What Predicts Geographic Variation in Opioid Mortality in Virginia?

Jong Hyung Lee
Derek A. Chapman
Steven H. Woolf

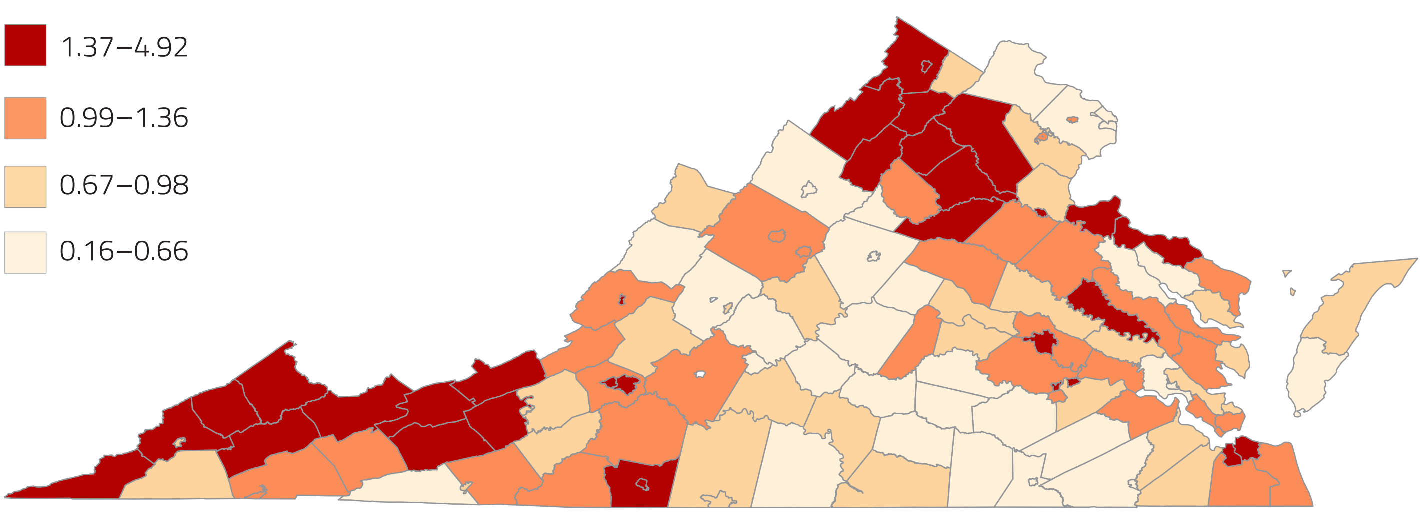
A Study by the Virginia Commonwealth University Center on Society and Health

In Virginia and elsewhere in the United States, the opioid epidemic has become an increasingly urgent public health crisis. Fatal overdose deaths have increased alarmingly throughout the state, doubling between 2010 and 2018. The regions with the highest opioid mortality rates are in southwestern Virginia, the northern Shenandoah Valley, and cities like Richmond and Norfolk (Figure 1). The overdistribution of prescription opioids and increasing access to illicit drugs like fentanyl explain much of this geographic variation,[1] but insufficient attention has been given to contextual factors that make individuals more vulnerable to addiction disorders.

In a study commissioned by the Virginia Department of Health, the Center on Society and Health at Virginia Commonwealth University applied Bayesian spatial regression techniques to explore relationships between place-based conditions in Virginia's 133 localities and their opioid mortality rates during 2007–2017. These methods were employed to account for geographic clustering that occurs among localities.

