Ascertaining the relative contribution of spatio-temporal effects to the synthetic opioid overdose epidemic in the United States.

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Abstract: 393 words (guideline: 200-400 words)

Background:
Since 2015, the United States overdose epidemic has been driven by synthetic opioids (mostly fentanyl), with some geographical areas experiencing much higher death rates than others. To better understand this geographical heterogeneity, we developed a geostatistical model investigating the extent to which spatio-temporal variations in synthetic overdose deaths can be accounted for by factors determining geographical mobility and access. Indeed, we hypothesize such factors drive both availability of drugs and of harm reduction services.

Methods:
A Bayesian spatio-temporal hierarchical mixed model was formulated using yearly synthetic opioid overdose crude death rate (SODR- y_{st}) by county (s = 1, ..., 3142) over 6 years (t = 2012, …, 2017) as the response variable, assumed to follow a Poisson distribution. Data to calculate the yearly SODR was extracted from the CDC Wonder database, and data for geographical mobility and access variables (i.e. income, urbanicity, vehicle possession, urgent care access and road access) from the American Community Survey, Highway Safety Improvement Program, and National Center for Health Statistics. Counties were divided in four geographic areas: Northeast, South, West and Midwest. A set of models were developed to understand the relative contribution of spatio-temporal structured random effects by including an intercept, a first-order autoregressive effect for each year, spatially unstructured, and structured random effects (to account for neighborhood dependency structure), and geographical mobility and access variables. Model parameters were estimated in a Bayesian framework using Integrated Nested Laplace Approximation. The R^2_{LR} statistic for mixed-effects models, based on a likelihood ratio test, was used to estimate the variation in SODR accounted for by each term.

Results:
In the Northeast, South and Midwest, the near totality (91-99%) of the variation in SODR death rates is associated with spatio-temporal terms. In each of these three regions, 26%, 18% and 36% of the spatio-temporal variation, respectively, is associated with factors determining geographical mobility and access. In contrast, spatio-temporal factors account for only 21% of SODR variation in the West and the latter was not explained by the geographical mobility/access factors included.

Conclusion:
The contribution of spatio-temporal autocorrelation to the synthetic opioid overdose epidemic varies across the U.S. and is predominant in the Northeast, South and Midwest. We have identified geographical access and mobility factors that partly explain this variation in the three regions. This is a first step towards constructing an early warning system of overdose epidemics incorporating spatio-temporal factors.

Geographic strata	model	R^2_{LR}	DIC	pD	CV log score
North-east	Only mobility/access factors	0.2725	14010.78	10.05	4.06
North-east	Only spatio-temporal	0.9976	4393.67	168.19	1.29
North-east	Full	0.9976	4391.88	165.51	1.29
South	Only mobility/access factors	0.1843	52094.26	10.17	2.29
South	Only spatio-temporal	0.9227	26516.67	625.65	1.17
South	Full	0.9226	26474.85	597.46	1.17
West	Only mobility/access factors	0.0047	7378.31	10.02	1.11
West	Only spatio-temporal	0.2095	6779.96	92.26	1.01
West	Full	0.2107	6788.43	99.16	1.01
Mid-west	Only mobility/access factors	0.3599	35719.13	10.11	2.12
Mid-west	Only spatio-temporal	0.9139	19628.26	421.21	1.17
Mid-west	Full	0.9139	19577.37	395.68	1.17