Predicting County-Level Synthetic Opioid Overdose Mortality Rates: Comparing Traditional Statistical and Machine Learning Modeling Approaches

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Abstract for ISSDP 400 word count (word limit: 400)

Aim: The U.S. opioid crisis is the result of a series of geographically concentrated, drug-specific overdose outbreaks. This study aimed to evaluate the performance of two models built to predict county-level synthetic opioid overdose mortality rates (SynthOD) in 2017 based on available data from 2010-2016, as tools to predict future outbreaks.

Methods: Data on SynthOD by county (n=3142) were extracted from the CDC Wonder database, and from the American Community Survey, Highway Safety Improvement Program, Esri, and the National Center for Health Statistics, for potential predictors. We fit a linear regression (LR) and random forest (RF) model to data from 2010-2015 (with subsequent year SynthOD as the outcome). These were used to predict SynthOD in 2017 from 2016 data. Predictive performance was evaluated by comparing predicted to actual SynthOD for 2017, calculating R^2, mean absolute error (MAE), root mean squared error (RMSE), and Spearman's ρ metrics. Post-prediction, we categorized counties as "high-rate" if predicted to experience >10 deaths per 100,000 in 2017 and determined how well each model identified these "high-rate" counties by calculating their sensitivity, specificity, and accuracy.

Results: Both models effectively predicted 2017 SynthOD with similar accuracy (LR R^2: 69%, RF R^2: 65%). Both models' predictions differed on average by about 2 deaths/100,000 from actual rates (LR MAE: 2.0, RF MAE: 1.9), though both were subject to outlying predictions (LR RMSE: 4.6, RF RMSE: 4.9). Both models effectively rank-ordered counties based on SynthOD (LR ρ: 0.90, RF ρ: 0.92). The LR model correctly predicted 350 of the 390 of the counties with an SynthOD above 10 per 100,000 (Sensitivity: 90% [95% Confidence Interval (CI): 86-93%], Specificity 92% [95% CI: 91-93%], Accuracy 92% [95% CI: 91-93%]), whereas the RF model correctly predicted 339 of the 390 counties (Sensitivity: 87% [95% CI: 83-90], Specificity: 93% [95% CI: 92-94], Accuracy, 92% [95% CI: 91-93%]). The RF model, though, identified fewer false positive high-rate counties (186) than did the LR model (208).

Conclusion: We show that, by leveraging observed data from 2010-2015, our models were able to accurately predict 2017 county-level SynthOD from 2016 data. We display the efficacy of both traditional epidemiological statistical modeling methods (LR) and machine learning algorithms (RF) for predicting SynthOD. The next steps entail improving model performance to better predict future overdose outbreaks. The availability of predictive tools will be critical to informing much needed preemptive public health responses to reduce related mortality in the United States.

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