Milestone 6

Ali Crump

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The goal of this project is to replicate the paper, "Fentanyl Shock: The changing geography of overdose in the United States," by Michael Zoorob. The data used in this paper is available on the Harvard Dataverse. This paper explores fentanyl seizures and deaths in the United States from 2011-2017, namely the increases of both. Zoorob uses two models; Model 1 shows that fentanyl exposure has a positive association with mortality rates, and Model 2 tries to estimate the causal effect of fentanyl exposure on mortality rates.

Zoorob runs a least squares regression for the first model. The model predicts overdose mortality as a function of fentanyl exposure. Fentanyl exposure takes into account the state, year, the natural logarithm of the number of test results containing fentanyl (in that state and year), and an error term. The standard errors are two-way clustered by state and year and includes population weights (Zoorob (2019)).

(When I include these equations in the final paper I'll have them in the proper format).

$$Overdose_{ij} = \alpha_i + \eta_j + \beta_1 Fentanyl_{ij} + \varepsilon_{ij}$$

The second model uses a two-stage least squares regression:

$$\widehat{Fentanyl}_{ij} = \alpha_i + \eta_j + \beta_1\left(\text{Longitude}_\text{i} \cdot \text{Year}_\text{j}\right) + \varepsilon_{ij} Overdose_{ij} = \alpha_i + \eta_j + \beta_2 \widehat{Fentanyl}_{ij} + \varepsilon_{ij}$$

Findings in the paper show that much of the variation in the increased overdose mortality is explained by fentanyl exposure, and that fentanyl deaths are highly correlated with geography, as the epicenter of the overdose crisis has shifted towards the eastern U.S. They also found that longitude is better able to explain levels of overdose mortality over time. States east of the Mississippi River tend to have greater fentanyl exposure and sharper increases in overdose deaths than states west of the Mississippi River (Zoorob (2019)). Zoorob also uses both models to estimate the number or overdose deaths attributable to fentanyl and claims that they are broadly consistent with official mortality statistics. For my replication paper I am going to run the same statistical analyses and compare the results.

More information on this project can be found on my Github repository.[1]

