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The Opioid Epidemic: A Geography in Two Phases

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The Opioid Epidemic: A Geography in Two Phases

David A. McGranahan and Timothy S. Parker

Abstract

The United States has been experiencing a drug overdose mortality epidemic marked by the introduction and spread of opioids across rural and urban communities over the past 20 years. The current Coronavirus (COVID-19) pandemic has overshadowed the opioid epidemic but aggravated the opioid problem by hindering access to health services and increasing the number of people out of work. Research on the geography of the opioid epidemic has focused on the association between declining local economic opportunities and increases in drug overdose mortality since 2000, but the link has not always been strong. This study identifies two phases comprising the epidemic and examines their differing demographic and geographic natures. Results show that in the first phase, beginning around 2000 and ending in the early 2010s, drug overdose mortality rates soared among the middle aged as prescription opioid painkillers drove the epidemic. Physical disability is associated with chronic pain, and during this period, drug overdose deaths rose most in areas with high physical disability rates. We found little evidence that the aggravation of local economic problems was associated with increases in drug overdose mortality in the 2000s.

Since the early 2010s, opioid drug reformulation and declining prescription rates have resulted in ebbing mortality from prescription opioids. At the same time, illicit opioids such as heroin and, increasingly, fentanyl and related synthetic opioids rapidly entered the scene—causing a growing share of drug overdose deaths, marking the beginning of what we call the illicit opioid phase of the epidemic. In this phase, drug overdose mortality has risen, particularly among young adult males, and its geography has shifted markedly. Physical disability seems less a factor in rising drug overdose mortality than local (county) economic hardship and outmigration in the northeastern quadrant of the United States, where the marketing of these drugs currently appears most developed.

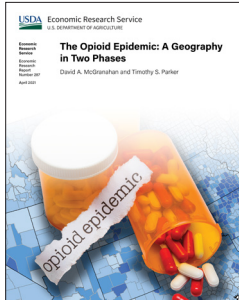
Keywords: drug overdose, chronic pain, opioids, rural, epidemic, prescription painkillers, physical disability, fentanyl, heroin, mortality, economic hardship.

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The Opioid Epidemic: A Geography in Two Phases

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What Is the Issue?

Since the late 1990s, an opioid epidemic has afflicted the U.S. population, particularly people in prime working ages of 25-54. Driven by the opioid epidemic, the age-adjusted overall mortality rate from drug overdoses rose from 6.1 per 100,000 people in 1999 to 21.7 per 100,000 in 2017, before dropping to 20.7 per 100,000 in 2018. The drug overdose mortality rate among the prime working age population was 36.5 deaths per 100,000 people in 2018. Among major causes of death in this population, this rate was exceeded only by cancer (40.5 deaths per 100,000) in 2018.

What caused this epidemic, and who has been most affected? One view is that economic misfortune has driven many working-age people to self-destructive behavior—marked by increasing drug and alcohol abuse and suicide. However, another line of research shows that local economic downturns have been a small factor in the geography of the drug overdose epidemic. A second view faults the widespread introduction of new opioid prescription painkillers, succeeded in recent years by the spread of heroin and powerful synthetics such as fentanyl. This view, which has received less research attention, is the focus of this study.

What Did the Study Find?

The study found evidence that the introduction and supply of new opioid drugs, whether through prescription painkillers in the 2000s or illicit opioids such as fentanyl in the 2010s, were major drivers of the opioid epidemic. These two drivers involved such different demographic groups and geographic areas that, in many ways, they comprise distinct phases of the epidemic. Mortality data indicate that the earlier “prescription opioid phase,” from about 2000 to 2011, most affected adults in the age range of 25-54, Native American/Alaskan Natives and Whites, and rural more than urban populations. In this phase, the epidemic was most severe in areas of high physical disability rates, which, following epidemiological research, we use as an indicator of physical pain. We found little evidence that local economic misfortune accounted for the substantial geographic differences in the severity of this phase across State rural areas or counties.

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A later “illicit opioid phase,” involving primarily heroin and extremely powerful synthetic opioids such as fentanyl, was concentrated in the northeastern United States at least through the 2014-18 period, affecting mostly young-adult (ages 25-39) urban and rural males. This phase has involved members of all the racial/ethnic groups studied—Hispanics, Blacks, American Indian/Alaskan Natives, and Whites.

Fentanyl and its analogs are often used to spike other addictive drugs, including other opioids and cocaine, creating powerful combinations of often unknown, sometimes deadly, strength. The arrival of these synthetics tended to make existing drug addictions more lethal.

In the Northeast, greater economic misfortune in certain counties in the 2010s, as measured by lower net migration rates or employment loss, was associated with greater increases in drug overdose mortality over much of the decade. While the evidence indicates that economic misfortune was an important factor in the rise of drug overdose mortality in the illicit opioid phase, it also seems likely that drug problems created economic misfortune by reducing employability and causing fewer people to move to the area.

We found economic misfortunes in the 2000s, however, just as relevant as misfortunes in the 2010s in accounting for drug overdose mortality gains in the 2010s. Our explanation is that while prescription opioids for populations with physical disability drove the rise in opioid mortality in the 2000s, the recessions of the late 2000s likely also resulted in higher addiction rates, addictions that became more fatal with the arrival of fentanyl and related drugs. Supporting this explanation is the finding that, outside the fentanyl-plagued Northeast, economic decline over the 2000s and 2010s continued to have little bearing on rising drug overdose mortality during the study period.

How Was the Study Conducted?