Initially, 19 place-based characteristics were selected[2] based on published research linking them to drug overdose mortality.[3] Nine variables were eliminated based on collinearity or weak correlations with opioid mortality, leaving 10 measures that included not only local opioid prescription rates but also: *demographic characteristics* (median age, the percentage of the population represented by non-Hispanic

Figure 1. Standardized opioid mortality ratio by locality, Virginia, 2007–2017



Note: Scale bar on the left displays standardized mortality ratios categorized by quartile whites, and percentage of those age 15 years and older who were divorced or separated) and measures of *socioeconomic position* (percentage of adults with a Bachelor's degree or higher, unemployment rate), *functional status* (percentage of the population with a disability),[4] *geographic setting* (share of population living in a rural area), and *local contextual conditions* (age of housing; percentage of the labor force working in agriculture, forestry, or extraction industries, such as mining). The statistical model determined which of these 10 variables were most predictive of high opioid mortality rates (i.e., those significantly higher than the state average). See the Technical Report for more details on methods.

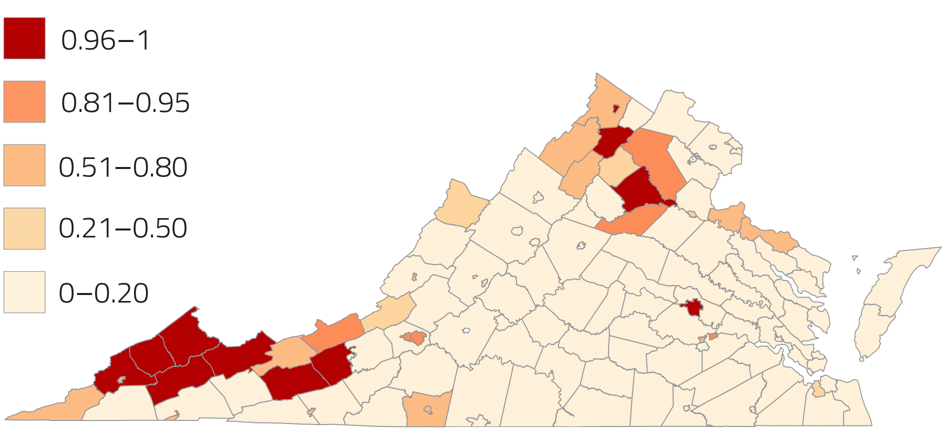
The statistical analysis identified "hot spot" localities (counties and independent cities) that were significantly more likely to have high mortality rates, even after adjusting for other factors (Figure 2).

Table 1 lists 11 counties and cities with the greatest risk of having a high mortality rate.

Table 2 shows the place-based characteristics that were most predictive of high opioid mortality rates; the first column displays crude rates, the second column displays risk ratios after adjustment for other factors in the model. As expected, the crude rates show that high opioid mortality rates were significantly correlated with the local opioid prescription rate, but other factors were also predictive. Specifically, risks were increased when a locality had a larger share of the population who had a disability, were divorced or separated, or worked in agriculture or extraction industries. Conversely, more educated populations (e.g., Bachelor's degrees or higher) were less likely to have high opioid mortality rates.

These factors are highly interrelated, making it necessary to conduct multivariable analyses to identify which predictive factors retain significance even after adjustment for other variables – and which do not. Notably, the rate of opioid prescribing rate lost statistical significance after adjustment for upstream social and demographic factors. More

Figure 2. Probability of (Bayesian modeled) increased risk (RR>1.5) for opioid mortality by locality, Virginia, 2007–2017



Note: Scale bar on the left displays probability (%) of relative risk exceeding 1.5

Table 1. Virginia localities with the highest modeled risk of opioid mortality, Pr (>1.5)†

Locality	Mean Adjusted Relative Risk (95% CI‡)
Cumberland Plateau Health District	
Buchanan County	3.64 (2.90–4.45)
Dickenson County	4.48 (3.51–5.58)
Russell County	2.63 (2.09–3.23)
Tazewell County	2.70 (2.23–3.21)
Lenowisco Health District	
Wise County	3.04 (2.52–3.61)
Lord Fairfax Health District	
Winchester City	2.19 (1.68–2.77)
Warren County	2.08 (1.65, 2.56)
Mount Rogers Health District	
Wythe County	2.01 (1.54–2.53)
New River Health District	
Pulaski County	2.34 (1.87–2.87)
Rappahannock/Rapidan Health District	
Culpeper County	1.81 (1.46–2.21)
Richmond City Health District	
Richmond City	1.83 (1.64–2.03)

