Reassessing the Stroke Belt

Using Small Area Spatial Statistics to Identify Clusters of High Stroke Mortality in the United States

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Background and Purpose—The stroke belt is described as an 8-state region with high stroke mortality across the southeastern United States. Using spatial statistics, we identified clusters of high stroke mortality (hot spots) and adjacent areas of low stroke mortality (cool spots) for US counties and evaluated for regional differences in county-level risk factors.

Methods—A cross-sectional study of stroke mortality was conducted using Multiple Cause of Death data (Centers for Disease Control and Prevention) to compute age-adjusted adult stroke mortality rates for US counties. Local indicators of spatial association statistics were used for hot-spot mapping. County-level variables were compared between hot and cool spots.

Results—Between 2008 and 2010, there were 393 121 stroke-related deaths. Median age-adjusted adult stroke mortality was 61.7 per 100 000 persons (interquartile range=51.4–74.7). We identified 705 hot-spot counties (22.4%) and 234 cool-spot counties (7.5%); 44.5% of hot-spot counties were located outside of the stroke belt. Hot spots had greater proportions of black residents, higher rates of unemployment, chronic disease, and healthcare utilization, and lower median income and educational attainment.

Conclusions—Clusters of high stroke mortality exist beyond the 8-state stroke belt, and variation exists within the stroke belt. Reconsideration of the stroke belt definition and increased attention to local determinants of health underlying small area regional variability could inform targeted healthcare interventions. **(*Stroke*. 2016;47:1939-1942. DOI: 10.1161/STROKEAHA.116.012997.)**

Key Words: attention ■ cause of death ■ chronic disease ■ risk factors ■ stroke

The stroke belt, an 8-state region in the southeastern United States, defined for its disproportionately high stroke mortality rates,[1,2] has been present since at least 1940 and persists despite recent decreases in stroke mortality, overall.[3] Differences in vascular risk factors may explain approximately half of the excess burden,[4] yet underlying drivers in this region are not fully understood.[1] Access to primary stroke centers (PSCs) is lower within the region, suggesting that differential access to care could be one contributing factor.[5,6]

Using the existing state-based definition may not provide adequate geographic precision to fully understand the impact of local demographic and healthcare factors as determinants of health. We used county-level data and spatial statistics to empirically identify geographic clusters of high stroke mortality, or hot spots, at a finer geographic resolution to compare with the traditional state-based stroke belt. We compared multiple county-level variables between high stroke mortality hot spots and adjacent low stroke mortality cool spots, to understand local factors contributing to stroke outcomes.

Methods

We used Multiple Cause of Death data (Centers for Disease Control and Prevention) from 2008 to 2010 to calculate a 3-year average age-adjusted adult stroke mortality rate for all US counties. *International Classification of Diseases*-Tenth Revision codes I60-I69 were used to identify stroke as cause of death.

Local indicators of spatial association statistics were used to describe spatial patterns of mortality rates. This technique categorizes counties as: clustered high-rate counties (High-High); low-rate counties adjacent to High-High counties (Low-High), clustered low-rate counties (Low-Low), and high-rate counties adjacent to Low-Low counties (High-Low [HL]). Nonsignificant counties demonstrate spatial randomness among neighbors. We compared High-High and Low-High counties, respectively hot spots and cool spots. Hot spots do not include HL counties and cool spots do not include Low-Low counties.

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We analyzed county-level demographic characteristics (2008–2012 American Community Survey), healthcare resources, and utilization rates (2008, 2010 Area Health Resource File), and prevalence of diabetes mellitus, obesity (2011 Food Environment Atlas), and hypertension (Institute for Health Metrics and Evaluation). Data describing access to PSCs used previously described methods.[7] We