This study drew on two primary sources of geographic data: county and State rural area mortality rates made available by the Centers for Disease Control and Prevention (CDC) and county physical disability rates and socioeconomic characteristics from the U.S. Census Bureau.

The study comprises three sets of analyses:

The first set uses graphical analyses of State rural areas to show both the strong relationship between area opioid prescriptions and physical disability rates at the 2010-12 peak of the epidemic’s prescription phase and the strengthening links between area physical disability rates and drug overdose mortality in the 2000s, as well as the subsequent dissipation of those links in the 2010s as increases in overdose mortality shifted to State rural areas in the Northeast.

The second set of descriptive analyses examines racial and ethnic differences in rural and urban drug overdose mortality trends in the 2000s and 2010s.

The last section uses individual mortality records from the CDC to compile county drug overdose mortality rates for prime-working-age White non-Hispanics. These county data are used in regression analyses to compare factors associated with gains in drug overdose mortality in the Northeast with those responsible for gains elsewhere in the country, both in the 2000s and the 2010s.

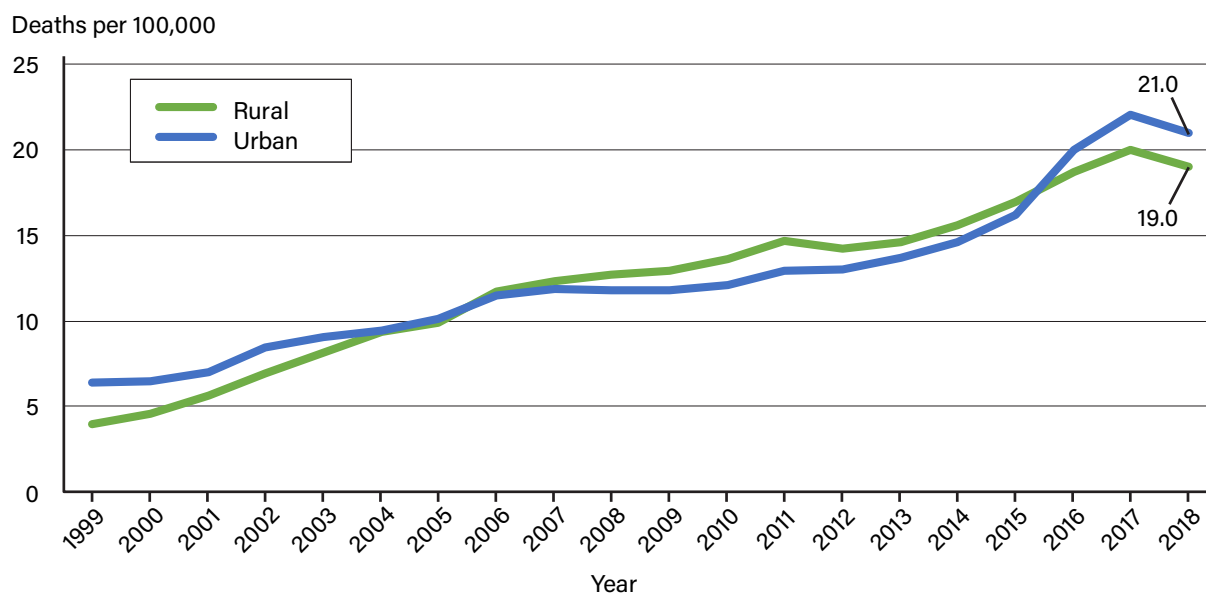
Introduction

In 2011, a Centers for Disease Control and Prevention (CDC) report labeled the high and rising mortality from prescription opioid overdoses a national epidemic (Paolozzi et al., 2011). The epidemic was largely responsible for doubling the number of drug overdose deaths nationwide, from 17,000 in 2000 to 36,000 in 2007.¹ The drug overdose epidemic has since surged, with the number of drug overdose deaths redoubling to more than 70,000 by 2017 before falling to 67,000 in 2018.^{2, 3}

Although drug abuse historically has been largely an urban problem, rural areas have been drawn into the opioid epidemic (Mack et al., 2017). According to a 2018 survey, rural Americans identify drug addiction or abuse (including opioids) and economic concerns as the two biggest problems facing their local communities (National Public Radio/Robert Wood Johnson Foundation/Harvard T.H. Chan School of Public Health, p.1). Indeed, throughout the 2000s, rural (nonmetropolitan) drug overdose mortality rates rose faster than urban (metropolitan) rates and exceeded urban rates by the end of the decade (figure 1).⁴ While rural rates continued to rise in the 2010s, the urban rates jumped even more. The central purpose of this study is to better understand the geography and demography of the opioid epidemic, particularly as it has spread into rural areas.

Figure 1

Between 1999 and 2011, rural growth in drug mortality exceeded urban
Rural and urban age-adjusted drug overdose mortality rates, 1999-2018



Note: Rural is equivalent to nonmetropolitan in 2013, while urban is metropolitan.

Source: USDA, Economic Research Service using data from the Centers for Disease Control and Prevention Wonder website.

¹Numbers downloaded from the Centers for Disease Control and Prevention Wonder website.

²To add perspective, deaths from firearms in the United States rose by 38 percent between 2000 and 2017 to a total of 39,000.

³Provisional national estimates for 2019 indicate that drug overdose mortality rose again in 2019, edging above the 2017 rate. A recent American Medical Association news brief cited a wide range of news sources suggesting the COVID-19 pandemic aggravated the opioid epidemic in 2020 by drawing away health resources, isolating addicts, and increasing unemployment, creating situations to drug abuse. The spread of fentanyl and its analogs out of the Northeast is likely adding to the fire.

