]**	**-2.23 [-3.39, -1.05]**	**-2.75 [-3.26, -2.24]**

Observed age-adjusted mortality rates are reported per 100,000 persons. APC stands for Annual Percentage Change and AAPC stands for Average Annual Percent Change. Segments 1 and 2 are APCs before and after joinpoint year. Bold indicates that annual percent change is significantly different from zero at the alpha = 0.05

Figure S1. Age-specific mortality rates in the Counties located in the U.S. Mexican Border vs. Non-Border Area, 1999-2018.

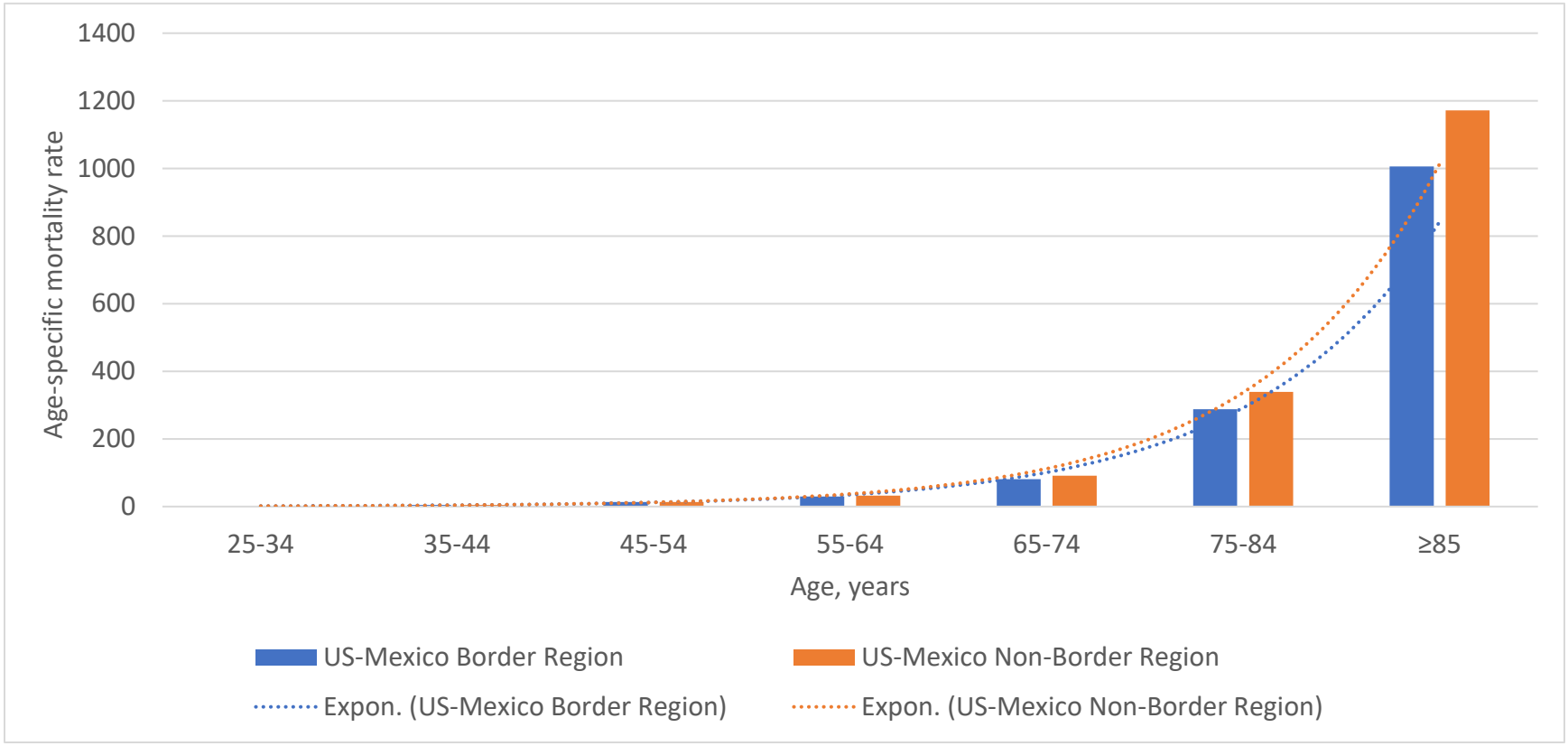
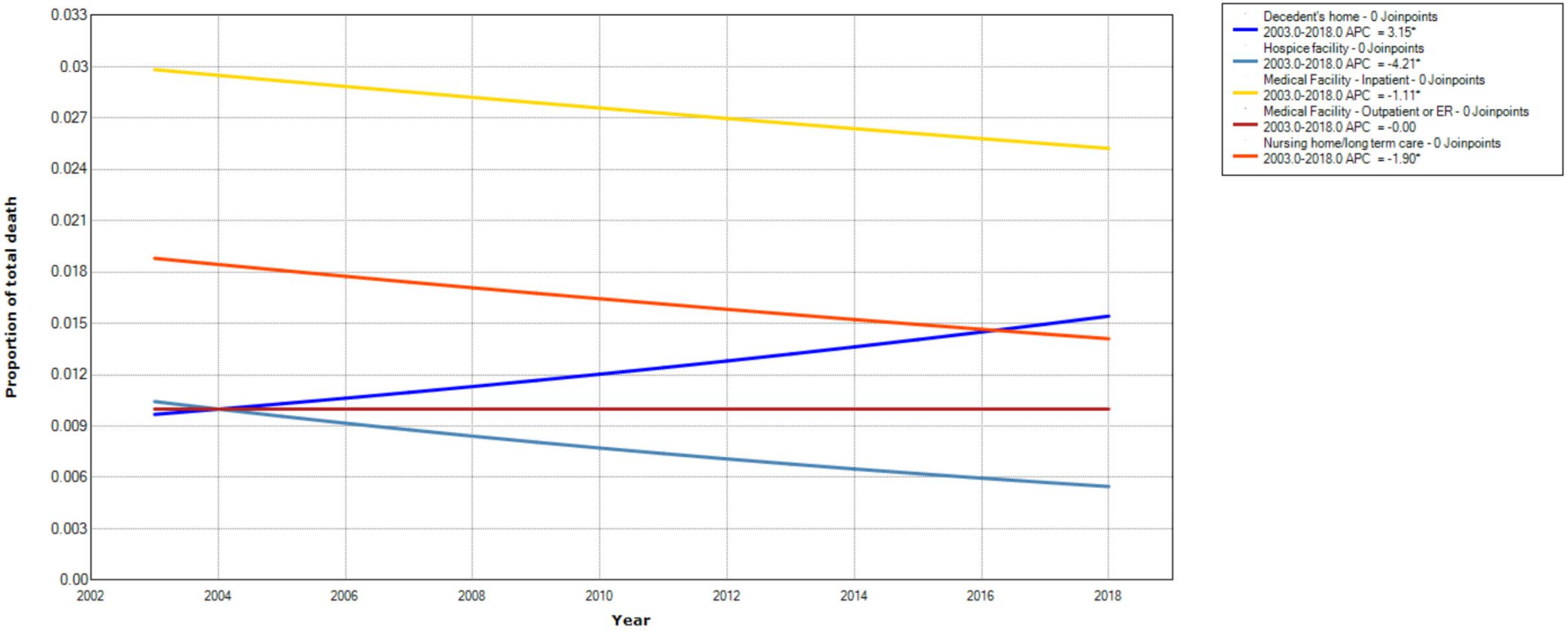
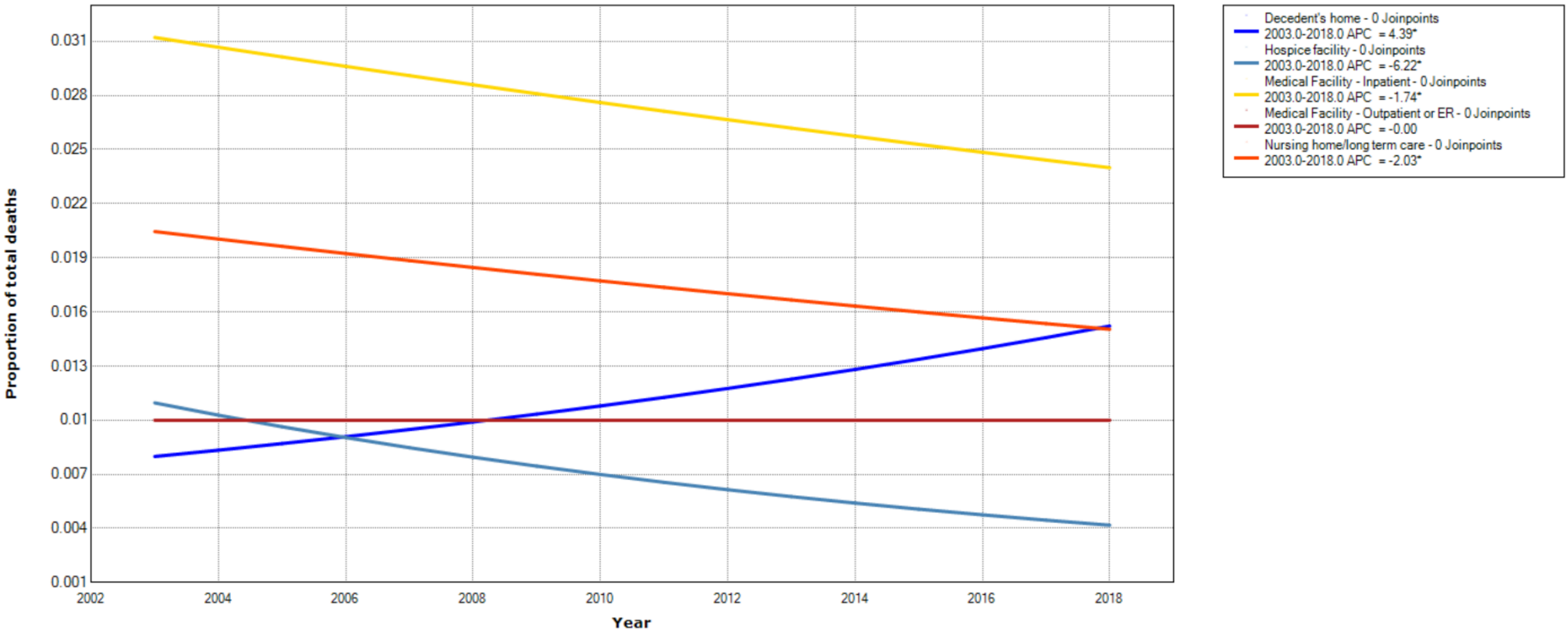


Figure S2. Joinpoint chart illustrating proportion of patients dying due to stroke in counties located in the U.S. Mexican Border Area, 2003-2018.



APC: Annual percent change; ER: Emergency room

Figure S3. Joinpoint chart illustrating proportion of patients dying due to stroke in counties located in the non-border area, 2003-2018.



APC: Annual percent change; ER: Emergency room