† *Probability that the mean relative risk (θ) of having an opioid mortality rate higher than the state rate was greater than 1.5*
‡ *Bayesian credible interval (analogous to confidence interval)*

Table 2. Association with opioid mortality based on Bayesian spatial analysis

Place-based factors	Crude Relative Risk (95% CI†)	Mean Adjusted Relative Risk (95% CI†)
Demographic		
Median age	1.05 (0.97, 1.15)	0.95 (0.85–1.07)
Non-Hispanic whites as proportion of population	0.98 (0.87–1.10)	**1.17 (1.03–1.34)***
Percent of adults who are divorced/separated	**1.20 (1.11–1.30)***	**1.11 (1.00–1.23)***
Socioeconomic position		
Percent of adults with Bachelor's degree or higher	**0.81 (0.73–0.89)***	0.88 (0.77–1.02)
Unemployment rate	1.09 (0.99–1.20)	0.99 (0.88–1.12)
Functional status		
Percent of population with a disability	**1.37 (1.22–1.53)***	**1.23 (1.04–1.47)***
Health care		
Opioid prescription rate (per 100 residents)	**1.11 (1.02–1.21)***	0.99 (0.88–1.11)
Geographic setting		
Percent of population in rural areas	0.98 (0.89–1.07)	**0.84 (0.71–0.98)***
Contextual conditions		
Percent of housing built before 1939	1.09 (1.00–1.19)	1.00 (0.92–1.09)
Percent of adults working in agriculture, forestry, mining	**1.11 (1.01–1.22)***	**1.14 (1.03–1.26)***

‡ Bayesian credible interval (analogous to confidence interval)
** Statistically significant at the 0.05 level (bolded for emphasis)*

Table 3. Crude opioid mortality rate by quartile (Q) and average values of predictors

Place-based variables	Opioid Mortality Q1	Q2	Q3	Q4
Mortality				
Crude opioid mortality rate per 100,000 (range within quartile)	4.4 (1.3–5.4)	6.9 (5.7–8.4)	9.5 (8.5–11.9)	16.4 (11.9–40.4)
Demographic				
Median age	39.2	41.6	41.8	40.5
Non-Hispanic whites (%)	68.2	79.2	74.5	80.2
Females 15 years and older who were divorced/separated (%)	12.5	12.6	13.4	14.8
Socioeconomic position				
Adults with Bachelor's degree or higher (%)	29.4	26.6	24.6	21.1
Unemployment rate (%)	6.5	6.0	6.6	7.3
Functional status				
Population with a disability (%)	13.7	13.8	14.9	16.8
Health care				
Opioid prescriptions (per 100 residents)	61.4	80.4	66.1	106.7
Geographic setting				
Population in rural areas (%)	53.9	54.0	53.0	48.5
Contextual conditions				
Housing built before 1939 (%)	10.6	10.3	9.1	12.6
Labor force working in agriculture, forestry, mining (%)	2.6	2.3	1.7	3.5

significant predictors included the percentage of the population with a disability (risk ratio [RR]=1.23), followed by the percentage of the population who were non-Hispanic whites (RR=1.17); working in agriculture, mining, or other extraction industries (RR=1.14); or divorced or separated (RR=1.11).[5]