⁴Throughout this report, we include drug overdose mortality from accidents, suicide, assault (intentional poisoning of another person), and unknown intent in our measure of drug overdose deaths.

There are basically two schools of thought about the rise in drug overdose mortality. One emphasizes drug supply, which involves an increased availability of licit drugs through the introduction and prescription of new opioid painkillers in the late 1990s and 2000s. This was encouraged by a growing belief in the medical community that pain should be treated independently of its cause and that treatment with narcotics rarely developed into addiction (Quinones, 2015).⁵ From this perspective, the geography of the rise in drug overdose deaths in the 2000s should mirror the geography of pain. However, while there has been research on the geography of prescriptions (e.g., McDonald et al., 2012; Paolozzi et al., 2014), the role of pain in this geography—or the geography of drug overdose mortality—has not been explored. An exception is a small English study that drew on the Health Survey of England for measures of pain and found regional differences in pain associated with variation in opioid analgesic use (Todd et al., 2018).

The second school of thought has focused on shrinking local economic opportunities that may increase people’s tendency to use drugs as a relief from mental stress. Case and Deaton (2015) noted the simultaneous rise in deaths from suicide, alcohol poisoning, and drug overdoses, particularly among midlife Whites without a college degree. Case and Deaton (2017) conjectured that the declining fortunes of Whites who had been middleclass led to an increase in what they called “deaths of despair.” From this perspective, drug mortality among middle-aged Whites rose because of an increase in demand for emotional painkillers.

The idea that unhealthful behavior rises in times of economic stress is not new. A recent international survey of published research on the effects of recession and unemployment on illegal drug use found broad evidence for this link (Nagelhout et al., 2017). Studies following Case and Deaton (2015) provided some support with respect to the influence of trade with China in the disappearance of manufacturing jobs (Pierce and Schott, 2016; Autor et al., 2018). In related results, Betz and Jones (2018) found that employment effects on county changes in opioid deaths were stronger when the analysis focused on industries likely to employ less-skilled workers. In a study of manufacturing counties between 1999 and 2016, counties exposed to auto manufacturing plant closures had greater increases in opioid deaths per 100,000 working-age people in the subsequent 5 years than over the same period among manufacturing counties not exposed to auto plant closures (Venkataramani et al., 2019).

It is easy to slip from the finding that economic misfortunes resulted in a rise in drug overdose mortality to an assumption that the opioid epidemic could be explained by a rise in despair. However, in a careful analysis including many of the same trade and industry measures analyzed in the above studies, Ruhm (2019) found that economic misfortune has played, at best, a small role in the drug overdose epidemic. This finding resonated with Betz and Jones (2018), who noted that their own analysis did little to explain why the epidemic affected some localities so much more than others since 2000. In addition, a series of studies by Shannon Monnat of the relationships between demographic, socioeconomic, and other factors with drug overdose mortality and mortality from specific opioids made clear that the antecedents to the opioid epidemic include social and economic factors that go well beyond the loss of manufacturing jobs (Monnat, 2018; Monnat, 2019; and Monnat et al., 2019). Finally, Case and Deaton (2017) raised questions about a direct link between the recessions in the post-2000 period and the spike in drug overdose mortality—suggesting a longer, even multigenerational, gestation.⁶

In the sharpest challenge to the “deaths of despair” story of the opioid epidemic, Ruhm (2019) noted changes in the demographic characteristics of opioid overdose mortality in the early 2010s as prescription opioids became less available and drugs such as fentanyl and heroin became more available. In this study, we examine

⁵Other investigative reporters (e.g., McGreal, 2018; Macy, 2018; Meier, 2018) looking into the development of the opioid epidemic also emphasized new and heavily marketed opioid drugs and greater emphasis on pain reduction in the medical community as contributing factors during this period.

⁶Most recently, Case and Deaton (2020) focused on the long-term decline in the economic well-being of midlife Whites without a college degree.

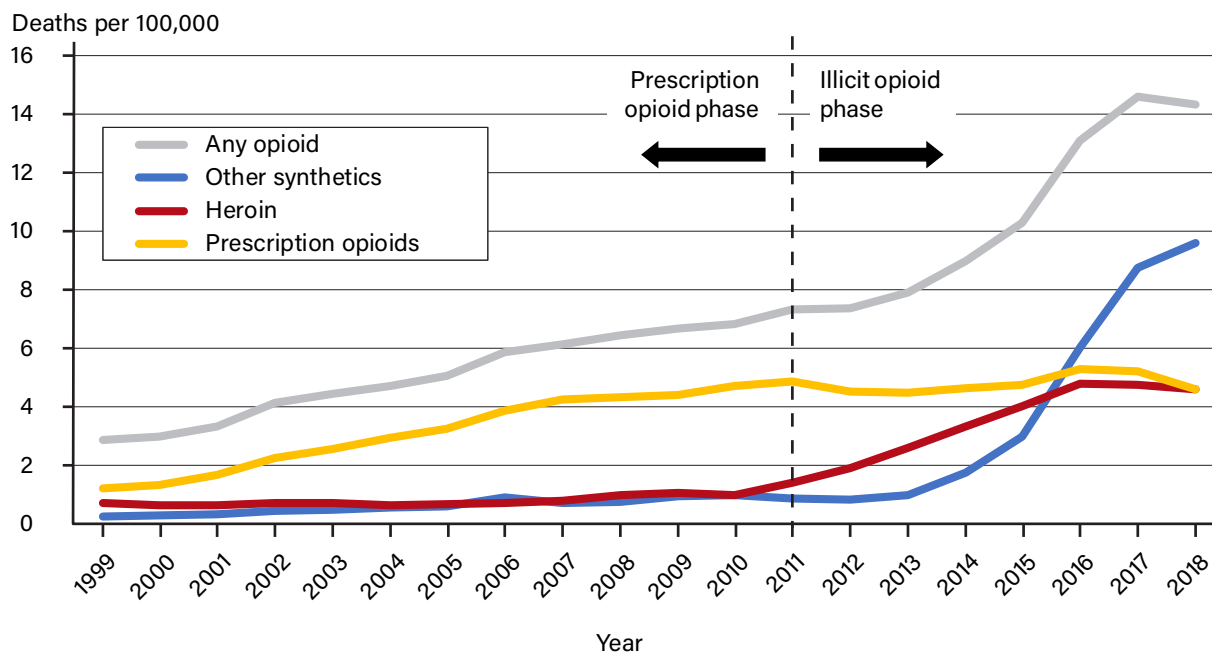
the changing geography of opioid mortality that accompanied this transition. This report presents evidence that the geography of the initial phase of the opioid epidemic more likely stemmed from the diffusion of new painkillers being prescribed to people with chronic pain than as a reaction to economic distress. Physical disability, with its associated pain, was essentially a pre-existing condition, and prescription opioids spread as healthcare providers, often encouraged by pharmaceutical companies, moved to treat physical pain with the new opioid drugs. Low education levels and weak local economies accompany physical disability but were not at the root of the prescription opioid epidemic.

