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MACROECONOMIC CONDITIONS AND OPIOID ABUSE

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ABSTRACT

Past research indicates that physical health measures (such as all-cause mortality) improve when economic conditions temporarily deteriorate, but the relationship between economic conditions and behavioral health remain unclear. The pro-cyclicality of mortality has declined in recent years while drug poisoning deaths have trended sharply upwards, suggesting a connection to the rising use of many types of drugs. We contribute new evidence to the literature by examining how severe, adverse outcomes related to use of opioid analgesics (hereafter abbreviated as opioids) and other drugs vary with short-term fluctuations in macroeconomic conditions. We use data on deaths and emergency department (ED) visits related to opioid and other drug poisonings together with information on state and county unemployment rates. We focus on opioids because they are a major driver of the recent, fatal drug epidemic. We use county-level mortality data for the entire U.S. from 1999-2014, and state and county level ED data covering 2002-2014 from a subset of states. We find that as the county unemployment rate increases by 1 percentage point, the opioid death rate (per 100k) rises by 0.19 (3.6%) and the ED visit rate for opioid overdoses (per 100k) increases by 0.95 (7.0%). We also uncover statistically significant increases in the overall drug death rate that are mostly driven by increases in opioid deaths. These results also hold when performing a state, rather than county, level analysis. In most specifications, the results are primarily driven by adverse events among whites. Additionally, the findings are relatively stable across time periods; they do not pertain only to recession years, but instead represent a more generalizable and previously unexplored connection between economic development and the severe adverse consequences of substance abuse.

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I. Introduction

Voluminous research conducted over the last two decades, covering a variety of countries and time periods, indicates that physical health improves when economic conditions temporarily deteriorate.[1] However, mental health shows apparent declines during periods of economic weakness (Ruhm, 2000; Ruhm, 2003; and Charles & DeCicca, 2008). Moreover, recent evidence suggests that the pro-cyclicality of physical health has declined considerably in recent years (Stevens et al., 2015; McInerney and Mellor, 2012; Lam and Piérard, 2015; Ruhm, 2015) just as drug poisoning deaths, often involving opioid analgesics (henceforth opioids) such as hydrocodone and oxycodone, have trended sharply upwards (Rudd et al., 2016).[2]

Understanding the relationship between local economic conditions and drug related adverse outcomes is important because the United States is "experiencing an epidemic of drug overdose (poisoning) deaths" (Rudd et al., 2016, p. 1378), with fatal drug poisonings increasing by 146% from 1999 to 2014 (author calculations). Poisoning deaths, around 90% of which are now caused by drugs (Warner et al., 2011), were the most important source of growth in the all-cause mortality rates of 45-54 year old non-Hispanic whites occurring between 1999 and 2013 (Case and Deaton, 2015). The involvement of opioids and, more recently, heroin in these deaths has received particular attention (Volkow et al., 2014; Jones et al. 2015; and Rudd et al., 2016), including a White House Summit in August 2014 (Hardesty, 2014). Drug poisoning deaths are higher for males than females, but have been rising rapidly over time for both sexes, as well as for all age

[1] This literature often dates from Ruhm (2000)'s study of the US for the 1972-1991 period. However, there are indications that mortality was procyclical in research from as early as the 1920s (Ogburn & Thomas, 1922).
[2] It is important to note that we classify heroin in a separate category of narcotics. Heroin deaths have risen extremely rapidly since 2010 but were relatively stable before that (Ruhm, 2017). This increase is too recent to be adequately captured in our study's timeframe.

groups of youths (15 and over) and adults, but particularly rapidly for 25-64 year olds (Ruhm, 2017). One notable feature is that non-Hispanic white (hereafter simply "white") and non-Hispanic black (hereafter "black") drug fatality rates closely tracked each other during the 1980s and 1990s, but since 1999 (the period examined here), white mortality rates have grown much faster. Figure 2 illustrates this divergence. From 1999 to 2014 the U.S. white drug death rate per 100,000 grew by 203%, while the black and Hispanic drug death rates increased by 49% and 31%, respectively. However, rising deaths are not the only indication of serious health consequences related to the growing use of opioids. Emergency department (ED) visits involving narcotic pain relievers increased 117% between 2005 and 2011 (Crane, 2015) and opioid related ED poisonings have increased by 46% from 2006 to 2014 (see Figure 3). While this increase has mostly been driven by prime aged adults, all age groups have seen an increase in the risk of opioid poisoning ED visits (Tadros et al., 2016).

This analysis examines how serious adverse health outcomes related to opioid and other drug abuse vary with short-term fluctuations in macroeconomic conditions. Specifically, we study how deaths and ED visits due to opioids and all drug overdoses are related to local unemployment rates. Our main findings are that both deaths and ED visits related to opioid overdoses rise when county unemployment rates temporarily increase. The same is true for all sources of drug poisoning mortality and consistent results are obtained when: performing the analysis at the state-level rather than the county-level; proxying for macroeconomic conditions with employment-to-population ratios rather than unemployment rates; and conducting a variety of other robustness checks. Importantly, our findings are relatively stable regardless of the time period considered, indicating that they represent a general connection between economic conditions and severe adverse consequences of substance abuse and are not restricted to periods of recession. Moreover, our mortality results are predominately driven by changes among whites (rather than blacks or Hispanics).

II. Prior Research and Contribution of this Investigation

The literature examining the connection between economic fluctuations and health is vast; it has considered effects on mortality and morbidity, as well as on health-related behaviors, health insurance and health care use.[3] Mortality has historically been found to be procyclical in studies covering a wide variety of countries and time periods (e.g. Ruhm, 2000; Neumayer, 2004; Tapia Granados, 2005; Gerdtham & Ruhm, 2006; Buchmueller et al., 2007; Lin, 2009; Gonzalez & Quast, 2011; and Ariizumi & Schirle, 2012). Similarly, many (although not all) studies suggest that lifestyle factors such as exercise, obesity, smoking and heavy drinking improve in bad economic times (e.g. see Freeman, 1999; Ruhm & Black, 2002; Ruhm, 2005; Gruber & Frakes, 2006; and Xu, 2013).[4] However, some current research suggests that these patterns weakened or reversed in recent years for both mortality (McInerney & Mellor, 2012; Stevens et al., 2015; Lam & Piérard, 2015; and Ruhm, 2015) and health behaviors (Dávlos et al., 2012; Colman & Dave, 2013; and Tekin et al., 2013).

Particularly relevant to the current analysis is suggestive evidence, provided by Ruhm (2015), that one of the main reasons deaths have moved from being sharply procyclical to acyclical or countercyclical in recent years is because poisoning fatalities have been rapidly increasing and now exhibit a strong countercyclical pattern. However, the precision of these estimates is low and the analysis does not separately examine *drug* (rather than more general poisoning) fatalities or the involvement of specific drugs, such as opioids.[5]

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[3] See Ruhm (2012) for a review of much of this research.
[4] However, there are exceptions (e.g. Dee, 2001; and Johansson et al., 2006)
[5] More recently, Pierce & Schott (2016) provide evidence that accidental poisoning deaths rise when local economic conditions deteriorate.

Although there has been substantial investigation of the relationship between macroeconomic conditions and a variety of health behaviors – including drinking, smoking and exercise, as discussed above – corresponding effects on drug use have received less attention (largely because of data limitations). Arkes (2007) provides evidence that teenage use of both marijuana and harder (illicit) drugs rises in economic downturns. Using data from 2002-2013 and a broader age range, Carpenter et al. (2016) find that such downturns are associated with increases in self-reported use of hallucinogens (particularly ecstasy) but with insignificant effects for most other drugs. However, when examining self-reported substance use disorders, they find results for analgesics (which include opioid and non-opioid forms) as well as for hallucinogens. Whether these estimated effects are large enough to result in higher rates of ED visits or deaths is unclear. Frijters et al. (2013) show that internet searches for terms related to alcohol abuse and treatment increase when economic conditions deteriorate. However, Maclean, Cantor, and Pacula's (2015) analysis of data from 1992-2010 suggests that alcohol and illicit drug admissions to (non-ED) substance abuse programs *decrease* in such periods. The exact mechanisms driving this decrease is unclear, as the utilization of substance abuse programs depends on both underlying health status and changes in the availability of treatment in ways that are hard to disentangle.[6] If temporary economic downturns simultaneously increase the demand for but lower access to treatment, the net result might be a rise in both deaths and ED visits.