[1] Github repository

Appendix

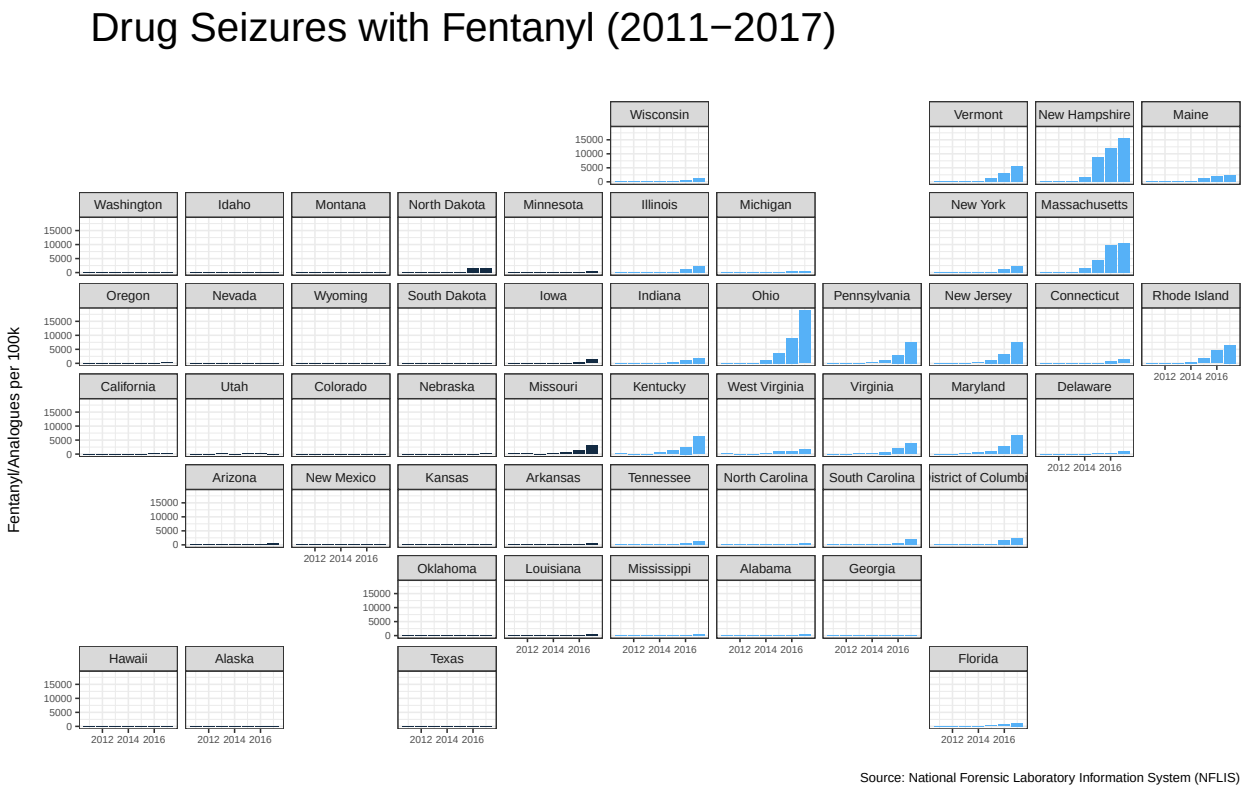

Table 1:

	Dependent variable:	
	age_adjusted_rate	
	(1)	(2)
fent_r	4.508***	
	(0.635)	
‘fent_r(fit)‘		5.443***
		(0.653)
Observations	357	357
R^2	0.928	0.923
Adjusted R^2	0.914	0.908
Residual Std. Error (df = 299)	5,372.861	5,545.678