This geography did not extend past the beginning of the decade, however. Opioid prescriptions have fallen from their 2011 peak as State and Federal policy changed to gain greater control over the use and abuse of prescriptions; the medical community became more aware of the danger of abuse; and since OxyContin, a time-release opioid, was reformulated in 2010 to inhibit abuse. However, an increase in the black-market availability of heroin and new, powerful synthetic opioids such as fentanyl⁷ has spurred the opioid epidemic to new heights (figure 2). We divide the analysis into a “prescription opioid phase” (1999-2011) and an “illicit opioid phase” (2011-18) to better identify the changing forces driving drug overdose mortality.

Figure 2

Prescription drugs initially drove the opioid epidemic but were succeeded by heroin and synthetics such as fentanyl after 2011

Age-adjusted drug overdose mortality involving opioids, United States, 1999-2018



Note: “Prescription drugs” includes natural, semi-synthetic opioids, and methadone, a synthetic. “Other synthetics” includes fentanyl, tramadol, and meperidine, among others. “Any opioid” includes these classes and heroin, plus deaths where the opioid is unspecified. Beginning in 2014, deaths in the overall category are less than the sum of the specific classes because fentanyl and kindred drugs are often mixed with the other opioids, with deaths assigned to more than one opioid type.

Source: USDA, Economic Research Service updating a chart from the Centers for Disease Control and Prevention using its Wonder data.

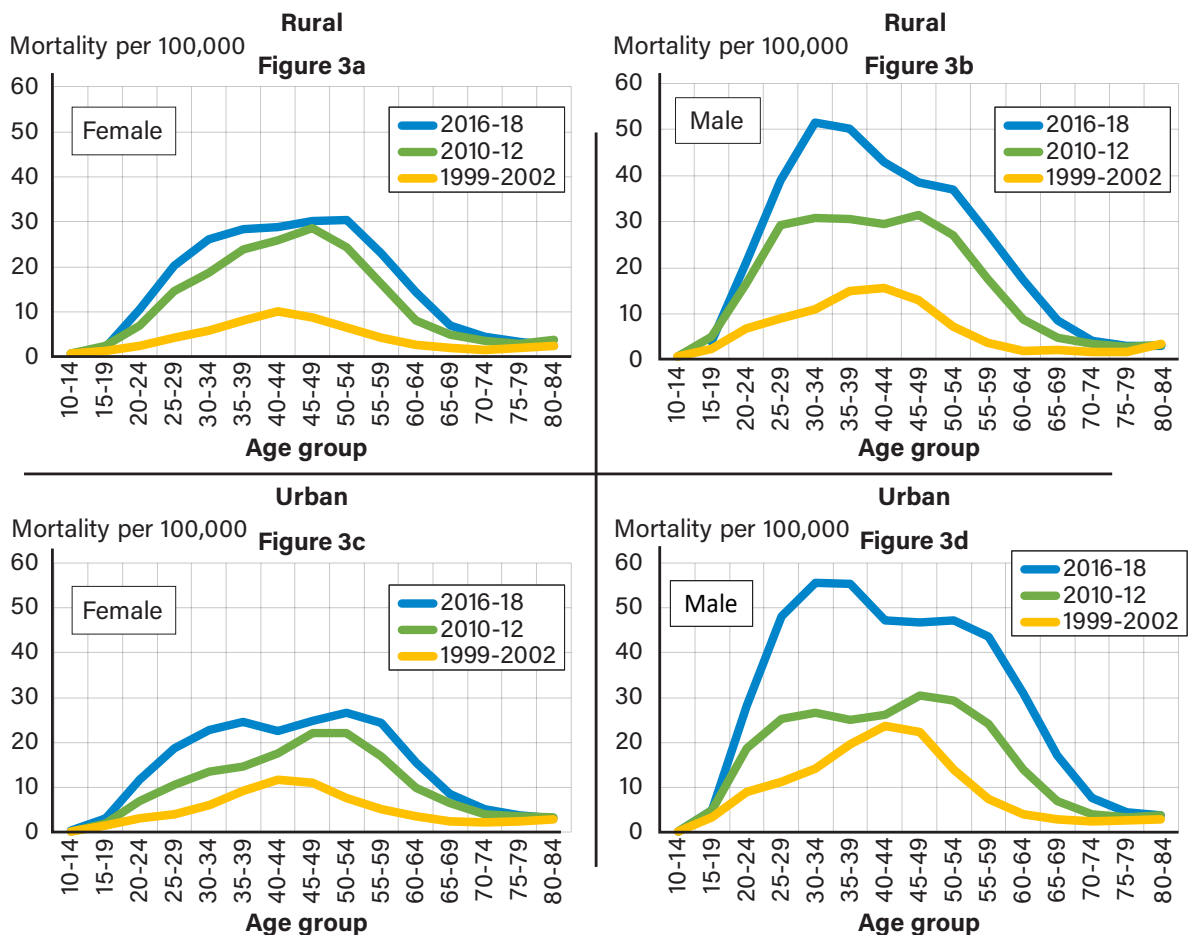
⁷We use the term “fentanyl” to refer to a group of related synthetic opioids classified as T40.4 in the International Code of Diseases 10 (figure 2). These opioids, sometimes prescribed for acute short-term pain, were classified in the past as prescription opioids (Paulozzi et al., 2011), but the preponderance of use is now illicit, and the Centers for Disease Control and Prevention now excludes them from prescription opioids, as figure 2 indicates.