Our analysis extends beyond prior research by focusing on drug poisonings, which have grown rapidly in the past fifteen years and are likely to be related to economic conditions in different ways than other types of poisoning. Furthermore, we study the severe outcomes of ED

[6] For example, Cawley et al. (2015) show that increases in state unemployment rates, during the 2004-2010 period, were associated with sharp decreases in health insurance coverage, especially for 50-64 year old men and college educated individuals.

visits and deaths. While examining all types of drug overdoses, we pay particular attention to those involving opioids. We do so because opioids comprise the majority of drug overdose deaths and are quite probably the most sensitive to macroeconomic conditions. For example, opioids were estimated to be involved in 53% of fatal drug overdoses in 2014 and to play a role in 64% of the increase in drug deaths occurring between 1999 and 2014 (Ruhm, 2017). Next most important was heroin, which was estimated to be involved in 30% of 2014 drug fatalities. However, we do not focus on heroin here because rates of deaths and ED visits were relatively low for most of our study period (until 2010) after which they rose extremely rapidly.[7]

We separately examine the connection between economic conditions and drug poisonings and deaths for whites, blacks, and Hispanics. Differences across racial groups may be important given recent evidence by Case and Deaton (2015) that mortality rates increased for 45-54 year old non-Hispanic whites, even while they rapidly decreased for blacks and Hispanics. Although poisonings are an important source of the observed changes in mortality rates, it is not obvious that the effects of macroeconomic conditions on deaths and emergency department visits involving opioids necessarily follow the same pattern. For instance, to the extent that minorities are more affected by economic downturns, we might anticipate stronger patterns for non-whites than whites. On the other hand, drug deaths have increased more slowly for nonwhites than for whites since 1999 (Ruhm 2017), which might predict a weaker relationship.

III. Data and Descriptive Statistics

Mortality data come from the National Vital Statistics System of the Centers for Disease Control and Prevention *Multiple Cause of Death* (MCOD) files for 1999-2014, which provide

[7] These statistics refer to any involvement of these drugs rather than the exclusive involvement of a particular drug. The distinction is important because many drug poisoning deaths involve combinations of drug classes (e.g. 49% in 2014 according to Ruhm, 2017).

information from death certificates (Centers for Disease Control and Prevention, 2016). Mortality data are one of the few sources of health information collected over a long time period and in a relatively comparable manner across areas of the country. The MCOD provide information on: a single underlying cause of death (UCD), up to twenty additional causes and basic demographics. Cause-of-death is categorized using four-digit International Classification of Diseases, Tenth Revision (ICD-10) codes, with details also provided on place of residence, age, race/ethnicity, gender, year, and weekday of death. We obtained a restricted use version of the data with information on state and county of residence for use in this study.

Drug poisoning deaths were defined using ICD-10 UCD codes, where the underlying cause is the "disease or injury that initiated the chain of morbid events that led directly and inevitably to death" (Centers for Disease Control and Prevention, 2014). Drug poisonings are defined to occur when the underlying cause of death is: X40-X44, X60-X64, X85, Y10-Y14, or Y35.2 (World Health Organization, 2014). In cases of drug poisoning, the death certificate lists one or more drugs involved as immediate or contributory causes of death. These are identified as ICD-10 cause of death "T codes," with opioids defined to be involved for T-codes 40.2-40.4 and heroin for T-code 40.1.[8]

Death certificate information tends to understate the involvement of opioids (and other drug categories) because the type or types of drugs involved are left unspecified (ICD-10 code, T50.9) in 20%-25% of fatal overdoses (Ruhm, 2017). To correct for this undercount, we impute opioid or heroin involvement in cases where the death certificate indicated only unspecified drugs. To do so, we estimated probit models on the sample of fatal overdoses where at least one drug was specified. The dichotomous dependent variable was set to one if opioids were mentioned and to

[8] See http://www.icd10data.com/ICD10CM/Codes/S00-T88 for additional details.

zero if they were not. The explanatory variables included dichotomous indicators for: sex, race (white, black, other nonwhite), Hispanic origin, currently married, education (high school dropout, high school graduate, some college, college graduate), age category (≤20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, >80), day of the week of death (seven dummy variables) and a vector of state fixed-effects. The probit models were estimated separately for each year. Next, we used the probit results to calculate year-specific predicted probabilities of opioid-involvement for cases where no drug was specified on the death certificate. We then calculated adjusted mortality rates using reported involvement for deaths where at least one specific drug was mentioned and using the imputed probabilities where no drug was specified.[9] The same procedure was used to adjust estimates of heroin involvement.

There is no comparable comprehensive national source of ED data similar to the Mortality files. ED data are only made available to researchers by specific states; these states decide terms of access independently with the Agency for Healthcare Research and Quality (AHRQ). We have assembled what, to our knowledge, is the most comprehensive currently available data on ED visits related to opioid and other drug use, covering 16 states in total. Our main dataset consists of counts of ED visits occurring in a given county and year, aggregated from microdata available for 5 states over some or all of the 2002-2014 period. We supplement this with a collection of aggregated state-level data for 15 states available for all or a portion of the 2000-2013 period.

Our micro data come from the State Emergency Department Databases (SEDD) for five states, assembled by the AHRQ's Healthcare Cost and Utilization Project (HCUP).[10] These data were derived from uniform medical billings at the ED visit level, but only for visits that did not

[9] Over the full time period (1999-2014), the overall drug mortality rate was 10.75 per 100,000. The opioid-involved death rate *without imputations* was 4.04 per 100,000. The adjustments increased this by around one-third, to 5.35 per 100,000.

[10] Further information on the HCUP online aggregated data access system is available at: http://hcupnet.ahrq.gov.

result in an inpatient stay. By comparing these data to available state-level aggregate data on both inpatient and outpatient ED visits, we determined that our microdata contains one-half to two-thirds of all ED visits for opioid overdoses, depending on the state and year.[11] The ED visit microdata include information on patient characteristics, diagnoses, procedures, and charges. Since the SEDD are not available for every year, and some state files are prohibitively expensive, our micro data cover the following states and years: Arizona (2005-2014), Kentucky (2008-2012), Florida (2005-2014), Maryland (2002-2012), and New Jersey (2004, 2006-2103). To increase the geographical representation of our data, we also obtained state-level aggregated ED visit records from the HCUPnet system (which provides a click-through public-access system for these counts) for 15 states in selected years. Specifically, we obtained state counts of ED visits (including those that did and did not subsequently result in an inpatient admission) for the following states and years: Arizona (2005-2013), Florida (2005-2013), Hawaii (2003-2010, 2013), Iowa (2004-2013), Illinois (2009-2013), Kentucky (2008-2013), Maryland (2005-2013), Minnesota (2001 - 2013), North Carolina (2007 - 2013), Nebraska (2001 - 2013), New Hampshire (2003 - 2009), South Carolina (2005 - 2013, Tennessee (2005 - 2013), Utah (2000 - 2011, 2013), and Vermont (2002 - 2013). The level of data available for each state and year combination is displayed in Table 1.

Unlike the mortality data which codes reason for death by ICD-10 codes, the ED data use ICD-9-CM codes. To ensure that our ED results are comparable to our mortality data, we used a CDC crosswalk that links ICD-10 cause of death and ICD-9-CM diagnosis codes for various categories of drug poisoning (CDC 2013). In the ED data, drug poisonings corresponded to ICD-9 codes 960.00 through 979.99, opioid overdoses to ICD-9 codes 965.00, 965.02, 965.09, E850.1, and E850.2, and heroin overdoses to codes 965.01and E850.0.

[11] Obtaining information on ED visits resulting in an inpatient stay would have required the purchase of the inpatient discharge records from HCUP for each state and year.

