THE RACIALIZED ROOTS AND REPERCUSSIONS OF PAIN PRESCRIPTIONS: A COUNTY-LEVEL ANALYSIS OF THE EVOLVING OPIOID EPIDEMIC

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ABSTRACT

Previous research on the burgeoning opioid epidemic finds that prescription opioids provided the foundation for increasing opioid demand. This thesis replicates prior studies documenting changes in the factors associated with opioid overdose using data from 2008-2010 and 2015-2017 to attend to shifting patterns over time. I also attempt to address the interaction of institutional, racial, and class forces in contributing to high prescribing and overdose rates. With a sample of 546 U.S. counties, I conduct regression analyses to examine how social ecology provokes the flood of prescriptions into an area and how these factors are associated with death rates from both prescription and illicit opioids. Consistent with my hypotheses, high levels of economic distress and a high percent of the population identifying as white interact to predict high prescription rates in both time periods. These factors are also predictive of overdose rates, but are mediated by prescription rates in the earlier time period. However, prescription rate loses predictive power in the second time period, which warrants further research into the racialized roots of this public health crisis and the underground market driving overdose rates today.

INTRODUCTION

In the last decade, illicit opioid use has entered the national spotlight as a leading concern of both public health and criminal justice reform. Drug overdoses accounted for 70,237 deaths in 2017, a record high for drug-related fatalities. Overdose is now the leading cause of death for people under 55, surpassing mortality rates from car accidents, guns, and even HIV at the peak of the epidemic (Hedegaard, Miniño, and Warner 2018; Katz and Sanger-Katz 2018). Today, opioids account for the majority of drug overdose deaths (HHS 2017). As opioid-related fatalities continue to riddle the U.S. in drastic proportions, this particular epidemic has been branded an unprecedented public health crisis. The renewed attention to medical, rather than punitive action coincides with a notable difference between the opioid epidemic and previous drug scares: white men are the ones dying at alarming rates (Zur and Tolbert 2018).

Situating the current epidemic within a social epidemiological framework helps reveal the historical and structural context surrounding patterns of opioid use. The introduction of OxyContin to the U.S. market in 1996 parallels patterns in opioid overdose that occur across geographic, socioeconomic, and racial lines, which scholars attribute, in part, to the privilege of access to prescription medication (Hoffman et al. 2016; Chapman, Katz, and Carnes 2013). Supply-side interventions to interrupt the misuse of pharmaceutical drugs include prescription drug monitoring programs and a more abuse-resistant version of OxyContin, but demand has continued to rise and

markets appear to be shifting from healthcare providers to drug dealers (Cicero and Ellis 2015; Cicero et al. 2017). Furthermore, temporal analysis charts the evolution of demographic and regional patterns associated with the supply of prescription opioids and the recent reemergence of heroin and synthetic opioids in contributing to overdose deaths (Jalal 2018). The role of prescriptions in this epidemic requires further attention to project future patterns and elucidate the changing impact of social and economic factors on drug use and death.

This study traces county-level patterns in opioid prescription rates and demographic patterns in drug overdose mortality in the U.S. over the last decade. Using regression models, I examine the interaction between racial composition and economic distress on predicted prescription rates and overdose rates at the county-level. My analysis focuses on two distinct time periods to allow for a more comprehensive examination of the origins and changing face of this deadly epidemic in the context of a shifting supply market for opioids.

LITERATURE REVIEW

Prescription Opioids as a Risk Factor for Overdose

Although opioid overdoses have risen exponentially in recent years, the individual impacts of specific drugs, such as heroin, and prescription and synthetic opioids have fluctuated (Jalal 2018). Extant literature has documented a link between prescription opioids and the misuse of opioids, increasing the potential for drug poisonings (Hall 2008; Hirsch et al. 2014; Paulozzi et al. 2014; Paulozzi, Budnitz, and Xi 2006; Paulozzi and Ryan 2006). Beginning in the 1990s, a frenzy to quantify pain and reassess management techniques provoked aggressive overprescribing when Purdue Pharma introduced OxyContin in 1996. Marketed as a non-addictive pain reliever, OxyContin flooded provider markets as a magic bullet pill promising to alleviate Americans of unnecessary chronic pain (Paulozzi et al. 2006; Paulozzi and Ryan 2006; Wininger 2004). However, these increases in opioid analgesic prescriptions were accompanied by growing drug overdose fatalities (Hall 2008; Paulozzi et al. 2006). Paulozzi and Ryan (2006) found a positive relationship between variation in prescription opioid sales and drug overdose mortality at the state level, while Hall (2008) echoed these results in a population-based study focused on West Virginia, the state with the largest increase in unintentional pharmaceutical overdoses from 1999-2004. In Hall's study, opioid analgesics were implicated in 93.2% of overdose deaths.

The surge in prescriptions for opioid analgesics has facilitated access to opioids for non-medical use (Keyes 2014; Paulozzi et al. 2006; Paulozzi and Ryan 2006). Hirsch et al. (2014) reported that 61% of North Carolinian oxycodone overdose victims had filled oxycodone prescriptions within the last 60 days and 76% of those with available toxicology reports had died from prescription drugs alone. Jones (2012) found that past year nonmedical use of prescriptions lasting over 200 days increased by 74.6% between 2002-2003 and 2009-2010, paralleling dramatic increases in overdose rates. As prescription opioid rates climbed in the early 2000s, so too did overdose rates. Yet, even

though prescribing has decreased on average since 2010, drug overdose rates have continued to rise dramatically (CDC 2017; Jalal 2018).