In some situations, these illicit drugs may be replacing and supplementing prescription opioids,⁸ but, as noted by Ruhm (2019), the demography of the epidemic changed as illicit opioids became more widely used. During the prescription opioid phase, drug-overdose mortality increased most among middle-aged men and women in both rural and urban areas, but more recently young men (ages 25-39) seem the most affected (figure 3). Moreover, it seems likely the sale of illicit opioids faces different contingencies than prescription opioids. For instance, because these new illicit opioids are less targeted toward pain relief, their geography and associated mortality may be more reflective of local economic misfortune than are prescription opioids. Also, without reliance on local pharmacies for distribution, sales networks may be thin in rural areas, especially those that are sparsely settled.

The study considers heroin and synthetic opioids such as fentanyl to be “illicit opioids,” since they track roughly the same demography and geography. However, their roles in the opioid epidemic have been quite different. Heroin generally serves as an alternative to other drugs, including prescription opioids.⁵ In contrast, illicit fentanyl and its analogs more often serve as high-strength supplements, mixed with and adding to the effects of heroin, cocaine, prescription opioids, or other addictive drugs (Hedegaard et al., 2008). More than creating new addictions, fentanyl and its analogs have likely made existing addictions more lethal.

Figure 3

After 2010-12, the rise in drug overdose mortality involved primarily young adult males
Drug overdose mortality rates by rural-urban (nonmetropolitan-metropolitan) location, sex, and age group, 1999-2002, 2010-12, and 2016-18 averages



Source: USDA, Economic Research Service calculations using Centers for Disease Control and Prevention Wonder data.

⁸Evans et al. (2019) found that the 2010 reformulation of time-release OxyContin, which made it impossible to release all the medication at once, “ignited the heroin epidemic” as people switched to more accessible drugs.

Previous research on the changing geography of opioids since 1999 has treated that time as a single period. The central thesis of this study is that drug overdose mortality in the prescription opioid and illicit opioid phases had different drivers and different geographies. Prescription opioids and resulting mortality were highest in counties with high incidences of physical disability, while illicit opioids went to more densely settled counties in the Northeast, particularly those with limited economic opportunities for young adults.

The study presents three distinct analyses related to the drug epidemic, each with its own section. The first focuses on physical disability as the driver of the spread of prescription opioids and drug overdose mortality in the 2000s and its subsequent ebbing influence on the opioid epidemic's geography as the illicit opioid phase became predominant. This analysis focuses on areas outside metropolitan boundaries, labeled "State rural areas." The second analysis focuses on the distinct experiences of different racial/ethnic groups, as the opioid epidemic has not been pandemic across all groups. The third analysis uses county data to consider community factors (such as local education levels and employment change) that may have affected the epidemic's geography during each phase.

Opioid prescription data

Yearly estimates of the number of county retail opioid prescriptions per capita were downloaded from the Centers for Disease Control and Prevention for 2006 to 2017 on its website under "drug overdose maps." The data are not available by age, race/ethnicity, or any other population subgroup. We present data for 2010-12, the 3 years with the largest number of prescriptions, recalculating rates from per 100 residents to per 100 residents ages 25 to 54, surmising from mortality rates that this is the population most likely to have received retail prescriptions (see figure 3). The data are from pharmacy records that provide the pharmacy location but not recipient residences. During this period, approximately 13 percent of the counties had no records because the county had no pharmacy, none was sampled, or the data were erroneously attributed to an adjacent, more populous county according to the sampling rules used. There are obvious questions about the validity of the data for smaller rural counties. Analyzing State rural areas rather than counties largely avoids these problems but at the expense of having a small number of cases (47) and eliminating within-State differences from the analysis.

Physical Disability and the Rural Prescription Opioid Epidemic

Prescription opioids are painkillers. The simplest explanation for the geographies of opioid prescriptions and drug overdose mortality in the 1999-2002 to 2010-12 period is that they rose most in places with the highest incidence of chronic pain. Although there are no direct measures of a geography of chronic pain, there are reasons to believe that physical disability rates may serve as proxies for the prevalence of chronic pain in a locality.