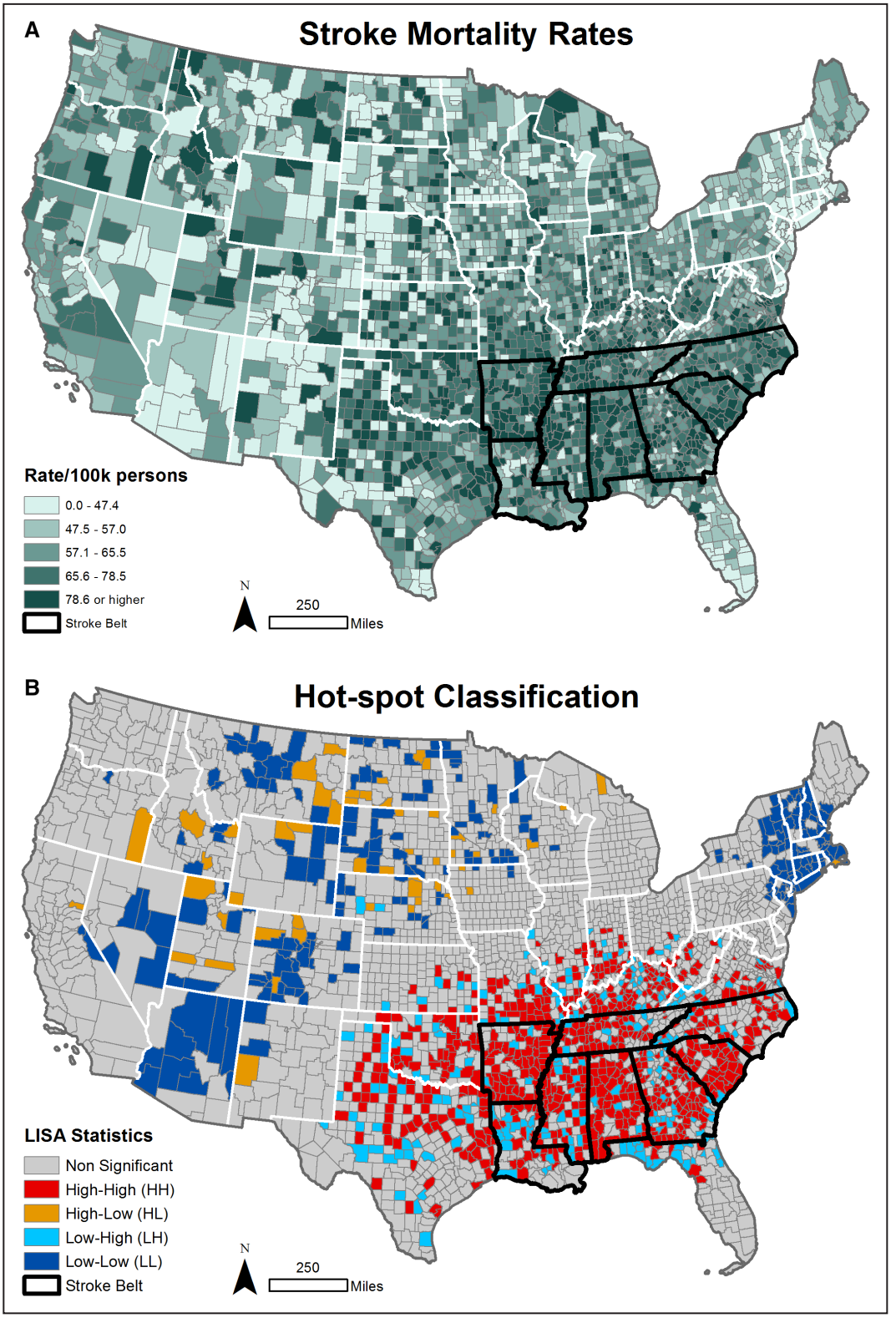

Figure. Stroke mortality rates and hot spots mapped by county. **A**, The US county map showing stroke mortality rates (2008–2010). Rates are reported per 100 000 persons; binned by quintile. **B**, Stroke mortality hot-spot classifications. Local indicators of spatial association (LISA) statistics identify counties (significance level $P<0.05$), as high-high (HH), low-high (LH), low-low (LL), high-low (HL), or not significant. In **A** and **B**, stroke belt states are outlined in black.

used Wilcoxon rank-sum tests to compare averages. Spatial methods are further described in the online-only Data Supplement.

Results

From 2008 to 2010, 393 121 stroke deaths were reported across 3137 counties. Median county-level age-adjusted stroke mortality was 61.7 per 100 000 persons (interquartile range=51.4–74.6; Figure [A]). The hot-spot analysis identified 705 High-High (22.4%), 234 Low-High (7.5%), 238 Low-Low (7.6%), and 52 HL (1.7%) counties (Figure [B]). Of the 688 counties included in the 8-state stroke belt, there were 391 High-High (57.4%) and 91 Low-High (13.2%). The other 314 High-High counties were located outside of the 8-state region.

Compared with cool spots, hot spots had significantly larger proportions of black residents; higher rates of unemployment, obesity, diabetes mellitus, and hypertension; more hospital admissions and emergency department visits per capita; and lower median income and educational attainment (Table). Sixty-minute access to a PSC was available for 65.2% of people nationally, 31.5% of the population in hot-spot counties, and 50.7% in cool-spot counties. Median county-level PSC access did not differ overall or stratified by urbanicity (Table I in the online-only Data Supplement).