Overall, our county-level mortality data cover 3,138 counties over 16 years, with almost every county reporting each year, yielding a maximum of 50,148 observations. However, when we examine deaths among specific racial or ethnic groups, our sample size decreases as some counties have no black or Hispanic residents. Overall, our county-level ED information (obtained from the micro data) includes 1,873 county-year observations from the 5 states in the SEDD sample. From 2005 to 2008, Arizona did not report patient race, so for ED analyses examining race, we omit Arizona from our analysis for these years. In addition, we discovered inconsistency in how states report Hispanic ethnicity across both states and years within a state. Thus we were unable to separately estimate specifications for Hispanics using the ED data.[12] Our state-level ED data contain 140 state-year cells, for the 15 states providing aggregated ED visit data.

We compiled additional data on county characteristics that we use either as key right-hand side control variables or to explore heterogeneity in the estimated effects. We obtained county population data from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER) to turn counts of deaths or ED visits into rates (per 100,000).[13] In addition to the full sample rates, we separately computed mortality and ED rates for non-Hispanic whites and non-Hispanic blacks, as well as death (but no ED) rates for Hispanics. Information on county and state unemployment rates, our main proxy for macroeconomic conditions, came from the Bureau of Labor Statistic's Local Area Unemployment Statistics (www.bls.gov/lau/lauov.htm). County level median incomes were obtained from the U.S. Census Bureau's Small Area Income and Poverty Estimates (www.census.gov/did/www/saipe/). Table 2 contains summary statistics for our county-level data.

[12] We verified this issue through personal communications with AHRQ researchers.
[13] Further information is available at http://www.seer.cancer.gov/data.

Figure 1 illustrates the relationship between the unemployment rate, our primary proxy for macroeconomic conditions, and death rates (per 100,000) from all drugs and from opioids. Over the entire period, 49.7% of drug deaths involved opioids, 17.1% involved heroin, and 38.7% involved only drugs other than heroin or opioids.[14] All three rates have risen over time.[15] At this national level of aggregation, Figure 1 shows no obvious relationship between the economic climate and drug poisoning death rates. Although the average unemployment rate was rising during this time period, drug related mortality increased even when the national unemployment rate decreased between recessions and especially during the steep decline in unemployment after 2011. Figure 2 separates the opioid mortality rates (the largest component of all drug deaths) by race, and demonstrates that white opioid death rates have risen considerably (closely tracking the all-drug death rate) while the rates for blacks, and especially for Hispanics are relatively low and flatten over this time period.

Figure 3 shows trends in the nationwide rate (per 100,000) of ED visits for opioid overdoses and all drug poisonings from 2006 to 2014. There is a similar, increasing trend displayed in both series. From 2006 to 2014, the rate of opioid-related ED visits increased by 6.82 per 100,000 (39.50%) and the rate of all drug-related ED visits rose by 13.70 per 100,000 (8.0%). These data come from the National Emergency Department Sample (NEDS), a 20% sample of records from all participating states (but not containing state identifiers) disseminated through HCUP. The NEDS estimates are based upon the entire set of SID and SEDD data and are weighted to be nationally representative. For expositional clarity, we plot the national estimates based upon

[14] These numbers sum to more than 100% because 2.6% of drug deaths involved the use of *both* opioids and heroin.
[15] In 2014, the drug death rate per 100,000 was 14.76, of which 7.34 were opioid related, 4.05 involved heroin, and 4.25 only drugs other than opioids or heroin.

the NEDS here, rather than state-level estimates based upon the SEDD data for the five states used in our analysis.[16]

Figure 3 also highlights a key distinction between the mortality and ED data. Opioid deaths are responsible for roughly half of all drug deaths in any given year, but opioids ED visits compose fewer than 14% of all drug-related ED visits. Breaking down the category of drug-related ED visits further, we find that 8 drug categories constitute approximately 60% of the drug poisoning ED visits in any given year: opioids, benzodiazepines, heroin, anti-depressants, aromatic analgesics (e.g. acetaminophen), insulin, anti-psychotics, and cocaine. Figure 4 displays the nationwide ED visit rate for each drug category from 2006 to 2014. While both opioid and heroin overdose ED rates have risen since 2006, the rate of overdose visits to the ED for all other majority drug categories remained constant or declined.[17]

The NEDS further allows us to determine the percentage of in-hospital deaths that occur after an ED overdose visit for each drug type.[18] Cocaine, heroin, and opioids are by far the deadliest of the seven major drug categories resulting in around two to three times more deaths per visit than the other four top drug categories. For every one-hundred ED visits for cocaine poisoning there are approximately 1.5 in-hospital deaths. Similarly, 1.4% of heroin and 1.2% of opioid overdose ED visits result in an in-hospital death. The death rate associated with an ED visit for a benzodiazepine overdose is roughly one-third as large or 0.4%. The weighted average death rate of an ED visit for the remaining four categories (anti-depressants, anti-psychotics, insulin, and

[16] When a similar figure is created for each state, a clear relationship between the ED visit rate for opioids and for all drugs is still present. However, some states in our sample do not exhibit strictly increasing trends over this time period. As we only have data for 5 states for county-level ED visits, we verified that the mortality trends were similar for these states as for the U.S. average. When we limit the mortality data from Fig 1 to these same 5 states: there is a 117 % increase in drug-related death rates for these five states, in which there was a larger (339%) increase in opioid deaths.

[17] Similar figures created for each state using the micro-data display consistent results.

[18] This includes all deaths that occur in the ED as well as all deaths that occur in any related inpatient stay following an admission from the ED.

aromatic analgesics) is <0.4%. One implication of these results is that the relationship between overall drug-related ED visit and death rates may be quite weak, since many of the most important sources of visits rarely result in death, whereas that between opioid-related ED visits and deaths is likely to be considerably stronger.

IV. Empirical Approach

We perform both a county and state-level analysis of the relationship between macroeconomic conditions and adverse drug outcomes. We first describe the county-level analysis and then discuss the modifications required when using state data.

Our main regression specifications take the form:

$$\boldsymbol{Y_{jt} = \beta U_{jt} + \eta_j + \delta_t + \mu_{st} + \epsilon_{jt}} \, , \qquad \textbf{(1)}$$

where the dependent variable, Y_{jt} is the mortality or ED visit rate, per 100,000, in county j and year t ; U_{jt}, the county annual unemployment rate, is the main proxy for macroeconomic conditions. We include county and year fixed-effects (η_j and δ_t) in all models, to control for potential confounding factors that vary across counties but are fixed over time, as well as determinants of mortality or ED visits that differ nationally across time, and we report results from these specifications in our full sample analysis.

One concern is that local policies influencing drug mortality or ED visits could have changed over time in ways that are spuriously correlated with unemployment rates. The most important of these policies – such as prescription drug monitoring programs, recreational or medical marijuana legalization, and Medicaid policies – occur at the state rather than county level (Dave et al., 2017, Dowell et al., 2016, Buchmueller and Carey, 2017). Therefore, the preferred specifications, in our county-level analysis, also include state-by-year fixed effects (μ_{st}) to control for these potential confounders. In alternative specifications, we instead include a vector of county-specific linear time trends.

Macroeconomic conditions may also have worsened (or improved) in areas that for other reasons were on different trajectories in terms of drug mortality. If so, a model with county, year and state-by-year fixed effects could still incorrectly attribute a continuing pre-existing trend in mortality to changes in unemployment rates. Theoretically, we could address this by simultaneously including both county-specific time trends and state-by-year fixed-effects in our specifications. However, doing so for every county in the United States, leaves our model with virtually no useful variation.[19] We discuss this issue further, below, when describing the large number of robustness checks that we performed.

Several points about our preferred regression specification deserve mention. First, given comprehensive controls for location and time-specific determinants, we generally do not include additional supplementary covariates. Second, we use levels, rather than natural logs, as the dependent variable. This is done because some counties (particularly smaller ones) will have zero values for the dependent variables in at least some years.[20] Third, we weight observations by population, to obtain nationally representative treatment effects. By contrast, unweighted estimates would overstate the influence of treatment effects in small counties. Fourth, the tables display robust standard errors with clustering at the county level, which is the level of variation of our key regressor, the unemployment rate.