In 2010 Perdue Pharma's reformulation of OxyContin to deter misuse amidst legal abuse allegations and state crackdowns on opioid overprescribing contributed to a shift in the most common drugs involved in overdose fatalities (CDC 2017; Cicero and Ellis 2015; Wininger 2004). Although prescription opioids overtook cocaine as the primary drug responsible for overdose deaths in 2006, heroin and synthetic opioids such as fentanyl have since surpassed opioid analgesics as the leading catalysts for overdose death, though pharmaceutical analgesic causes remain prominent (Jalal 2018). While fentanyl is commonly prescribed, illicitly manufactured fentanyl has seeped into the opioid market and is largely responsible for the rapid accumulation of drug-related deaths (Jalal 2018). The aforementioned barriers to obtaining prescription OxyContin interrupted the stream of prescription opioids relied on by many users and left a supply-side gap to be filled by heroin and fentanyl. Cicero (2017) documented heroin as an initiator of opioid abuse at 8.7% in 2005 which rose to 33.3% in 2015. In the same period, hydrocodone and oxycodone dropped nearly 20% as initiators of abuse, suggesting that heroin has replaced the supply of opioid analgesics for first time users. It appears the impact of prescription opioids has dwindled in light of cheaper, illicit substitutes (Cicero et al. 2017; Jalal 2018). To my knowledge, minimal scholarship has suggested statistically significant associations between the decline of prescription opioids, the emerging illicit market, and the shifting demographics suffering from opioid addiction and overdose.

Health Disparities in Prescription Opioids and Drug Overdose

Substance use disorders and drug overdoses are contextually situated and necessitate social epidemiological approaches to understand the culturally and socially constructed causes and repercussions of drug use. Much of the literature documents correlations between prescription pills and drug overdoses, but it is important to note that overdose rates are not uniform across all populations. Consistent with ecosocial theory, the social context of a community and characteristics of the broader society give rise to health disparities (Krieger 2001). Historically, heroin use has been concentrated in urban centers and among young black communities (James and Jordan 2018). Recent data shows changing vulnerable populations as economic and social determinants of health, such as racially disparate drug policies and variances in poverty rates, create new conditions for differential health outcomes and affect population distributions in drug use and mortality (Carpenter et al. 2016; James and Jordan 2018). While variation has been documented socioeconomically, geographically, and racially in overdose rates, lacking from present analysis is a historical foundation to help explain responses grounded in treatment rather than punishment and to project future societal patterns in drug use and public health policy.

Patterns of Economic Distress

It is difficult to separate the effect of economic distress on rates of prescription opioid abuse from other factors. Stress derived from the interaction of economic

deprivation and disability produces a market for pain prescriptions (Keyes 2014; Carpenter, McLellan, and Rees 2016). Drug use, abuse, and access to treatment are situated within the broader societal context that puts people differentially at risk for overdose depending on job status and occupation, which in turn impact access to health insurance and susceptibility to chronic pain (Carpenter et al. 2016). Overdose rates linked to economic conditions suggest that structural discrimination and inequality perpetuate drug use (Keyes 2014). Although Medicaid facilitates access to treatment, Zur and Tolbert (2018) found that 38% of non-elderly opioid addicts are on Medicaid, which simultaneously positions them for access to treatment options and increases the potential for additional income from sharing opioid analgesics with friends and neighbors. People who illegally resell prescription opioids stand to gain social and financial capital, especially in rural communities (Keyes 2014; Leukefeld et al. 2007).

Particular subpopulations are more at risk for substance use disorders than others. According to recent studies, economic distress coupled with the use of illicit pain medication has disproportionately affected working-class white men (Carpenter et al. 2016). Hollingsworth, Ruhm, and Simon (2017) found that a one percentage point increase in county unemployment rate coincides with 3.6% and 7% percent rises in the opioid death rate and in emergency department visits for opioid overdose, respectively. Similarly, in 2016, 28% of opioid-addicted non-elderly adults lived below the poverty line, while over half had low incomes (Zur and Tolbert 2018). While evidence suggests that economic distress, measured by levels of unemployment and poverty, appears to be associated with drug use, attention to the interaction of economic conditions, race, and overdose rates has yet to be fully explored. As prescriptions decline and cheaper and more potent alternatives like heroin and synthetic opioids enter the illicit market, opioid abuse may shift across socioeconomic demographics. Furthermore, as these alternatives appear in urban and suburban centers, it is possible that economic distress will play a more marginal role in influencing drug use and access to treatment.