First, Krueger (2017, table 6) showed that pain and self-reported disability were significantly linked. In a survey of men ages 25-54, he found that 62 percent of respondents with a self-reported disability also reported episodes of pain the previous day, and 45 percent reported taking pain medication the previous day. In contrast, among those not reporting a disability, the proportions were halved—about 29 percent reported episodes of pain, and 21 percent reported taking pain medication the previous day. Epidemiological survey research has also found a close link between pain and physical disability (see, for example, Scudds and Robertson, 2000, and Lee et al., 2015).

Second, epidemiological research has found that physical disability is strongly linked to chronic disease. According to a literature review, “The major underlying causes of physical disability are chronic diseases, including both acute events, such as hip fracture and stroke, and slowly progressive diseases such as arthritis and heart disease,” (Fried and Guralnik, 1997, p. 92). Chronic disease is likely related to opioid prescription, addiction, and overdosing. As addiction builds over time, increasing dosages eventually are required to obtain the same pain relief (Chou et al., 2015; Krebs et al., 2018).⁹

The 2000 Census question on physical disability provides a good proxy for chronic pain due to its wording and the national economic circumstances under which it was conducted. The question asked if the respondent had “a long-lasting condition that substantially limits one or more basic physical activities such as walking, climbing stairs, reaching, lifting, or carrying” (Census 2000 Summary File 4 Technical Documentation/prepared by the U.S. Census Bureau, 2003, Appendix D, p. 13).¹⁰ As noted above, associated pain often limits these activities.

Is our physical disability measure valid?

As noted by Case and Deaton (2015), economists are generally skeptical of physical disability measures as indicators of health. People who become unemployed will often apply for physical disability insurance, so a physical disability measure may reflect local economic conditions as well as actual disability (Autor et al., 2013). Physical disability claims rise during economic recessions, likely resulting in higher reports in the Census (Maestas et al., 2015). However, April 2000, the Census enumeration month, had the lowest unemployment rate (3.8 percent) of any month (seasonally adjusted) between January 1969 and August 2018. This minimized any potential for the influence of job loss on the measure.

⁹For pain-relief regimes lasting longer than 3 months, the Centers for Disease Control and Prevention now recommends non-opioid treatment (Dowell et al., 2016).

¹⁰The 2000 Census reports physical (and other) disability for only four age categories: up to 15 years, 15-20, 21-64, and 65 and over. Although chronic health problems and disability seem likely to be much higher for people over 50 than people in their 20s, it is not possible to adjust physical disability statistics for differences in age distribution within this broad 21-64 age group.

Further evidence of the validity of our physical disability measure

Despite using a measure from the population census rather than administrative records and using a gauge from a time of prosperity, continued skepticism among some researchers led us to undertake two analyses to test the validity of physical disability as a measure of chronic pain.

The first analysis examined two issues: whether physical disability was negatively associated with prior employment change, and whether the measure was sensitive to conditions known to be associated with chronic disease. Here we drew on the “life course” approach to health problems, which has shown that difficult experiences in childhood tend to be associated with health problems later in life (Case et al., 2005; Montez and Hayward, 2014; Monnat and Chandler, 2015). The closest precedent to our analysis is Bowen and Gonzalez (2010), who used survey data from older Americans to show that childhood socioeconomic stress had a bearing on chronic disabilities in adulthood, even when taking respondents’ present-day socioeconomic situations into account.

Using child poverty rates in 1970 to reflect county socioeconomic stress when the current middle-age population was young, we found this stress correlated with local adult physical disability (ages 21-64) rates in 2000, even when considering current adult poverty (see Appendix 1 and its table 1.2). Further, self-reported physical disability in the working-age population in 2000 was not related to employment change over the previous decade as skeptics of physical disability measures have suggested, perhaps because the U.S. economy was relatively healthy in the 1990s.

The second analysis related to physical disability outcomes. To the extent that our measure reflects the pervasiveness of chronic disease, counties with high physical disability rates should also have high mortality rates from natural causes (defined here to include all deaths except those related to accidents, suicide, or homicide), other conditions being equal. Even after taking into account local education—a strong predictor of health (Cutler and Lleras-Muney, 2011) and longevity (Lleras-Muney, 2005)—and the deleterious effects of poverty (Adler and Stewart, 2010), we found across State rural areas that 2000 physical disability rates among Whites (ages 21-64) were strongly related to their natural cause mortality rates in 1999-2002 (appendix table 1.3). We obtained similar results when we repeated the analysis for rural counties alone and for all counties, confirming their robustness.

These analyses together support the validity of our physical disability measure and suggest that residents of counties with high levels of reported physical disability were likely target populations for prescription opioids.