[19] Specifically, a regression of county unemployment rates over this time on a set of county FE, year FE, state by year FE and county specific linear time trends has an R^2 of 0.96.

[20] Prior related research (e.g. Ruhm, 2000) shows that comparable predicted effects are obtained using linear versus log-linear specifications. An alternative would be to estimate zero inflated negative binomial models, although the interpretation of the coefficients in such specifications would be somewhat less transparent.

There are pros and cons to using counties, rather than some larger geographic aggregate such as states, as the unit of observation. On the one hand, there is likely to be more error in the measurement of both mortality and unemployment rates at smaller geographic units.[21] On the other, counties within the same state could face different economic climates and what happens far away may not affect lives as much as what happens nearby (e.g. in funding of public health). However, a further question involves the level of geographic aggregation at which the macroeconomic effects actually occur. In this regard, Lindo's (2015) conclusion that more disaggregated analyses will often understate the extent to which downturns affect health is particularly instructive. For our application, there is an additional advantage to using a broader level of geography; while county-level mortality data is nationwide in coverage, we only have ED visit data at the county level for 5 states, while we have state level data for 15. For these reasons, we provide a full replication of analysis at the state level. When doing so, we are naturally no longer able to include state-by-year fixed effects and so instead estimate specifications with and without state-specific linear time trends, as well as state and year fixed effects in all specifications.

We summarize in Section VII and detail in the electronic appendix the large number of specification checks we conducted. For example, since the relationship between unemployment rates and macroeconomic conditions may have changed over time, we estimate supplemental models with shorter time windows of analysis.[22] We also allowed for heterogenous relationships between the economic climate and drug adverse outcomes (across factors such as county population density, education levels and industrial structure) by estimating models that exclude

[21] The greater measurement error in county than state unemployment rates is well known (see for example Ganong and Liebman, 2013). Errors in classifying the county of residence at death have been less studied but Pierce and Denison (2006) provide evidence of substantial misrecording of counties using mortality data from Texas.
[22] For instance, declines in labor force participation rates were particularly pronounced during the "great recession" that began in 2007, when compared to other economic downturns (Shierholz, 2012).

categories of counties. In addition, we explore the sensitivity of the findings to the use of alternative proxies for macroeconomic conditions.

V. County-Level Results

Table 3 shows three county-level specifications for our dependent variables of primary interest: opioid-involved drug death rates, all drug mortality rates, opioid overdose ED visit rates, and all drug overdose ED visit rates. The first column shows the specification with only county and year fixed effects. The second column adds county specific time trends, while the third instead includes state-by-year fixed-effects, and corresponds to Equation 1. We view the models in columns (2) and (3) as superior to that in column (1) because they better control for possible confounding factors. However, we generally prefer models that include state-by-year fixed effects since, as mentioned, many potential policy determinants are likely to vary across both time and states, but less so across counties within states.

Turning to the primary findings in column (3) of the first panel for opioid-involved drug deaths, the coefficient of 0.19 implies that a one percentage point rise in the county unemployment rate is predicted to increase opioid fatalities by a statistically significant 0.19 per 100,000. This represents a 3.55 percent growth from the sample average of 5.35 per 100,000. A one standard deviation change in the unemployment rate corresponds to 3.25 percentage points, suggesting effect sizes of around a 0.62 per 100,000, or a 11.5 percent, increase in fatal opioid overdoses. This also implies an unemployment rate elasticity of around 0.28.[23]

The estimated unemployment rate effect for all drug fatalities is also highly significant but is somewhat sensitive to the inclusion of state-year fixed-effects versus county-specific time

[23] A one percentage point rise in unemployment is approximately a 12.6 percent increase from the sample mean rate of 7.95 percent: 3.55%/12.58% = 0.28.

trends. In the preferred model (column 3), a one-point rise in unemployment predicts a 0.36 per 100,000 increase in drug mortality rates, corresponding to a 3.3 percent increase from the sample average of 10.77 per 100,000, and an unemployment rate elasticity of around 0.27. Results from the preferred specifications suggest that around half of the macroeconomic effect on drug mortality operates through opioid-related deaths. We confirmed this by estimating our preferred specification where the dependent variable was non-opioid related drug deaths (see Appendix). The unemployment coefficient is (a statistically significant) 0.17, accounting for the remainder of the total effect.

The two lower panels of Table 3 show results for drug-related ED visits, rather than deaths. The samples are smaller– being restricted to selected county-year observations from five states – leading us to anticipate less precise estimates. Nevertheless, we find that, as with mortality rates, there is a strong and significant positive relationship between opioid-related overdose ED visits and unemployment rates that is relatively robust across specifications. In the model with state-year fixed-effects and county time trends (column 4), a one percentage point rise in unemployment predicts a 0.95 per 100,000, or 7.0 percent, increase in opioid overdose ED visits, corresponding to an elasticity of around 0.56.

The results for all drug ED visits are more sensitive to the choice of specifications, and statistically insignificant, but still suggestive of a countercyclical macroeconomic effect. Specifically, in our preferred model, a one-point rise in unemployment predicts a statistically insignificant 1.19 per 100,000, or 1.2 percent increase in drug-related ED visits. The imprecision of these results is not unexpected since, as discussed above, a large set of drugs cause individuals to seek ED care, and many of these relatively infrequently result in death. One consequence is that opioid overdose ED visits reflect a small share (13.9%) of all drug overdose ED visits, and it is unlikely that our analysis will have sufficient statistical power to detect any plausible minimum effect size. Put differently, opioid overdose ED visits would need to be implausibly sensitive to the unemployment rate for there to be statistically significant effects of the unemployment rate in the large category of 'all drug' ED visits.[24]

Substance use disorders is a public health threat that is thought to have an uneven toll across different segments of the population. We next examine whether the effects of macroeconomic decline on opioid adverse events differ across race/ethnicity groups. Table 4 provides results from our preferred specification for each race/ethnic group.[25] The first column repeats the full sample results (from column (3) of Table 3). The remaining columns separately present the findings for whites, blacks, and Hispanics. As mentioned, we do not present ED visit results for Hispanics because it is not classified consistently in the ED visit data.

The countercyclical variation in opioid-involved deaths is primarily driven by effects on whites, where a one-point rise in unemployment predicts a highly significant 0.23 per 100,000 (or 3.6 percent) mortality increase. Conversely, the predicted effects are negative for blacks (-0.14 per 100,000) and positive but smaller for Hispanics (0.04 per 100,000). This finding is not unexpected

[24] To show this more formally, we conducted a simulated power analysis, where we estimated the minimum detectable effect size across all power levels and for a range of type-I error thresholds. Following conventional standards, for 80% power and a 0.05 type-I error threshold, the minimum detectable effect size in the county-level all drug overdose ED visit specification was just below 7 visits per 100,000 caused by a one percentage point increase in the unemployment rate. (displaying the minimum detectable effect size for all power levels and for a variety of type-I error thresholds (0.1, 0.05, 0.01, and 0.001) are reported in the Appendix.) Results. To put this in context, consider that in our preferred model, a one percentage point increase in the unemployment rate predicts a 0.95 per 100,000 increase in the mean opioid overdose ED visit rate, from the baseline average of 13.54 to 14.49 (7.0%). Such an increase in the opioid ED rate, ceteris paribus, would imply a 0.95 increase the mean "all drug" overdose ED rate, from 97.52 to 98.47 (0.97%), which would be undetectable statistically. Specifically, this expected effect size of 0.95 is well below the minimum detectable effect size of 7. (Our power simulations show that for a minimum detectable effect size of 1 and a type-I error threshold of 0.05, the power is near 0%.) Indeed, the point estimate we recover, 1.19, is quite near the expected effect size, but it is imprecisely estimated due to a lack of power.

[25] Tables A6 – A8 in the Appendix report results across a variety of specifications by race, mirroring Table 3.

as clear common trends between white and total opioid death rates are depicted in Figure 3.[26] It is worth pointing out that the smaller estimates for nonwhites often represent lower levels for mortality risk, rather than smaller percentage effects. For instance, the 0.04 unemployment coefficient for Hispanics in the model corresponds to a 2.5 percent growth from the relatively low average rate of 1.60 per 100,000, which is similar to the corresponding relative change for whites.