Health Disparities in Opioid Access by Race

The burden of opioid overdoses has largely fallen on white communities with 74% of opioid addicted nonelderly adults identifying as white in 2016 (Zur and Tolbert 2018). Health care disparities perpetuated by a pain treatment gap between whites and ethnic and racial minorities renders whites more vulnerable to opioid addiction and overdose than other populations (Chapman et al. 2013). A significant body of literature has traced the association of implicit racial bias in the medical community with underprescribing of pain medication to racial minorities (Morrison et al. 2000; Hoffman et al. 2016). False beliefs about biological differences in pain perception by race and lack of attention to the pain of racial minorities results in black patients receiving fewer days of opioid analgesia treatment than white patients for comparable pain (Anderson, Green, and Payne 2009; Chapman et al. 2013; Hoffman et al. 2016). Hoffman et al. (2016) reported that the medical students who endorsed false beliefs in biological differences between blacks and whites were more likely to be racially biased in assessing patient pain and 15% less accurate in pain treatment recommendations. The impact of racial stereotyping on access to pain prescriptions remains relevant at the community level as well. Morrison et al. (2000) found that 25% of pharmacies located in predominantly

Hispanic and African American neighborhoods stocked opioid analgesics sufficient to relieve severe pain compared with 72% of pharmacies in white neighborhoods.

Framing the opioid epidemic as solely a white epidemic neglects the impact of opioids on non-white communities where racial bias in pain treatment has been well documented. Several studies point to the privileged access to pain medications that renders largely white populations susceptible to pharmaceutical overdoses, while other sub-demographics are simultaneously underprescribed pain medication (Anderson et al. 2007; Chapman et al. 2013). The media attention and public health declarations aimed at shedding light on those affected by the opioid epidemic have ignored patterns in the deaths of racial minorities who were the principal demographic suffering from heroin addiction in the 60s and 70s (James and Jordan 2018). Recent scholarship suggests that the racial gap in pain prescriptions is diminishing, but that blacks tend to be dying at higher rates from synthetic opioids than whites, while penalization for addiction disproportionately persists along racial lines (Harrison et al. 2018; James and Jordan 2018). The opioid epidemic has garnered significant publicity and scholarly attention for affecting predominantly white populations, but as the role of pain prescriptions diminishes in the face of other illicit opioids, the demographics affected may change as well. Current scholarship lacks attention to racially disparate legal and medical responses to opioid overdoses. Cause for concern is that whiteness as a risk factor for opioid abuse and addiction has garnered significant national attention and public health action, whereas the risk factors associated with deaths occurring in other populations have historically been met with criminalization and reinforced existing racial hierarchies.

Intersections of Racial Composition and Economic Distress

In many instances, racial composition and adverse economic conditions intersect based on geography, likely driving patterns in prescribing and mortality. A number of studies have documented geographic variation in prescription drug use and mortality rates for drug poisoning, demonstrating the drastic impact of opioid analgesics on death rates in rural communities (Dwyer-Lindgren et al. 2018; Jalal 2018; Rossen, Kahn, and Warner 2013; Vivolo-Kantor et al. 2018). Rossen et al. (2013) found that between 1999-2009, age-adjusted drug-induced death rates increased by 279% in large central metropolitan areas, while rural counties experienced a 394% increase. Additionally, the Southeast and Appalachian regions consistently exceeded national averages for overdose death rates from 1999 to 2016 (Jalal 2018; CDC 2018). Jalal (2018) described geospatial patterns in overdose deaths by drug type and revealed that deaths from prescription drugs are becoming more widespread, whereas the contribution of fentanyl and heroin to overdose deaths remains heavily concentrated in the Northeast.

Hotspots for drug abuse have varied over the years, but geospatial patterns are consistent with the historical availability of specific drugs by region. Paulozzi et al. (2011) argue that demographic variation between states is insufficient to explain emergency room visits and mortality trends and that patterns in opioid analgesic sales account for these rural-urban discrepancies instead. Furthermore, county-level drug-related mortality rates from the National Vital Statistics System point to differing prescription rates along rural-urban distinctions (CDC 2018; Jones, Mack, and Paulozzi 2013; Dwyer-Lindgren et al. 2018). Several studies extend this analysis to explain the

increase in prescription opioid deaths in rural areas by identifying Purdue Pharma's overpromotion of OxyContin in rural areas. In Appalachia, prescription narcotics have long been used to maintain a heavy labor occupation workforce and are ingrained in local culture (Leukefeld et al. 2007; Wininger 2004). Here, the geographic intersections of race and class are visible. Entrenched histories of painkiller use and social networks have been shown to influence varying dominance of opioids across population geographics (Leukefeld et al. 2007). Job-related stress and financial insecurity differ by occupation and industry, which may account for some of the variation in access to pharmaceutical analgesics and subsequently to overdose rates. These regional economies reinforce the potential for an intersection between race and class based on geography.

Furthermore, much of the literature rests too comfortably on the assumption of a linear and additive effect of race and economic hardship on increasing overdose rates. The assumption that racial composition and economic conditions independently affect overdose rates neglects the possibility that economic distress impacts prescription rates at different racial compositions. While it makes sense that prescriptions have flooded predominantly white, economically distressed areas—because of racialized access to prescriptions, vulnerability of economically distressed communities to pharmaceutical marketing, and culturally acceptable prescription overuse—a more variable effect based on racial composition might be taking place, warranting an examination into the interaction between race and economic conditions (Keyes 2014; Leukefeld et al. 2007; Morrison et al. 2000).