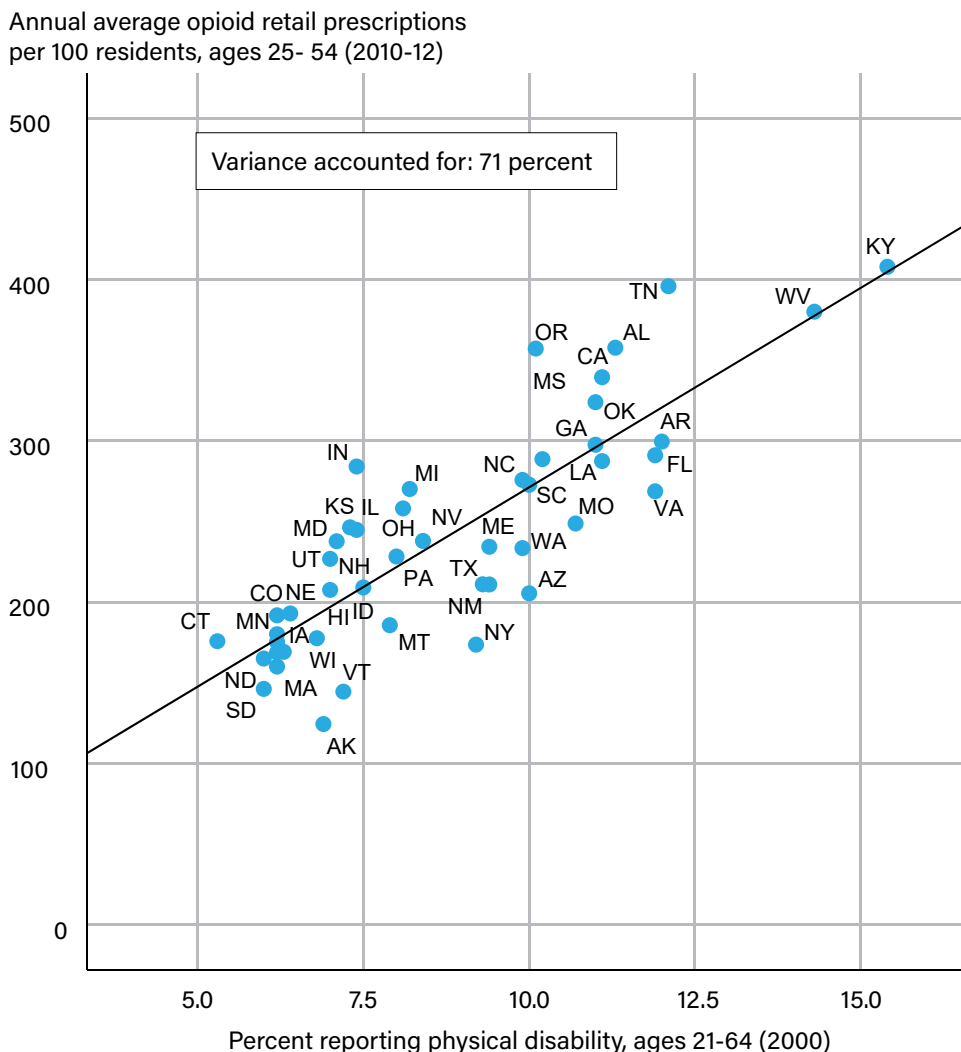
State rural area physical disability, opioid prescriptions, and drug overdose mortality

The tie between physical disability and opioid prescriptions is remarkably strong. Physical disability in the rural (nonmetropolitan) population ages 21-64 in 2000 accounted for a substantial 71 percent of the variance in opioid prescriptions across State rural areas 10-12 years later (figure 4).¹¹ Rural Kentucky, West Virginia, and Tennessee had the highest physical disability rates—and the highest opioid prescription rates in 2010-12. Heavily agricultural States, including the Dakotas, Iowa, Minnesota, and Nebraska, had among the lowest physical disability rates and correspondingly relatively few prescriptions per prime-age adult.

¹¹Variance here is a statistical term denoting differences across units, in this case State rural areas. If physical disability allowed us to predict county drug prescriptions exactly, it would account for 100 percent of the variance in prescription rates across counties. At the other extreme, if physical disability was absolutely no help in predicting county prescription rates, the variance accounted for would be zero. As evident in the scatter plot, physical disability is a good predictor of State rural area prescription rates.

Rural county opioid retail prescription rates in 2010-12 were closely tied to 2000 physical disability rates

Physical disability rate, ages 21-64, 2000, and average annual retail opioid prescription rates per 100 residents ages 25-54, 2010-12, by State rural (nonmetropolitan) area



Note: The line and its variance accounted for are derived from regression analysis. The “variance accounted for” measures how close the dots are to the line and ranges from zero percent (no association) to 100 percent (perfect fit).

Source: USDA, Economic Research Service calculations using data from the Centers for Disease Control and Prevention and U.S. Census Bureau.

Affirming the relevance of physical disability, the socioeconomic measures in this study (also from Census 2000) accounted for much lower proportions of the variation in opioid prescription rates: middle-age poverty rate (24 percent), share of people ages 25-64 with no schooling beyond high school (43 percent), and share of single-parent families with children (10 percent).

Given the thesis that drug overdose mortality rose because of increasing economic hardship, we also looked at the relationship between employment change in 1999 to 2006-10 and the 2010-12 opioid prescription rates. We found that the better the employment situation, the lower the opioid prescription rates. However, our analysis also showed that physical disability in 2000 was associated with less favorable subsequent employment change across State rural areas. Once this was taken into consideration, it was apparent that recent employment change itself had little bearing on the rate of opioid prescriptions. This is consistent with previous research on the opioid epidemic in the 2000s that found local economic problems could account for little of the epidemic's geography.

Figure 5 plots the relationships between physical disability in State rural areas in 2000 and drug-overdose mortality rates (ages 25-54) at three time periods: at the beginning of the opioid epidemic (1999-2002), at the height of the prescription phase (2010-12), and in the new phase involving heroin and fentanyl and related drugs (2016-18). In 1999-2002, there was little relationship between physical disability and the drug overdose mortality for those ages 25-54. For example, the drug overdose mortality rates were only slightly above average in rural West Virginia and Kentucky, which had the highest physical disability rates.