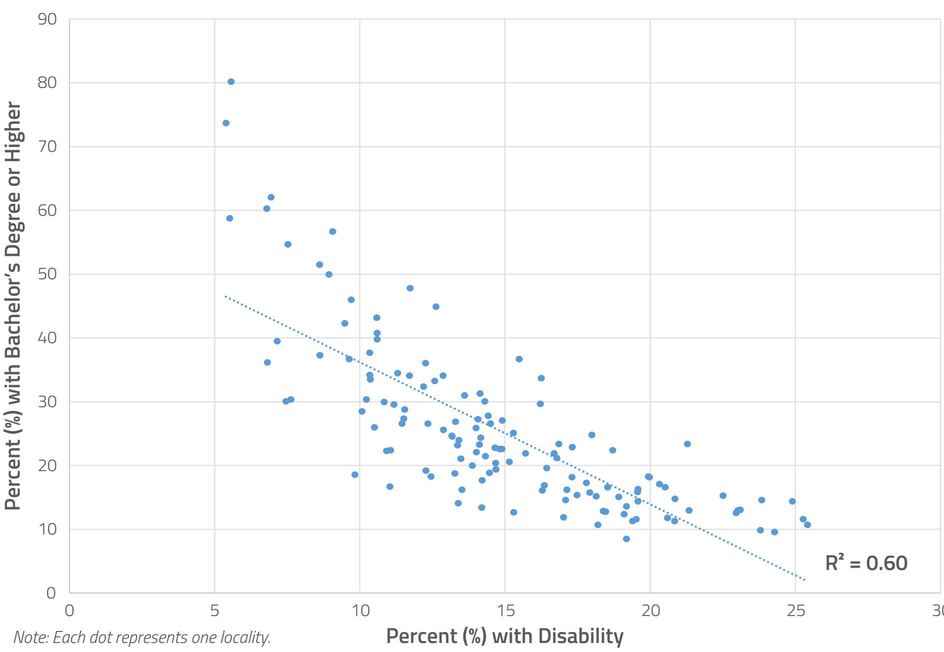
Table 3 shows the gradient in place-based characteristics at different levels (quartiles) of opioid mortality. It is important to emphasize that many of these predictors may be serving as proxies for social determinants of health with more direct causal roles in substance abuse. For example, having a disability – the strongest predictor of high opioid mortality rates – had a strong inverse relationship with educational attainment, a major determinant of health (Figure 3).

The bottom line: the opioid epidemic is driven not only by proximal factors, such as physician prescribing habits or access to illicit drugs, but also by upstream factors that make people susceptible to addiction.[3] Despite widespread policy initiatives to combat the opioid epidemic, opioid mortality has continued to accelerate, underscoring the importance of prevention, treatment, and attention to root causes.[6]

Contextual conditions in localities are important. Virginia communities that are dependent upon mining and farming are more likely to have residents with work-related injuries and disabilities who need relief from chronic pain. These communities are also more likely to be economically distressed by the closure of coal mines and other industries that produced jobs. These stresses can cause family disruption, such as divorce; induce unhealthy coping behaviors, such as substance abuse; and alter pain thresholds and needs for analgesic drugs.

A comprehensive strategy to address the opioid epidemic must, therefore, include not only downstream interventions (e.g., emergency care for overdoses, addiction counseling, physician prescribing guidelines, prosecution of drug trafficking), but also upstream efforts to ease the adverse living conditions that fuel drug use. Policies to promote education, bring economic relief to distressed communities, and strengthen social services and support systems for families in need may ultimately be required to successfully stem the current drug crisis.

Figure 3. Association between education and disability prevalence by locality, Virginia, 2008–2012



Note: Each dot represents one locality.

NOTES

1. Virginia Department of Health. Opioid deaths (website). Accessed 11-13-19 at http://www.vdh.virginia.gov/opioid-data/deaths/

2. See the technical appendix for more details on methods

3. Dasgupta, N., Beletsky, L., & Ciccarone, D. (2018). Opioid crisis: no easy fix to its social and economic determinants. *American Journal of Public Health*, *108*(2), 182–186.

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4. Disability includes difficulty with hearing, vision, cognition, ambulation, self-care, or independent living.

5. Rurality emerged as a protective factor after adjustment for other variables, in part because one third of localities with the highest opioid mortality rates were cities.

6. Kertesz, S. G. (2017). Turning the tide or riptide? The changing opioid epidemic. *Substance Abuse*, 38(1): 3–8. DOI: 10.1080/08897077.2016.1261070