Informed by the abundant body of literature tracing demographic and spatial patterns in opioid prescription rates and opioid overdose mortality rates, this study takes previous analyses a step further by examining county-level data to assess the interaction of racial composition and a composite economic distress indicator in effecting prescription rates. Subsequently, I examine the effect of these sociodemographic variables and prescription rate on overdose rate during the periods of 2008-2010 and 2015-2017. My main factors of analysis include racial composition in terms of percent white non-Hispanic, economic distress, and prescription rates, while controlling for population density. Based on previous research indicating that the majority of opioid overdoses are transitioning away from primarily white, rural communities with high economic distress, I formulated the following testable hypotheses:

1. Explaining Prescription Rate
    a. Evidence suggests that predominantly white communities have increased access to prescriptions and opioid prescriptions have been heavily marketed and culturally supported in economically distressed areas. Therefore, percent of the population identifying as white and economic distress are positive predictors of prescription rate.
    b. Rather than being independent of one another to produce additive effects on prescription rates, racial composition and economic distress interact to affect prescription availability. The impact of racial composition on prescription rate depends on economic distress, and vice versa.
2. Explaining Overdose Rate
    a. High levels of unemployment and poverty are associated with increased emergency department visits for opioid overdose and increased death rate.

Additionally, nearly three quarters of opioid users identify as white and white communities are generally experiencing more overdoses than nonwhite communities. Thus, racial composition and economic distress are predictive of opioid overdose rates.

b. By transitive property, if racial composition and economic distress are positive predictors of prescription rate and evidence suggests an association between opioid analgesic sales and prescription-related overdose mortality, then opioid prescription rates mediate, at least in part, the effect of racial composition and economic distress on overdose rates.

3. Explaining Temporal Change: The reformulation of OxyContin and crackdown on prescriptions coupled with a growing underground market for opioids renders the prescription basis of the epidemic less predictive of the variance in overdose rates today. Likewise, the emergence of heroin and fentanyl afflicts a broader spectrum of counties than predominantly poor, white communities. Therefore, percent white, economic distress, and prescription rates are more predictive of overdose rates in the earlier stages of the epidemic, but have less of a bearing on overdose rates in the present moment.

METHODS AND DATA

I examined two time periods using statistical analysis to attend to the changing geospatial, pharmaceutical, and demographic dynamics of the opioid epidemic. I identified Time 1 as occurring just prior to Purdue Pharma's reformulation of OxyContin in 2010 and the illicit market surge in heroin and fentanyl, and Time 2 using the most recent available data up to 2017. Three data sources comprise my dataset. I obtained data on prescription opioids from the Centers for Disease Prevention and Control National Center for Injury Prevention and Control, which accounts for 90% of retail prescriptions and covers 87.6% to 94.0% of counties from 2006 to 2017. To create a more robust sample, I aggregated prescription rates for 2007-2009 and 2014-2016. Prescription rates are based on both initial prescriptions and refills per 100 people in a given year, and are therefore understood to be representative of the flood of drugs into a county.

Death information was compiled from the Center for Disease Control Multiple Cause of Death 1999-2017 files provided by the National Center for Health Statistics. I identified underlying intent of drug poisoning (overdose) deaths through the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revisio*n ICD-10 Codes: unintentional drug poisoning (X40-X44), suicide by self-poisoning (X60-X64), homicide (X85), and drug poisoning of undetermined intent (Y10-Y14), further specified by opioid-related contributory causes (T40.0-T40.4, T40.6). I aggregated overdose rates for the years 2008-2010 for Time 1 and 2015-2017 for Time 2, using a one-year lag time from prescription data to remain consistent with my causal narrative permitting the possibility for an association between prescription opioids and subsequent opioid overdose. Counties in which fewer than 20 deaths were recorded over the three-year period are considered unreliable by the NCHS and excluded from analysis, leaving 546 out of roughly 3,000 counties with available overdose data.

Both opioid prescription rates and death rates were linked to county-level demographic information from the U.S. Census Bureau American Community Survey (5-year estimates) for the 2006-2010 and 2013-2017 cycles. Consistent with prior research, I included covariates for various demographic characteristics shown to be associated with opioid use and the pharmaceutical availability of opioids. Among these was percent of the population identifying as white non-Hispanic and population density (per square mile) as a measure of the relative urbanization of a county. As described earlier, economically distressed populations are also associated with disproportionate risk for opioid use and overdose, so I used Cronbach's Alpha to develop a composite measure approximating economic distress using variables with a high inter-item correlation (Time 1 $\alpha = .82$; Time 2 $\alpha = .84$) and no minimum as every case included all component variables. As directed by the literature, I indexed unemployment rate (measured as percent of unemployed civilian population in labor force aged 16 or older), median household income (adjusted for 2010 inflation in Time 1 and adjusted for 2017 inflation in Time 2), impoverished population (ratio of income to poverty level under 1.00), population with low education (percent of the population 25 years and over with less than a high school education), and rate of unstable housing (measured as the percent of vacant housing units) for the composite economic distress variable.

To provide an initial understanding of the relationship between variables, I conducted correlation analyses. Then, I developed ordinary-least-squares (OLS) regressions using Stata statistical analysis software. To address Hypotheses 1a and 1b, I used multivariate models to assess the association of the aforementioned demographic variables with the availability of opioid prescriptions by county, as well as models concerning the interaction of economic distress and racial composition in predicting prescription rates. Based on previous scholarship and initial modeling suggesting that prescription rates influence overdose rates, I examined overdose rate as the dependent variable in further models to assess Hypotheses 2a and 2b. Finally, I attended to the temporal change as stated in Hypothesis 3 by modeling Hypotheses 1 and 2 for both time periods and assessing the difference in outcomes.