Note:	*p<0.1; **p<0.05; ***p<0.01	

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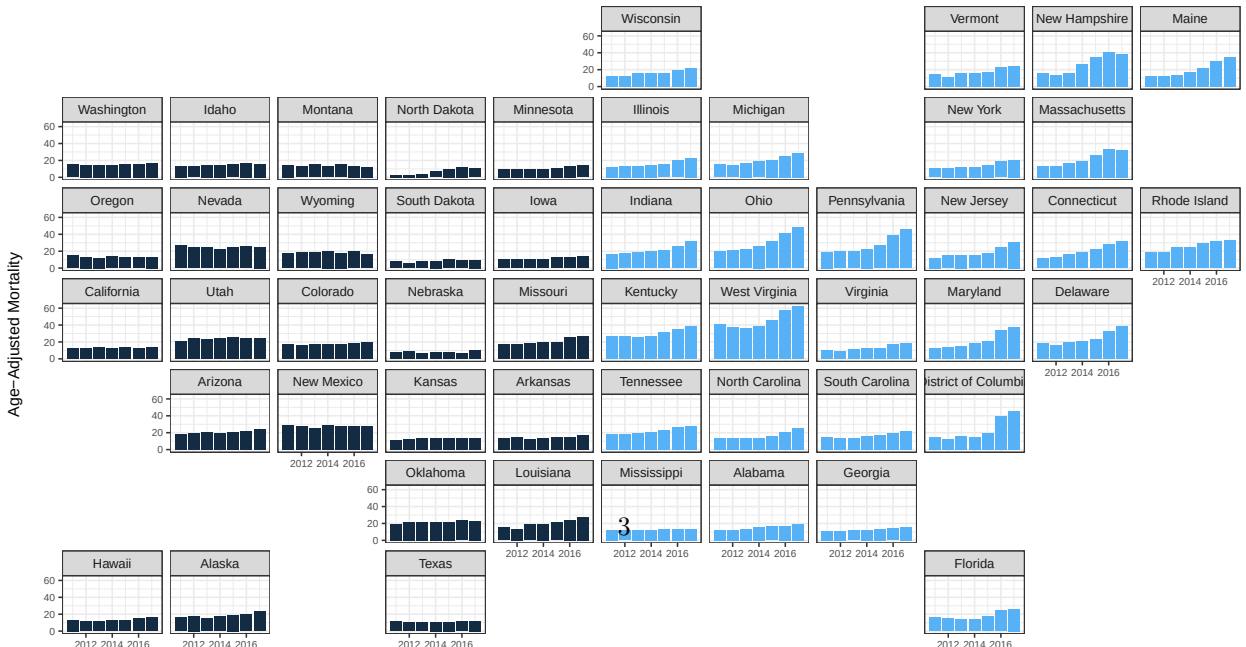
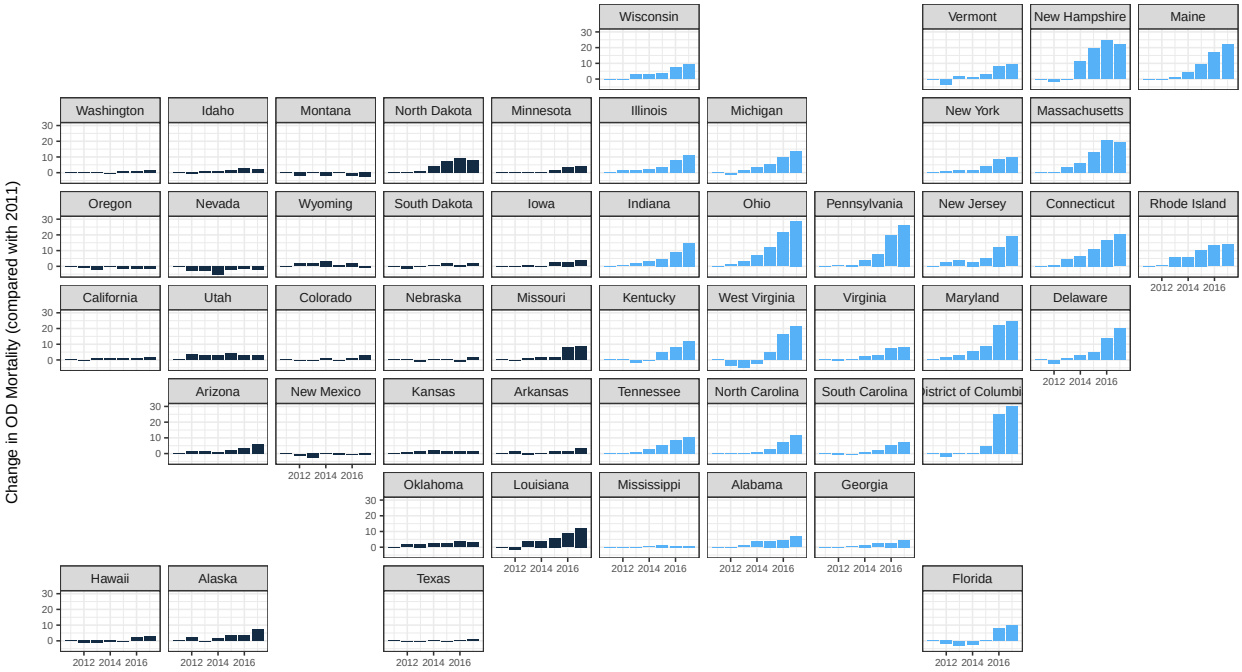
	Model 1 Deaths	Model 2 Deaths
2011	2580	3115
2012	2659	3210
2013	3723	4495
2014	9973	12041
2015	17367	20969
2016	26491	31985
2017	34176	41263