The predicted macroeconomic effects on all drug deaths are also dominated by whites with a 0.48 per 100,000 (4.5 percent) increase anticipated to result from a one-point rise in the unemployment rate. Corresponding estimates are -0.13 per 100,000 for blacks and 0.11 per 100,000 for Hispanics. For opioid-related ED visits the patterns are somewhat different, with strong countercyclical predicted effects for both whites and blacks: a one-point increase in unemployment is expected to raise white ED visits by 0. 91 per 100,000 or 4.8% percent and black visits by 1.25 per 100,000 or 17.4% percent. However, the results for nonwhites should be interpreted with considerable caution as they are often reasonably sensitive to the choice of specifications. For instance, small and statistically insignificant unemployment coefficients are obtained for blacks, when examining all drug or opioid-related mortality rates, in models that include county and year fixed-effects and county-specific time trends but not state-by-year fixed-effects.

VI. State-Level Results

Table 5 replicates the previous analysis at the state rather than county-level. Information on ED visits is here aggregated information for 15 states (rather than for the 5 states for which we have micro-data). Observations are weighted by the relevant state (rather than county) population

[26] There are similar observable common trends between the total and white opioid ED visit rates in the ED data series.

and standard errors are clustered at the state-level. Our preferred specification includes state and year fixed-effects, as well as state-specific time trends. Appendix Table A1 contains relevant sample means for the outcomes and explanatory variables.

The first two columns of Table 5 present full-sample estimates. Separate findings for whites, blacks and nonwhites are shown in columns (3) through (6). The full sample results are largely consistent with those observed using county-level data. Specifically, drug and opioid-related drug deaths, as well as opioid-related ED visits, are all strongly countercyclical. For example, a one-point increase in the unemployment rate is predicted to raise the opioid-related mortality rate by 0.33 per 100,000, a growth of 6.2 percent and an elasticity of around 0.39. Similarly, a one-point increase in the unemployment rate increases the predicted opioid ED visit rate by 3.12 (6.2%), with small positive (but statistically insignificant) predicted effects on drug ED visits. Although this pattern of results is quite similar to our county-level findings presented earlier, the magnitude is larger for each coefficient. This is consistent with Lindo's (2015) evidence that macroeconomic effects are often understated when using county-level data.[27] The estimates suggest that almost all of the predicted increase in drug deaths is due to opioid-related mortality, as evidenced by the similar (0.35 vs. 0.33) unemployment coefficients for the two dependent variables.

The third through eighth columns of Table 5 again indicate that the mortality effects are primarily due to changes among whites and, more generally, that the countercyclical variation in opioid-related deaths and ED visits is very strong for them. Interestingly, while the unemployment

[27] Another important driver of the difference in coefficient size for opioid ED visit rate between our preferred county-level specification (0.95) and our preferred state-level specification (3.12) is due to a difference in data. The county-level ED data count the number of *individuals* with an opioid overdose diagnosis, while the state-level ED data count the number of opioid overdose *ED visits* (of which there could be more than one per individual). However, a one percentage point increase in the unemployment rate has similar percentage effects on county-level opioid ED visits (7.0%) and state-level ED visits (6.2%).

coefficients on drug and opioid mortality were negative (in at least some specifications) for blacks when using county-level data, they reverse sign (but are often insignificant) with state-level data. This provides further evidence of the sensitivity of the estimates to samples or specifications for blacks, suggesting that we should be cautious about making conclusive statements about the macroeconomic effects for this group. Conversely, for Hispanics, evidence of a countercyclical variation in drug deaths is obtained using both county and state level data.[28]

VII. Robustness Checks

Our results to this point indicate that drug mortality is strongly counter-cyclical, with the most important role being played by deaths involving opioids in most specifications. Opioid-related ED visits are also counter-cyclical and both of these effects are strongly driven by the effects on whites. Conversely, the results for blacks and Hispanics are more sensitive to the choice of model specification, suggesting difficulties in making conclusive statements for these demographic groups. We next conducted a variety of further tests of the robustness of these results to changes in samples or specifications. We summarize the results of these robustness checks here, with full discussion and details of the estimates provided in the electronic appendix.

All of our county-level specifications include county and year fixed-effects, and we also show models that contain either state-by-year fixed effects (in our preferred models) or county-specific linear time trends. Unfortunately, it is not possible to simultaneously control for both county-specific time trends and state-by-year fixed-effects, because doing so for every county in

[28] We also estimated models for heroin-related ED visits. These showed no clear pattern, ranging from strongly and significantly positive to strongly and significantly negative, and were highly sensitive to the choice of specifications. These results are displayed in the Appendix in Table A5. The majority of the coefficients are not statistically different from zero. Thus we cannot make statements about the relationship between heroin abuse and local macroeconomic conditions

the United States, leaves our model with no useful variation.[29] As an alternative, we examined whether our results were robust to incorporating alternative, but more limited, sets of time trend variables. These included: separate trends for counties by population quintiles (5 trends) or percentiles (100 trends). We also allowed the top 1% of counties (by population size) to have their own individual trends, with separate trends by percentile for the other 99% of counties. Similarly, we estimated models with individual trends for the top 5% of counties, and with the other 95% of counties having separate trends by population vigintile (5% bins). Finally, we ran models that incorporated consumer zone rather than county time trends. Countercyclical variations in opioid death and ED visit rates were obtained in all of these specifications and the estimates were almost always statistically significant, although sometimes smaller than in the main specifications. For instance, the unemployment coefficient for opioid death rates was 0.19 in the preferred model and ranged from 0.12 to 0.19 in the alternative specifications just described.[30]

We also examined whether the relationship between macroeconomic shocks and opioid abuse differed by time period. This was done by systematically removing sets of three years at a time.[31] For drug deaths, the unemployment coefficients and 95% confidence intervals were always well above 0, although they did fluctuate a bit. Importantly, the estimate that excluded the 2008-2010 was typical of those obtained when removing other periods, indicating that the results were not being driven by unusual effects occurring during the great recession. For opioid-related deaths and ED visits we obtained a similar story of fairly consistent and strong (although not always

[29] Specifically, a regression of county unemployment rates over this time on a set of county FE, year FE, state by year FE and county linear time trends has an adjusted R^2 of 0.96.
[30] Similarly, our ED findings were robust to a majority of alternative time trends, but given the smaller number of counties in our sample, the results were also insignificant when using commuter zone specific time trends.
[31] Three year bins were chosen to ensure the full great recession period is removed in one specification, to insure that our results are not driven the recession or other short run macroeconomic events.

statistically significant) effects when removing sub-periods. We did not find significant results for any drug ED visit specifications.

We next investigated whether the results were sensitive to the proxy used for macroeconomic conditions by running models where the key explanatory variables were employment-to-population (EP) ratios or percent changes in manufacturing employment or import exposure between 1990 and 2007.[32] Since there is no readily available series of county level EP ratios, the specifications using those were run at the state level and, as expected, provide coefficient estimates that were of the opposite sign, and slightly smaller in magnitude, than those obtained when controlling for unemployment rates. For changes in manufacturing employment or import exposure, we followed a strategy analogous to that used for different time periods, by examining how the results changed when successively omitting sample county quintiles for each variable. We obtained consistent coefficients across the omitted quintiles for each variable, indicating that our findings were not being driven by areas with the greatest loss of manufacturing jobs or the largest increase in imports.

Similarly, we explored potential heterogeneity in the effects dacross urban and rural areas by successively excluding quintiles of counties based upon 2010 population density.[33] The mortality findings were not driven by population density, except that the estimated effects for opioid deaths were slightly weaker (and statistically significant at the 10% but not the 5% level) when excluding the densest areas. The results for all-drug ED visits were noisier and centered around zero, while those for opioid-related visits were statistically significant and consistent in magnitude across all quintiles. Next, we performed the same exercise except systematically

[32] The last two proxies were obtained from Autor et al. (2013).

[33] County characteristics, including percent of persons aged 25 and over who had graduated high school and land area (to later calculate population density) were extracted from the 2010 U.S. decennial census. (www.census.gov/2010census/data/).

dropping counties by quintile of 2010 high school graduation status and percent non-white. Our main results were robust to these exclusions.