Diagnostic checks revealed heteroscedasticity and several outliers, but no presence of multicollinearity. Although I made note of heteroscedasticity indicating that errors are not uniform in variance, I opted to leave the analyses as is, unadjusted. I used Cook's D and a leverage-residuals-squared plot to identify several counties as outliers, including New York County, which appeared as an outlier in every model. However, the explanatory capacity of the models was largely unchanged by the absence of New York County, so I elected to keep all 546 counties in my analysis. The following models represent counties from every state except Wyoming and North Dakota due to missing data, as well as the District of Columbia.

ANALYSIS

Table 1 shows descriptive statistics for the regression variables. It is worth noting that while the mean and range of demographic variables has remained fairly constant between Time 1 and Time 2, prescription rate and overdose rate have changed in accordance with extant research. The mean opioid prescription rate dispensed per 100

people in a county has decreased from 95.0 to 85.4 and the maximum rate has fallen from 375.1 to 268.3. Crude death rates from opioids, however, have jumped from 10.1 to 17.9 deaths on average per 100,000 people, likely reflecting the proliferation of illicit opioids. Population density serves as a control in all models based on evidence that overdose and prescription rates exhibit geographic patterns.

Table 1: Descriptive Statistics of Regression Variables (N=546)

	Time 1				Time 2			
Variable	Mean	SD	Min	Max	Mean	SD	Min	Max
Prescription Rate	95.0	45.0	25.8	375.1	85.4	35.1	24.1	268.3
Overdose Rate	10.1	7.5	1.2	76.3	17.9	12.7	2.0	100.8
Population Density	1052.6	3946.2	2.4	69537.7	1117.7	4168.8	2.4	72447.3
White non-Hispanic (%)	72.9	18.4	3.6	98.3	70.3	19.0	3.5	97.9
Economic Distress	0.00	0.77	-2.07	2.80	0.00	0.79	-2.05	3.17

Bivariate relationships between variables for each time period are depicted in Tables 2 and 3 with correlation matrices. Prescription rate and overdose rate in Time 1 exhibit the strongest correlation of any variables at 0.62, which decreases to 0.31 by Time 2. Economic distress shifts from a moderately strong correlation with overdose rate in Time 1 ($r = 0.44$) to a weak correlation in Time 2 ($r = 0.2523$). Percent white non-Hispanic and economic distress both show moderately strong positive correlations with prescription rate during both time periods. Furthermore, Figures 1 and 2 provide a visual representation of the change in overdose rates and prescription rates between the two time periods. The line shows a linear prediction of rates should they have remained the same between the periods. In Figure 1, we see that most counties have decreased prescription rates from Time 1 to Time 2 with clustering just under 100 prescriptions dispensed per 100 people. From 2007-2009, a greater number of counties are outliers at the high end of the prescribing scale from about 200-300 prescriptions per 100 people. Figure 2 shows the opposite pattern for overdose, in which death rates appear to have increased for the majority of counties from Time 1 to Time 2. Only six counties experienced overdose rates over 40 deaths per 100,000 people from 2008-2010, but by 2015-2017, 33 had counties surpassed this rate.

Table 2. Correlation Matrix of Variables for Time 1

Variable	Overdose Rate	Prescription Rate	Population Density	White non-Hispanic	Economic Distress
Overdose Rate	1.000				
Prescription Rate	0.6231	1.000			
Population Density	-0.1110	-0.1948	1.000		
White non-Hispanic (%)	0.3360	0.4199	-.2902	1.000	
Economic Distress	0.4385	0.4515	0.0254	-0.1662	1.0000

Table 3. Correlation Matrix of Variables for Time 2

Variable	Overdose Rate	Prescription Rate	Population Density	White non-Hispanic	Economic Distress
Overdose Rate	1.000				
Prescription Rate	0.3142	1.000			
Population Density	-0.0453	-0.2292	1.000		
White non-Hispanic (%)	0.3620	0.4387	-0.2825	1.000	
Economic Distress	0.2523	0.4853	0.0061	-0.1502	1.0000