Discussion

Our results confirmed past findings that high stroke mortality is geographically clustered in the southeast, and detected clusters of high stroke mortality existing outside of the traditional 8-state stroke belt. A state-based approach misses nearly half of the counties identified empirically as hot spots. We identified cool spots within the stroke belt where mortality is lower than expected. County-level heterogeneity suggests that state-based analyses may limit our understanding of the underlying drivers of survival through misclassification bias. Because things that are geographically close tend to be more similar,[8] identifying areas that have significantly different mortality rates, despite close proximity, may help explain the drivers of disparities in outcomes.

There was a higher rate of 60-minute PSC access for people living in hot spots than cool spots; however, a statistically significant difference for county-level averages was not observed. We found a paradoxical relationship between the number of physicians and mortality, with more physicians on average in hot spots than cool spots. These findings combined may suggest that differential access to health care and specialty stroke care may not be the key factor underlying geographic variability in stroke mortality. It is possible that more granular scales of analysis are needed to detect meaningful differences (the mortality data used restricted us to a county-level analysis).

We found statistically significant differences in prevalence of diabetes mellitus, obesity, and hypertension between hot spots and cool spots. However, differences in disease severity or disease control may be magnifying relatively small differences in prevalence.

This study has limitations. The stability of spatial patterns of mortality over time is not known, but a previous study

Table. Comparison of Hot-Spot and Cool-Spot Counties

	All Counties, n=3137		Hot-Spot Counties (HH), n=705	Cool-Spot Counties (LH), n=234	
	National Total	Median (IQR)	Median (IQR)	Median (IQR)	*P* Value
Adjusted stroke mortality rate (per 100k pop)	56.1	61.7 (51.4–74.7)	83.6 (76.5–95.5)	46.1 (38.9–51.6)	<0.001
Urban population, %	80.6	40.6 (12.2–67)	31.4 (10.4–51.5)	26.5 (0–55.1)	0.459
Median age, y	37.2	40.4 (37.4–43.3)	39.9 (37.6–42)	40.4 (38–42.9)	0.033
Black population, %	12.6	2.1 (0.5–10.4)	10.4 (1.9–32.1)	4.8 (1–19)	<0.001
Hispanic population, %	16.4	3.3 (1.6–8.3)	2.6 (1.4–5.7)	2.9 (1.5–6.3)	0.221
Median household income ($, 2012)	53 046	43 809 (37 970–50 697)	37 508 (33 333–42 256)	40 682.5 (34 848–48 596)	<0.001
Unemployment rate, %	9.3	8.4 (6.2–10.7)	10.2 (8–12.6)	9 (6.9–10.7)	<0.001
Education high school or less, %	42.5	51.2 (43.8–58.7)	58.7 (53.1–63.7)	56 (47–62.6)	<0.001
No health insurance, %	14.9	14.6 (11–18.5)	17.1 (14.7–19.9)	16.7 (13.8–20.2)	0.131
Adult diabetes mellitus, %	9.0	9.8 (8.5–11.3)	11.6 (10.4–12.7)	10.7 (9.5–11.9)	<0.001
Adult obesity, %	26.5	29.1 (27.2–31)	31.1 (29.5–32.8)	29.9 (27.5–31.8)	<0.001
Adult hypertension, %	37.2	38.8 (37.1–41.2)	42.2 (40.4–44.9)	40.4 (38.7–42.9)	<0.001
MDs (per 100k pop)	30.3	25.5 (15.5–39.4)	22.7 (14.5–33.3)	20.1 (11.5–31.8)	0.031
Hospitals (per 100k pop)	2.1	1 (1–2)	1 (1–1)	1 (0–1)	0.034
Hospital admissions (per 100k pop)	86.8	69 (27.2–119.2)	71.6 (21.1–126.7)	48.2 (0–95.9)	<0.001
ED visits (per 100k pop)	396.3	369 (169.7–536.1)	432.1 (110.5–603.3)	331.7 (0–521.9)	<0.001
Medicare eligible population, %	14.7	18.2 (15.3–21.3)	19.1 (16.5–21.5)	18.3 (15.1–20.6)	0.003

The Table provides national totals and county medians for multiple variables and compares hot spots and cool spots using Wilcoxon rank-sum (Mann–Whitney) tests. ED indicates emergency department; HH, High-High; IQR, interquartile range; and LH, Low-High.

found that 75% of stroke hospitalization clusters were stable >10 years.[9] This cross-sectional, population-level analysis cannot assess causality. Population-level associations may not apply at the individual level. Because of the low number of HL counties (n=52), comparisons of HL and Low-Low precluded a meaningful analysis.

Conclusions

Clusters of high stroke mortality exist beyond the 8-state stroke belt, and variation exists within the stroke belt. Reconsideration of the stroke belt definition and increased attention to small area regional variability using spatial methods may allow for better classification of regional disparities and inform targeted healthcare interventions.

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Disclosures

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