Table 2:

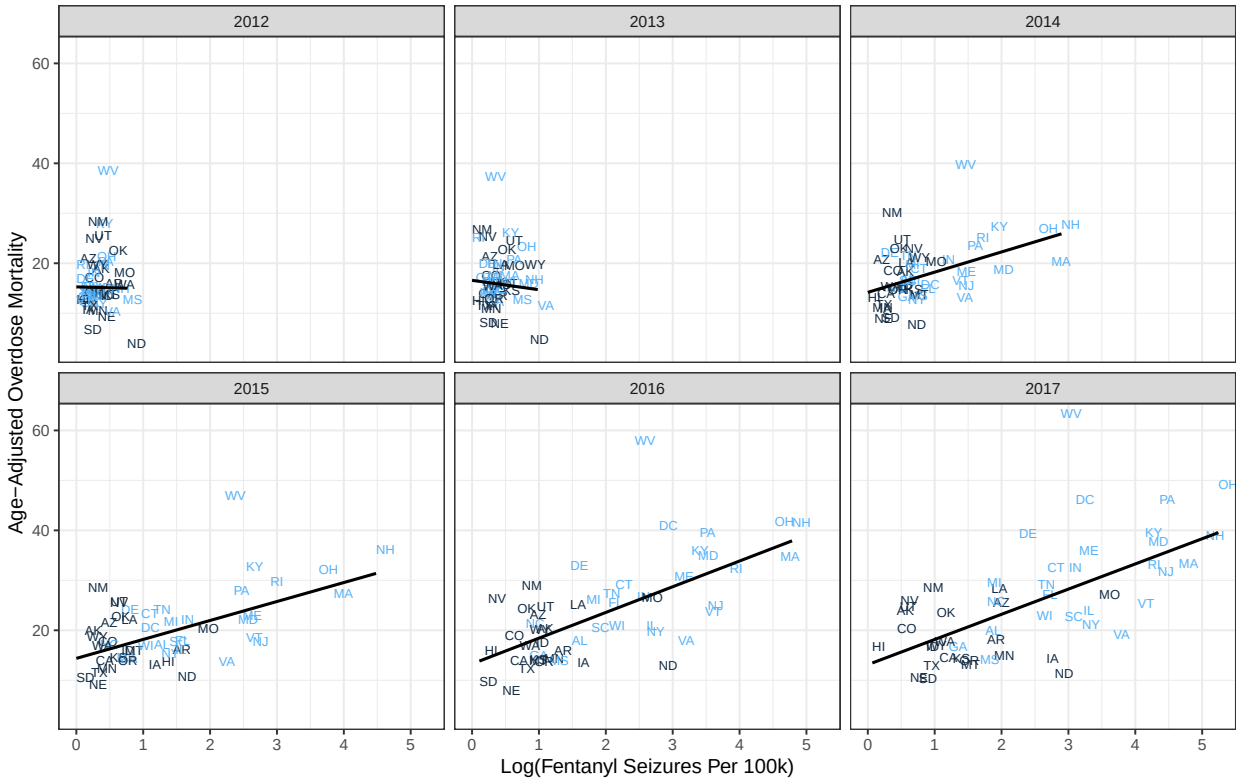
	Dependent variable:				
	fent_r				
	(1)	(2)	(3)	(4)	(5)
longitude	0.002	0.019***	0.030***	0.044***	0.053***
	(0.002)	(0.004)	(0.006)	(0.006)	(0.007)
latitude	0.008	0.025*	0.017	0.049**	0.037*
	(0.005)	(0.013)	(0.020)	(0.020)	(0.021)
MORT_2013	−0.003	0.034**	0.035	0.033	0.028
	(0.006)	(0.014)	(0.022)	(0.022)	(0.023)
Constant	0.241	0.985	2.853**	3.498***	5.338***
	(0.290)	(0.679)	(1.070)	(1.084)	(1.130)
Observations	51	51	51	51	51
R^2	0.076	0.406	0.366	0.536	0.590
Adjusted R^2	0.017	0.368	0.325	0.507	0.564
Residual Std. Error (df = 47)	0.233	0.546	0.861	0.872	0.909
F Statistic (df = 3; 47)	1.286	10.706***	9.029***	18.110***	22.591***
Note:					*p<0.1; **p<0.05; ***p<0.01