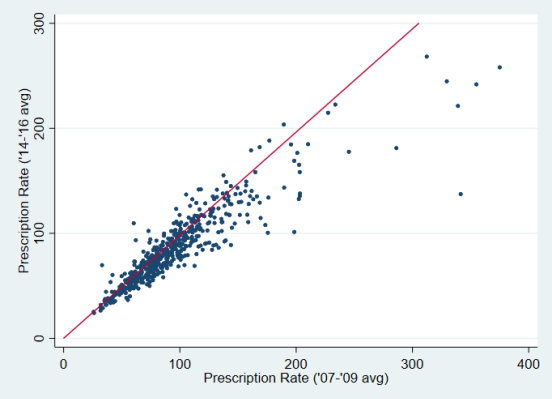

Figure 1. Time 1 Prescription Rate Versus Time 2 Prescription Rate

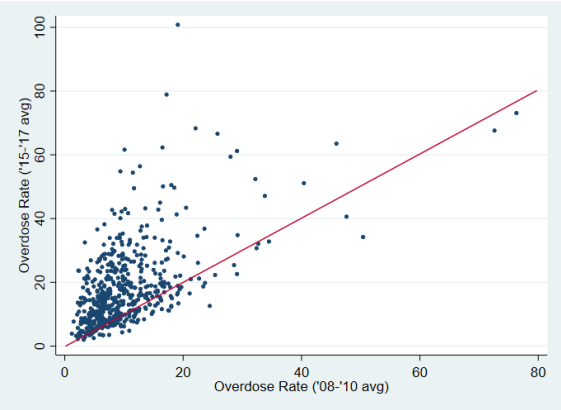

Figure 2. Time 1 Overdose Rate Versus Time 2 Overdose Rate

I developed 8 models of OLS regression to assess my hypotheses and explain opioid prescription and overdose rates based on initial correlations between variables. Models 1-4, presented in Table 4, address Hypothesis 1 by examining the interaction between racial composition and economic distress when predicting opioid prescription rate. Models 5-8, presented in Table 5, show regression results explaining predictors of overdose rate and comparing the predictive capacity of my variables between Time 1 and Time 2, as outlined in Hypotheses 2 and 3.

Table 4 reports regression results comparing prescription rate between the two prescribing periods, 2007-2009 (Models 1 and 2) and 2014-2016 (Models 3 and 4). Models 1 and 3 predict prescription rate based on population density, percent white, and the composite economic distress indicator. In Model 1, we can see that all variables are statistically significant, which assumes that as the concentration of whites increases so too does prescription rate, regardless of economic distress (and vice versa). This pattern holds in Time 2 (see Model 3) with percent white non-Hispanic and economic distress accounting for 31% and 39% (eta-squared values) of the variance in prescription rates, respectively. However, with the introduction of the interaction of percent white and economic distress in Models 2 and 4, the partial contributions of these variables appear to share some of the effect on prescription rate. For both Time 1 and Time 2, the interaction between percent white and economic distress is significant (Time 1 *b*=.6084, p=.000; Time 2 *b*=.295, p=.000). These findings support Hypotheses 1a and 1b. To better understand such results, see Figure 3 and Figure 4, which depict Models 2 and 4, respectively. Consistent with Hypothesis 1b, both graphs show that at high levels of economic distress, increasing concentration of whites corresponds with predicted increases in opioid prescribing rates. Low levels of economic distress, however, reduce the model's ability to predict differences in prescribing rates by racial composition. We can see a clear interaction between economics and race, in which economically distressed, majority white counties result in higher predicted prescription rates than comparably distressed majority minority communities. Although the mean prescribing rate amongst U.S. counties has decreased since 2007-2009, a similar phenomenon between sociodemographic factors persists to explain prescribing rates today.

Table 4: OLS Regression Results Modeling Predictors of Opioid Prescription Rate

	Time 1		**Time 2**	
Variable	Model 1	Model 2	Model 3	Model 4
Population Density	-.001*	-.001	-.001**	-.001**
	(.000)	(.000)	(.000)	(.000)
White non-Hispanic (%)	1.194***	1.002***	.917***	.817***
	(.082)	(.083)	(.058)	(.061)
Economic Distress	31.363***	-13.069	25.042***	4.066
	(1.879)	(6.737)	(1.358)	(4.560)
Interaction of % White by Economic Distress		.6084***		.295***
		(.089)		(.061)
Constant	8.825	24.143	21.897	29.555
R^2	0.4597	0.5028	0.5112	0.5312

NOTE: N = 546; *b*=unstandardized regression coefficient with standard error in parentheses
*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

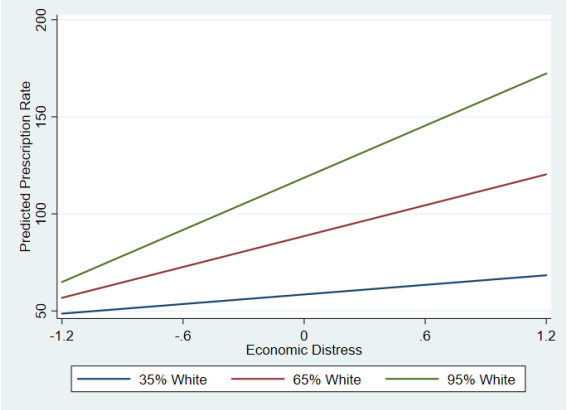

Figure 3. Predicted Prescription Rate at Different Racial Compositions and Levels of Economic Distress Using Time 1 Model 2

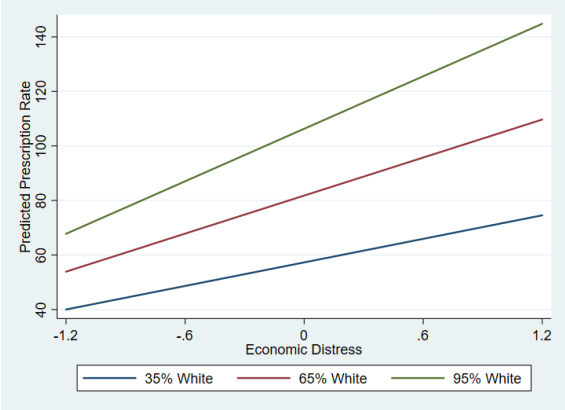

Figure 4. Predicted Prescription Rate at Different Racial Compositions and Levels of Economic Distress Using Time 2 Model 4

Table 5 presents models explaining rates of opioid overdose to attend to Hypothesis 2a and 2b. Again, population density serves as a control and percent white non-Hispanic and economic distress are the primary independent variables in Model 5 and 7. In Model 5, we see racial composition and economic distress both have significant positive effects on overdose rate with percent white responsible for 20% of the variance in overdose rates and economic distress responsible for 28% of the variance (eta-squared values). In Time 2, the unique contributions of these variables is reduced to 18% and 11%, respectively.