We attempted to decompose the effect of the unemployment rate on opioid-related ED visits by age and payer type group. The opioid ED visits results were consistent across all age groups and payer types, except for the elderly, for whom both an age group analysis and the Medicare payer type estimates were positive but not statistically different from zero.[34]

Finally, we performed a series of placebo tests, examining the unemployment coefficients on ED visit rates for causes not anticipated to be related to macroeconomic conditions including.: vomiting during pregnancy, open head wounds, broken legs or arms and broken noses. With the exception of broken noses, none of these outcomes were statistically related to macroeconomic conditions.

VIII. Discussion

Overall, we obtain strong evidence that opioid-related deaths and emergency room visits increase during times of economic weakness, although the results vary somewhat with the unit of observation (county vs. state) and the exact specifications estimated. In the main county-level models, our preferred specification indicates that a one percentage point increase in the unemployment rate raises the predicted opioid-involved mortality rates by 0.19 per 100,000, corresponding to a 3.6 percent growth and an unemployment elasticity of mortality of around 0.28. These effects are largely driven by changes in the death rates of whites, with much smaller (but still mostly positive) increases predicted for Hispanics. Opioid-related emergency department visits are also predicted to rise when in bad economic times, in most specifications, with strong effects here observed for blacks as well as whites. There are weaker, and less consistent, results

[34] This null finding makes sense, since job losses and economic declines during recessions should affect the working age population and children more than the elderly.

for other mortality and emergency department outcomes (e.g. heroin-involved or other drug deaths), although often with results in that are in the same direction as for opioids.

Negative economic shocks are estimated to have bigger adverse effects on drug related mortality and ED visits when conducting the analysis at the state (rather than county) level. A one-point rise in unemployment is predicted to increase overall opioid-related mortality by 0.33 per 100,000, over one and a half times the size of the county-level estimates, corresponding to growth of 6.2 percent and an unemployment elasticity of around 0.39. These larger estimates could occur because counties are too narrow a unit of observation to observe the full macroeconomic effects (Lindo, 2015) or because the county-level models are more fully able to control for potential confounding factors.

Our results should be interpreted in light of several limitations. First, while we have data for all deaths to US residents, the information on emergency department visits is more restricted, especially in our county level analysis. Second, although we use the two proxies of macroeconomic conditions most often used in the related literature (unemployment rates and employment to population ratios), and provide a limited investigation using changes over time in manufacturing employment or import penetration, a variety of others could be considered. These include measures like home foreclosures at the zip-code level (Currie and Tekin, 2015) or stock market losses at the national level (Schwartz et al., 2012) that capture different dimensions of economic decline. Third, there could be errors in the recording of the specific drugs involved in fatal overdoses and in the reasons for ED visits. We use imputation procedures to minimize effects of the former, but cannot be sure that the methods are completely successful. Finally, it is unclear what is the “best” model specification or unit of analysis. We have attempted to surmount this issue by providing results for a wide variety of models and while most results are robust to these alternatives, some are not. In particular, unemployment rates are negatively correlated with black mortality rates in the county-level models but not in the state-based specifications and most, but not all, specifications suggest that the countercyclical variation in drug mortality rates is predominantly due to changes in opioid-related related deaths (as opposed to other types of drug fatalities)

There are numerous causal pathways that link macroeconomic developments to health behaviors and their consequences but we know little about the mechanisms for the effects observed here. During periods of economic weakness, lower incomes might be expected to reduce purchases and use of legal or illicit drugs (Riddell and Riddell, 2006; Dobkin and Puller, 2007) and mechanisms emphasizing reductions in time costs (e.g. having more time to engage in time-intensive health-improving behaviors like exercise or recovery treatment programs) would lead to better outcomes in bad economic times. Neither of these appear to be a dominant factor for opioids or other drugs that lead to emergency department visits or deaths, since both are predicted to increase as a result of negative macroeconomic shocks.[35] On the other hand, our results could be consistent with a role for supply-side factors, such as the loss of health insurance or of public health funding for treatment or prevention programs during periods of economic weakness.

Notwithstanding the possible pathways described in the previous paragraph, we suspect that the dominant factor linking macroeconomic conditions to health outcomes studies in this paper may be that fatal and near fatal abuse of opioids often (and increasingly over time) reflect a physical manifestation of mental health problems that have long been known to increase in periods of economic decline.[36] In this regard, we note that although opioids are prescribed to treat pain,

[35] However, worsening economic conditions could lead to reductions in some types of drug use but with changes in the composition of consumption such that adverse events increase.

[36] This dates back to Durkheim's (1897) work on suicides and includes a great deal of later research including that by Hamermesh and Soss (1974), and in the more closely related literature, to Ruhm (2000) and others.

there are strong linkages between pain, mental health problems and the use of analgesics.[37] With the increased availability of prescription opioids (and reductions in heroin prices), it seems likely that the use of these drugs rise when economic conditions worsen and that some of this increased use leads to adverse outcomes including emergency department visits or death. Obtaining a better understanding of the causal pathways for the results we observe is an important direction for future research.

[37] Depression and other forms of mental illnesses increase the experience of pain; pain is associated with more depressive symptoms and the two share many of the same biological pathways (Bair et al. 2003) Persons with depression, dysthymia and generalized anxiety or panic disorders use narcotics at relatively high rates (Sullivan et al., 2006; Braden et al., 2009)and opioids have been shown to have a palliative effect on mental health problems such as depression and obsessive-compulsive disorder (Koran et al. 2005; Bodkin, Zornberg, and Lukas, 1995).

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Figure 1: U.S. Unemployment Rate and Drug Death Rates by Type, 1999-2014