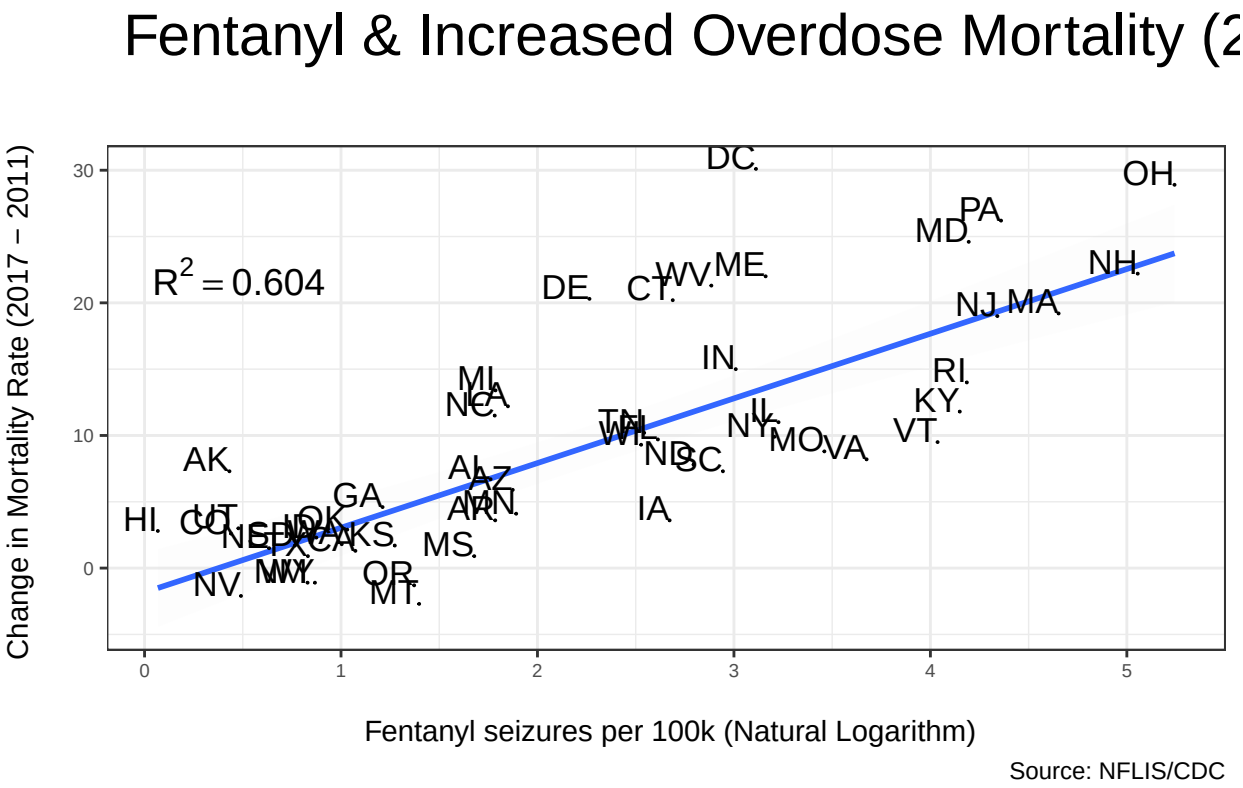


Regionality of Changing Overdose Mortality



Fentanyl, Geography, & Overdose Mortality (2012−2017)





Discussion

All of the figures and tables appear to be nearly the same, with a few exceptions. Firstly, the tables presented in the paper are of a different format than those produced by stargazer; I suspect the author might have just copied the information into a different table format in Excel for example for clarity (the values are all about the same). Secondly, Table 2 in the paper does not include the residual standard errors when presented in the paper, but I think maybe it should be? Finally, and perhaps most importantly, I see some differences between the small table after table one and this one provided in the paper:

B: Total Estimated Deaths Attributable to Fentanyl by Model.		
	Model 1 Deaths	Model 2 Deaths
2011	2,295	2,705
2012	2,365	2,788
2013	3,312	3,904
2014	8,870	10,458
2015	15,446	18,211
2016	23,188	27,339
2017	30,398	35,841

I will have to look into this further to see whether this is perhaps due to chance or the way I organized the code. The differences are not insignificant as some estimates are off by nearly 6,000 deaths.

Extension

For my extension I am looking to find data on fentanyl related seizures and overdoses in 2018 or 2019, hopefully both. I would then run the same model to see if geography, specifically longitude, still does explain much of the variation in the intensity of fentanyl exposure as found in 2017 ($R^2 = 0.55$). The CDC has several pages on the opiod crisis, so I've been looking through their website to try to find data. I found some news sites claiming that drug overdose deaths have dropped for the first time in 30 years, so I'm hoping to find that data available somewhere (Abby Goodnough (2019)).

If I am unable to find the 2018 or 2019 data available anywhere, I would perhaps look into adding more variables to the regressions. The data Zoorob uses is limited, but I could perhaps look into the form of the fentanyl and see if the form of the drug (powder, tablet, etc.) informs the drug overdoses at all or if there are other drugs like Cannabis or Methamphetamine present in the system. I think Zoorob also included data points whose second substance present was fentanyl, so I might remove those since they could have died as a result of the first substance and the first substance might complicate things.

If none of these extension ideas work I might try splitting the states into different regions (Northeast, Southwest, Midwest, etc.) and see if that improves the model at all, but I'm skeptical about this since state is already in the model. I'm going to keep brainstorming and think of other extensions to explore.

References

Abby Goodnough, Margot Sanger-Katz, Josh Katz. 2019. *Drug Overdose Deaths Drop in U.s. For First Time Since 1990.* The New York Times. https://www.nytimes.com/interactive/2019/07/17/upshot/drug-overdose-deaths-fall.html.

Zoorob, Michael. 2019. *Fentanyl Shock: The Changing Geography of Overdose in the United States. International Journal of Drug Policy.* https://www.sciencedirect.com/science/article/abs/pii/S0955395919301136.