Initial correlations prompt the introduction of prescription rate as an additional independent variable of interest in Models 6 and 8. Incorporating prescription rate in Model 6 reduces the predictive capacity of economic distress and percent white to less than a third of their relative effect size in Model 5 (b=2.860, p=.000; b=.090, p=.000), indicating that prescription rate mediates some of the effect of economic distress and racial composition on overdose rate as anticipated in Hypothesis 2b. Confirming this, a mediation analysis not shown (using SEM command) finds that 42% of the total effect of economic distress and 47% of the percent white effect on overdose rates are mediated by prescription rates. During Time 1, the explanatory power of prescription rate accounts for nearly 14% (eta-squared value) of the variance in overdose rate (b=.067, p=.000). For each increase of 50 prescriptions per 100 people, we see a predicted increase of 3.3 opioid deaths per 100,000 people, holding other variables at their means (Figure 5). What is more, the full model explains 45 percent of the variance in predicted overdose rates (R^2=0.4513).

Although economic distress and percent white remain positive predictors of overdose rates in Time 2 (Model 7), their unique predictive effects have decreased. Both Models 5 and 7 are consistent with Hypothesis 2a, which expects greater economic distress and higher concentrations of whites to correspond with increased overdose rates. While no significant effects are seen with the incorporation of prescription rate in Model

8, the proportion of variance in overdose rates accounted for by economic distress (*b*=5.316, p=.000) and percent white (*b*=.295, p=.000) remains significant and positive. The absence of a prescription rate effect in Time 2 indicates that the pharmaceutical opioid foundation explaining overdose rates in the earlier stages of the epidemic no longer adequately predicts overdose rates today.

Additionally, the explanatory capacity of percent white on overdose rate is of note in Model 8 as the predicted effect size changes from 5% to 14% (eta-squared values) between the two time periods. One explanation is that the predominantly white counties who were outliers in Time 1 (McDowell county, WV and Wyoming county, WV) hindered the ability of the model to predict overdose rates based on racial composition. Overall, fewer extreme outliers and higher residuals in Time 2 indicate that Model 8 is a better fit in terms of predicted versus observed rates of overdose based on racial composition. Although this finding runs counter to my hypothesis that racial composition loses explanatory power in Time 2, the overall model is not nearly as strong. Adjusting for county-level variables and including prescription rate in Time 2 (Model 8) explains only 23% (R^2= 0.2326) of the variance in overdose rates compared with 45% in Time 1 (R^2= 0.4513). Such a substantial reduction in the predictive capacity of the full model indicates that factors may be at play to predict overdose rates that are unaccounted for by the included variables. This change over the two time periods supports Hypothesis 3 in that prescription rate no longer carries the same explanatory power for overdose rates and adds to the growing body of evidence that death by opioids from 2015-2017 are less confined to predominantly poor, white communities than in 2008-2010.

Table 5: OLS Regression Results Modeling Predictors of Opioid Overdose Rate

	Time 1		**Time 2**	
	Model 5	Model 6	Model 7	Model 8
Population Density	-.000	.000	.000	.000
	(.000)	(.000)	(.000)	(.000)
White non-Hispanic (%)	.170***	.090***	.287***	.295***
	(.015)	(.016)	(.026)	(.032)
Economic Distress	4.95***	2.860***	5.108***	5.316***
	(.338)	(.387)	(.615)	(.785)
Prescription Rate		.067***		-.008
		(.007)		(.019)
Constant	-2.326	-2.914	-2.472	-2.290
R^2	0.3642	0.4513	0.2324	0.2326

NOTE: N = 546; *unstandardized regression coefficient / standard error in parentheses*
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

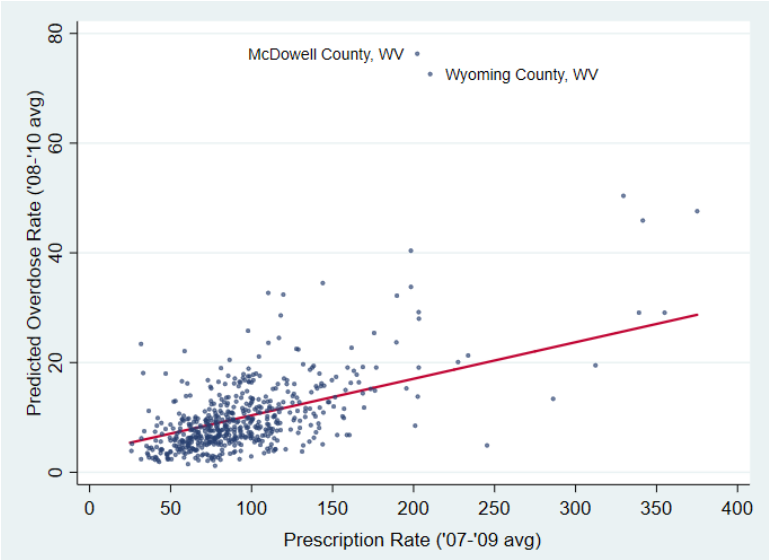

Figure 5. Predicted Versus Real Overdose Rate for Prescription Rate, Holding Other Variables at Means Using Model 6