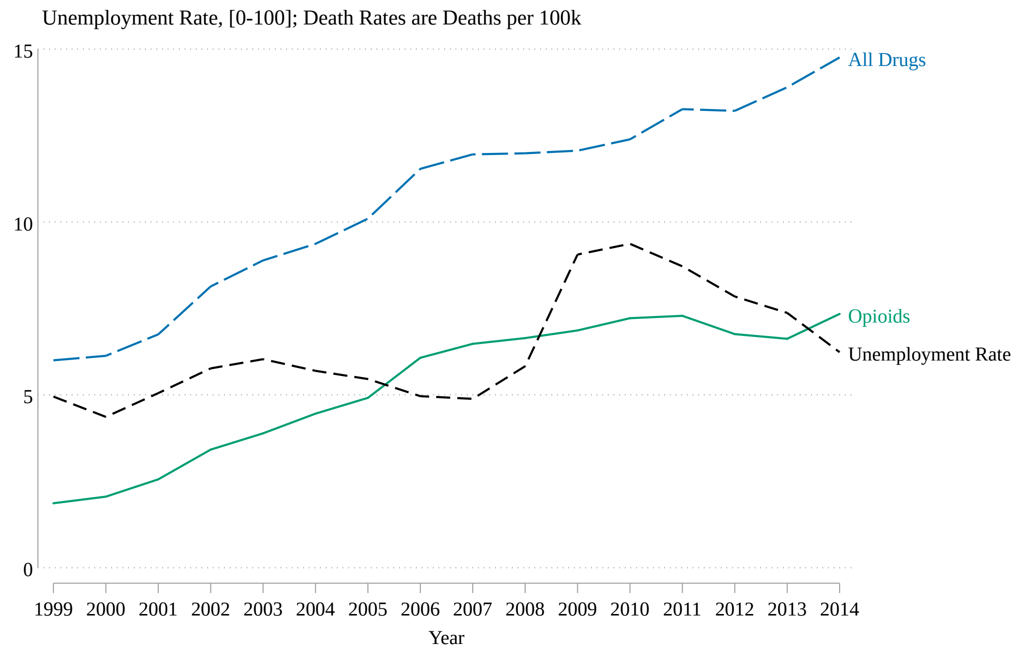

Figure 2: Total Opioid Death Rate by Race, 1999-2014

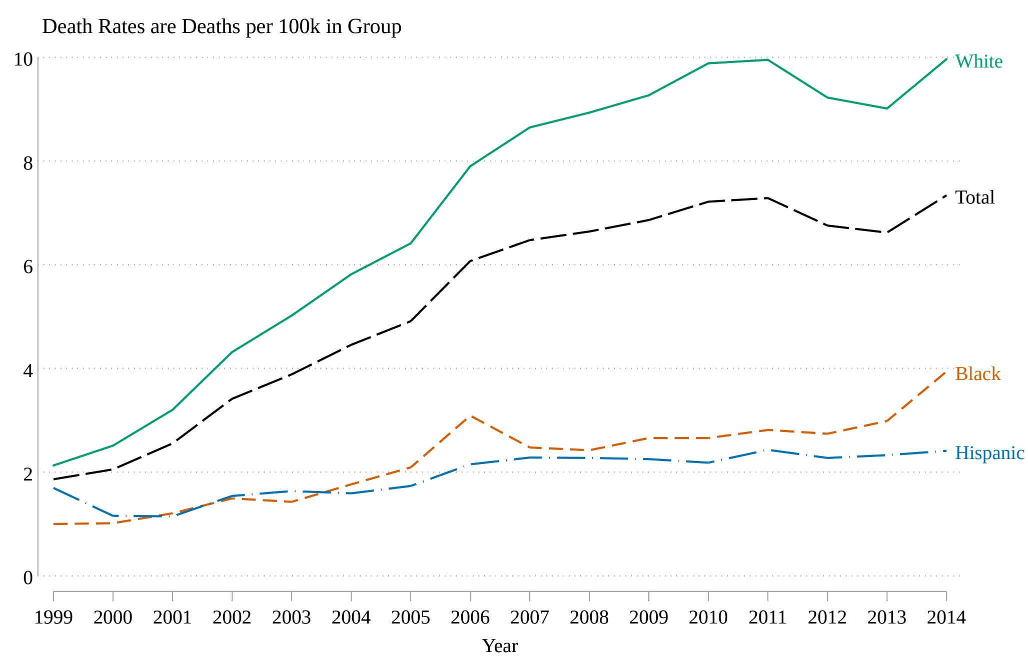

Figure 3: Opioid and All Drug Overdose ED Visit Rate, 2006-2014

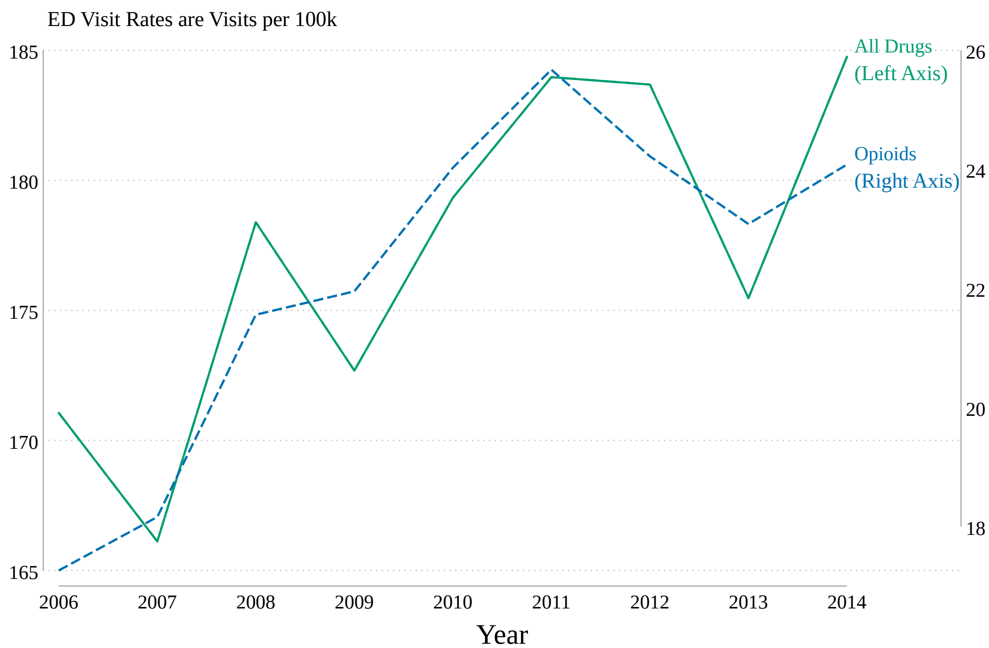

Figure 4: Drug Overdose ED Visit Rate by Major Drug Type, 2006-2014

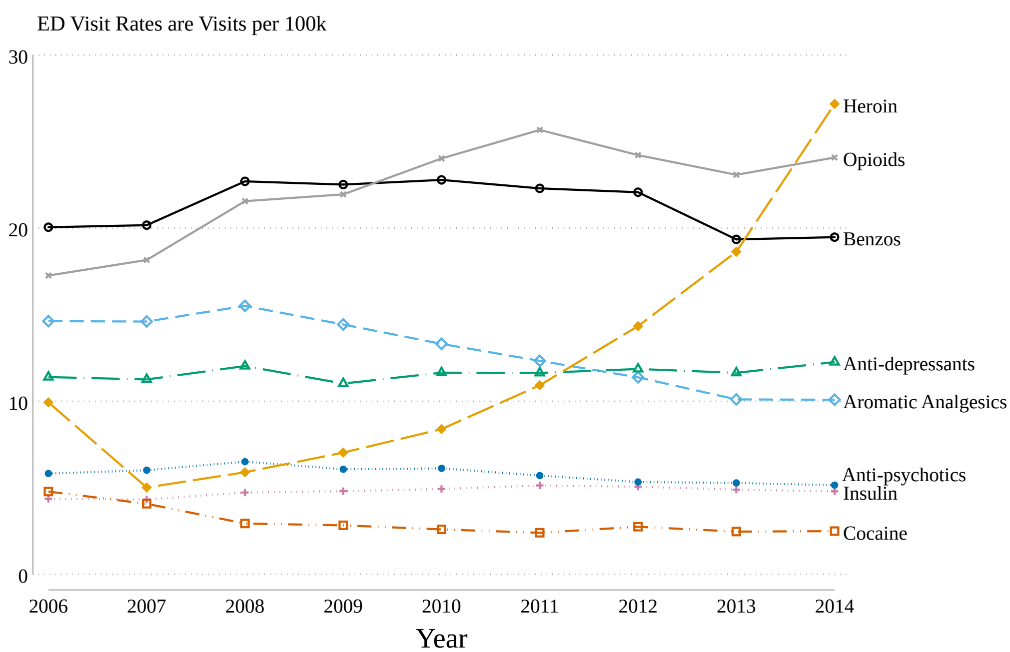

Table 1: Emergency Department Data: Geographic Detail and Years Used in Analysis

State	County-Level Data	Years	State-Level Data	Years
Arizona	Yes	2005-2014	Yes	2005-2013
Florida	Yes	2005-2014	Yes	2005-2013
Hawaii	No		Yes	2003-2010, 2013
Iowa	No		Yes	2004-2013
Illinois	No		Yes	2009-2013
Kentucky	Yes	2008-2012	Yes	2008-2013
Maryland	Yes	2002-2012	Yes	2005-2013
Minnesota	No		Yes	2001-2013
North Carolina	No		Yes	2007-2013
Nebraska	No		Yes	2001-2011, 2013
New Hampshire	No		Yes	2003-2009
New Jersey	Yes	2004, 2006-2013	No	
South Carolina	No		Yes	2005-2013
Tennessee	No		Yes	2005-2013
Utah	No		Yes	2000-2013
Vermont	No		Yes	2002-2013

Note: County-level data are constructed from the micro-data (visit-level) provided by the Healthcare Cost and Utilization Project's (HCUP) State Emergency Department Databases (SEDD). The state-level data is taken directly from the "State Statistics on All ED Visits" portion of HCUPNet, available at https://hcupnet-archive.ahrq.gov.