DISCUSSION AND CONCLUSION

Several pertinent and intriguing conclusions arise from the preceding analysis. Economic distress and racial composition predict prescription rates in both time periods and interact even as average prescription rate has decreased in the last decade. Percent of the population identifying as white and economic distress also predict overdose rates in both time periods, with increases in percent white predicting higher death rates in Time 2 than Time 1. Consistent with previous assertions, the data show that over the last decade, although prescription rates have decreased, the rate of death from opioids has dramatically increased (CDC 2017; Jalal 2018). Furthermore, where prescription rate positively predicts overdose rate in Time 1, it loses significance in Time 2, while coinciding with a reduction in the overall fit of the full model (Model 8). These findings tell a story of the roots and repercussions of the U.S. opioid epidemic.

Together, economic distress and racial composition describe the social ecology of a community, which in turn reflects access to healthcare and resources, including social and economic institutions. As predicted, the presence of adverse economic conditions coupled with a lack of racial minorities is associated with higher prescription rates in both time periods, though slightly less so in the latter time period. Instead of an arbitrary influx of prescription opioids into communities, economic factors and whiteness drive access to pain relievers. The unpoliced practices of both doctors and the pharmaceutical industry are central to understanding the origins of the opioid epidemic, which rendered majority white, economically distressed communities susceptible to Perdue marketing and to a culture of pain killer acceptability (Leukefeld et al. 2007; Paulozzi et al. 2011). These results suggest that the same unchecked practices have perpetuated racial

inequities in access to healthcare (either through understocked pharmacies or underprescribing by doctors) in economically distressed, majority nonwhite communities. The interaction between economic distress and racial composition in predicting prescription rates mirrors previous research that points to discrepancies in the stocking of opioid analgesics between white and nonwhite neighborhoods and individual-level racially disparate prescribing of opioid medications (Anderson, Green, and Payne 2009; Chapman et al. 2013; Hoffman et al. 2016; Morrison et al. 2000).

Economic distress and percent white non-Hispanic are also significant in predicting overdose rates in both time periods. The effect of percent white on overdose rates increases from Time 1 to Time 2, while the predictive capacity of economic distress remains about the same (comparing Table 5: Model 5 and Model 7). One possible explanation for the observed increase in effect of percent white is that only a few counties have high overdose rates in the early stages of the epidemic, whereas by Time 2, many predominantly white counties exhibit high death rates, allowing racial composition to hold more explanatory power. Simultaneously, the counties with the highest overdose rates in the earlier time period (McDowell and Wyoming, in particular) do not appear as outliers in Time 2, while three predominantly nonwhite counties (Rio Arriba, Baltimore City, and St. Lewis) have since developed high overdose rates. These exceptional cases warrant further qualitative examination into the mechanisms operating to reduce death rates in regions like Appalachia, while leading to hotspots of increased death rates elsewhere. Future research might explore the influence of regional phenomena and public health interventions to unpack cases that defy overdose trends.

Although the link between race and economic distress remains prevalent, the epidemic has escaped the bounds of opioid prescription. Prescription rate is not a significant predictor of death rates from 2015-2017, suggesting that increasing overdose rates today are likely related to the emerging underground market for opioids as opposed to the prescription-based pharmaceutical market. The emphasis on pain management in the late 1990s garnered enthusiasm around prescription opioids and established a demand that has maintained inertia, despite declining prescription rates (Keyes 2014; Paulozzi et al. 2006; Paulozzi and Ryan 2006). It is possible that users are seeking a more accessible market by substituting cheaper alternatives to prescription narcotics. This increased complexity in the market for opioids likely weakens the explanatory power of the overall model as well. Opioid overdose rates are more varied based on race and class today than they were in the past, which helps to explain the diminishing ability to account for their variance between the two time periods. With prescription rate no longer significant, these models are unable to identify potential mechanisms mediating the effect of sociodemographic predictors. Thus, researchers might further study the increasing effect of whiteness in explaining overdose rates. As the opioid epidemic has matured, escaping its geospatial and prescription-based origins, future research should explore factors to capture the emerging illicit market.

The underground opioid market contains numerous variables, unaccounted for by my models. Additionally, the scope of the data presents a limitation to elucidating patterns in prescription and overdose rates. My sample excluded counties with fewer than 20 deaths over the three-year period, which might have added depth to understanding the socioecological and regional mechanisms at play. Dispersion in data and spatial

autocorrelation may also have impeded the ability of the regressions to best predict prescription and overdose rates.

In the meantime, policy makers, public health officials, and scholars can use these findings to direct optimal prevention and treatment efforts to stymie the toll of opioids on mortality. Although the illicit market for opioids presents many unknowns, interventions will have limited impact if they do not address the historical context of a racialized pharmaceutical landscape, an inequitable healthcare system, and a drug war prioritizing punitive action rather than public health measures (James and Jordan 2018). Labeling the epidemic "unprecedented" absolves the racist institutions involved as it becomes clear that interrogating the profit-oriented pharmaceutical industry is a key piece to grappling with the opioid epidemic and to creating a just and effective public health response.

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