Table 2: County-Level Summary Statistics for Drug Related Deaths and ED Visits

	Mean	S.D.	Min.	Max.	N
Mortality Data					
Unemployment Rate, [0-100]	6.39	2.59	0.70	30.30	50148
Median Income, $1000s	49.50	13.66	15.03	125.64	50162
Year	2006.50	4.61	1999.00	2014.00	50162
All					
Population, in 100k	0.95	3.07	0.00	101.17	50162
Opioid Death Rate per 100k	5.35	4.84	0.00	127.80	50162
Drug Death Rate per 100k	10.77	6.92	0.00	194.46	50162
White					
Population, in 100k	0.63	1.48	0.00	31.22	50162
Opioid Death Rate per 100k	7.03	6.14	0.00	161.64	50162
Drug Death Rate per 100k	13.07	8.61	0.00	234.19	50162
Black					
Population, in 100k	0.12	0.54	0.00	14.08	50162
Opioid Death Rate per 100k	2.28	4.65	0.00	4166.67	49661
Drug Death Rate per 100k	8.50	9.67	0.00	8333.33	49661
Hispanic					
Population, in 100k	0.14	1.10	0.00	48.98	50162
Opioid Death Rate per 100k	2.00	3.87	0.00	1492.54	50120
Drug Death Rate per 100k	5.25	6.53	0.00	3571.43	50120
Emergency Department Data					
Unemployment Rate, [0-100]	7.95	3.25	2.20	25.50	1873
Median Income, $1000s	45.75	15.06	19.83	108.23	1873
Year	2009.50	2.86	2002.00	2014.00	1873
All					
Population, in 100k	2.21	4.24	0.02	40.87	1873
Opioid Overdose ED Visit Rate per 100k	13.54	8.41	0.00	145.84	1873
Drug Overdose ED Visit Rate per 100k	97.52	36.91	0.00	460.87	1873
White					
Population, in 100k	1.34	2.29	0.02	23.73	1873
Opioid Overdose ED Visit Rate per 100k	17.18	10.31	0.00	152.56	1828
Drug Overdose ED Visit Rate per 100k	109.05	42.06	0.00	464.01	1828
Black					
Population, in 100k	0.34	0.82	0.00	5.69	1873
Opioid Overdose ED Visit Rate per 100k	9.46	7.93	0.00	246.31	1828
Drug Overdose ED Visit Rate per 100k	90.60	38.24	0.00	4347.83	1828

Source: Mortality data are at the county-year and come from the Centers for Disease Control and Prevention's Multiple Cause of Death files from 1999-2014 and are adjusted as in text. ED data at the county-year level and are provided via the Healthcare Cost and Utilization Project's State Emergency Department Databases (SEDD). SEDD data come from Arizona (2005-2014), Kentucky (2008, 2010-2012), Florida (2005-2014), Maryland (2002-2012), and New Jersey (2004, 2006-2103). See text for ICD-9 definitions of outcomes. County level unemployment data come from Bureau for Labor Statistics. Information on county level median income comes from the Census' Small Area Income & Poverty Estimates. Unemployment rate, median income, death rates, and ED visit rates are all weighted by total county population of group. Hispanic ED visits are omitted as the ED data do not contain a reliable indicator of Hispanic ethnicity.

Table 3: The estimated effect of county-level unemployment on the rate of opioid/drug mortality and emergency department visits across multiple specifications.

	(1)	(2)	(3)
Opioid Death Rate per 100k			
Unemployment Rate, [0-100]	0.22***	0.19***	0.19***
	(0.05)	(0.04)	(0.05)
Mean of Dependent Variable	5.35	5.35	5.35
Observations	50148	50148	50148
Drug Death Rate per 100k			
Unemployment Rate, [0-100]	0.29***	0.18***	0.36***
	(0.08)	(0.05)	(0.07)
Mean of Dependent Variable	10.77	10.77	10.77
Observations	50148	50148	50148
Opioid Overdose ED Visit Rate per 100k			
Unemployment Rate, [0-100]	0.57**	1.10***	0.95***
	(0.26)	(0.30)	(0.28)
Mean of Dependent Variable	13.54	13.54	13.54
Observations	1873	1873	1873
Drug Overdose ED Visit Rate per 100k			
Unemployment Rate, [0-100]	0.71	1.54	1.19
	(0.88)	(1.04)	(1.20)
Mean of Dependent Variable	97.52	97.52	97.52
Observations	1873	1873	1873
County Fixed-Effects	Yes	Yes	Yes
Year Fixed-Effects	Yes	Yes	Yes
County Specific Time Trends	No	Yes	No
State-by-Year Fixed-Effects	No	No	Yes

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the county level in parentheses. Each regression is weighted by total county population.

Table 4: The estimated effect of county-level unemployment on the rate of opioid/drug mortality and emergency department visits for our preferred specification across race/ethnicity.

	(1) All	(2) White	(3) Black	(4) Hispanic
Opioid Death Rate per 100k				
Unemployment Rate, [0-100]	0.19***	0.23***	–0.14**	0.04
	(0.05)	(0.05)	(0.07)	(0.03)
Mean of Dependent Variable	5.46	6.33	2.19	1.60
Observations	50132	50132	49630	50090
Drug Death Rate per 100k				
Unemployment Rate, [0-100]	0.36***	0.48***	–0.13	0.11*
	(0.07)	(0.08)	(0.10)	(0.06)
Mean of Dependent Variable	9.46	10.71	6.16	3.45
Observations	50132	50132	49630	50090
Opioid Overdose ED Visit Rate per 100k				
Unemployment Rate, [0-100]	0.95***	0.91**	1.25***	
	(0.28)	(0.37)	(0.45)	
Mean of Dependent Variable	16.91	18.92	7.18	
Observations	1873	1828	1828	
Drug Overdose ED Visit Rate per 100k				
Unemployment Rate, [0-100]	1.19	1.01	–1.07	
	(1.20)	(1.29)	(1.97)	
Mean of Dependent Variable	117.43	123.45	99.26	
Observations	1873	1828	1828	

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the county level in parentheses. All specifications include county fixed-effects, year fixed-effects, and state-by-year fixed effects. Each regression is weighted by county population of group. Hispanic ED visits are omitted as the ED data do not contain a reliable indicator of Hispanic ethnicity.

Table 5: The estimated effect of state-level unemployment on the rate of opioid/drug mortality and emergency department visits across multiple specifications and race/ethnicity.

	All		White		Black		Hispanic	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Opioid Death Rate per 100k								
Unemployment Rate, [0-100]	0.24***	0.33***	0.45***	0.41***	0.08	0.13	0.05	0.14***
	(0.08)	(0.08)	(0.10)	(0.11)	(0.06)	(0.09)	(0.05)	(0.05)
Mean of Dependent Variable	5.35	5.35	7.03	7.03	2.28	2.28	2.00	2.00
Observations	816	816	816	816	816	816	816	816
Drug Death Rate per 100k								
Unemployment Rate, [0-100]	0.24**	0.35***	0.54***	0.40***	0.18	0.33**	0.05	0.18**
	(0.10)	(0.11)	(0.11)	(0.14)	(0.12)	(0.14)	(0.07)	(0.09)
Mean of Dependent Variable	10.75	10.75	13.06	13.06	8.50	8.50	5.25	5.25
Observations	816	816	816	816	816	816	816	816
Opioid ED Visit Rate per 100k								
Unemployment Rate, [0-100]	3.24***	3.12***	5.45***	4.52***	0.73	1.05		
	(0.58)	(0.82)	(1.14)	(1.58)	(0.69)	(0.81)		
Mean of Dependent Variable	50.50	50.50	65.98	65.98	29.05	29.05		
Observations	138	138	101	101	73	73		
Drug ED Visit Rate per 100k								
Unemployment Rate, [0-100]	2.46	5.03	5.19	4.10	8.23	3.60		
	(2.65)	(3.25)	(6.48)	(6.72)	(5.22)	(5.17)		
Mean of Dependent Variable	318.67	318.67	352.22	352.22	264.87	264.87		
Observations	139	139	106	106	100	100		
State Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Specific Time Trends	No	Yes	No	Yes	No	Yes	No	Yes

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level in parentheses. Each regression is weighted by total state population of group. Hispanic ED visits are omitted as the ED data do not contain a reliable indicator of Hispanic ethnicity.