By 2010-12, however, the local rate of physical disability became a good predictor of drug overdose mortality as well as opioid prescriptions.¹² Drug overdose mortality rates had more than quadrupled in rural Kentucky and West Virginia and doubled in rural areas with average physical disability rates. Among the rural State areas with low physical disability rates, the upper Midwest agricultural regions (Nebraska, Iowa, North Dakota, South Dakota, and Minnesota) had scarcely any gain in drug overdose mortality between 1999-2002 and 2010-12.¹³

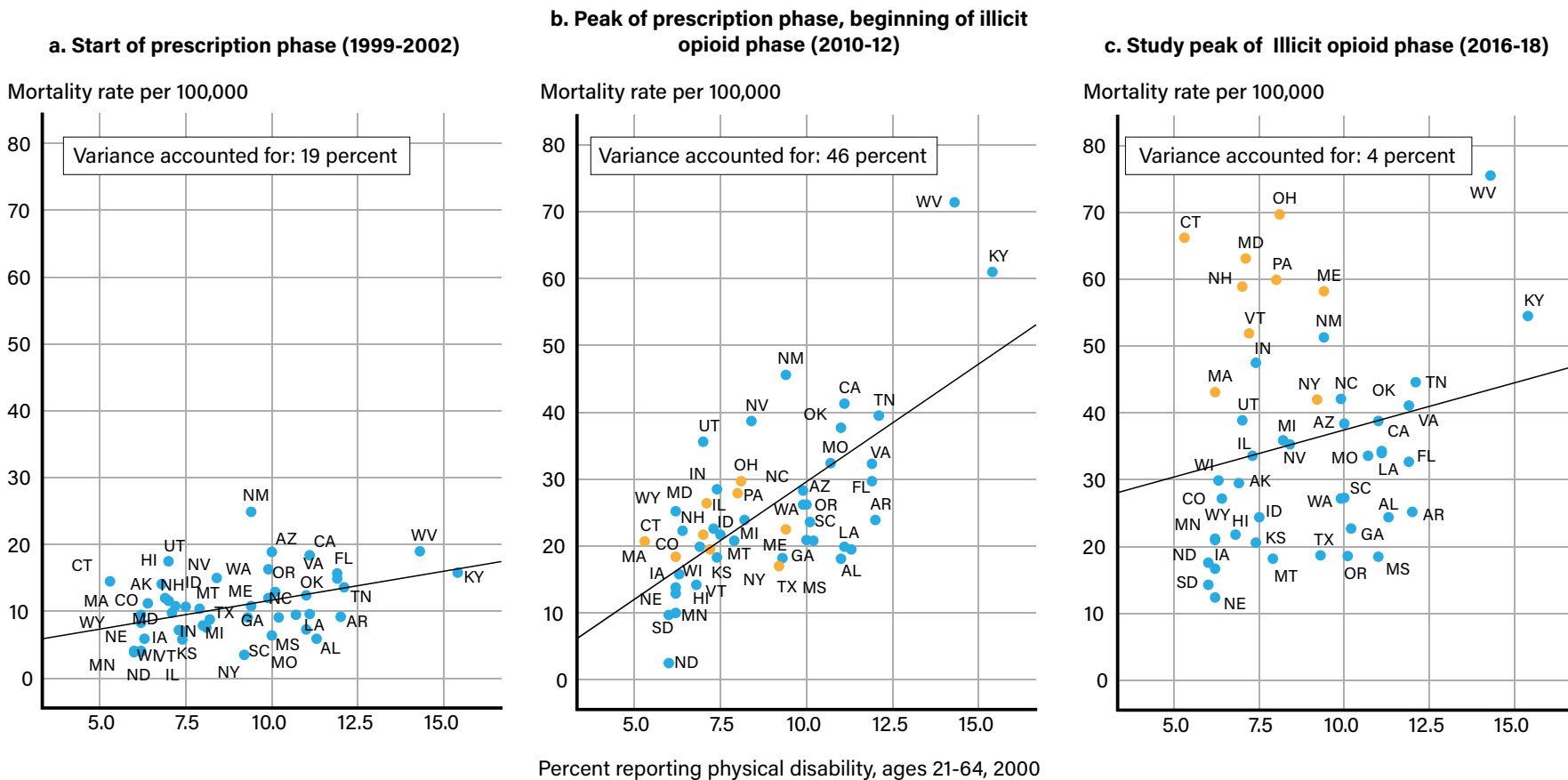
¹²As noted in the box "Drug overdose mortality in State rural areas," the State rural area variation in drug overdose mortality accounted for by opioid prescriptions in 2010-12 was 40 percent.

¹³This pattern may have been reinforced by the marketing strategy of drug companies. For instance, OxyContin, the delayed-release opioid, was marketed most heavily to doctors already prescribing opioids (Van Zee, 2009).

Figure 5

Drug overdose mortality was most closely associated with physical disability at the peak of the opioid prescription phase in 2010-12

State rural (nonmetropolitan) area physical disability, ages 21-64, 2000 and age-adjusted drug overdose mortality rates, ages 25-54, at three stages of the opioid epidemic



Note: Physical disability is for ages 16-64. Sloped lines and variances accounted for derive from regression analyses. The variance accounted for is a measure of how close the dots are to the lines and varies from 0 to 100 percent, when the dots are all on the line. The orange dots represent the top 9 States in gains in rural drug overdose mortality between 2010-12 and 2016-18: CT, ME, MD, MA, NH, NY, OH, PA, and VT.

Source: USDA, Economic Research Service calculations using the Centers for Disease Control and Prevention Wonder and U.S. Census Bureau data.

Drug overdose mortality in State rural areas

Any analysis of the opioid mortality epidemic faces unfortunate tradeoffs as to the choice of a measure to use. Data on opioid overdose mortality alone are available but incomplete. Although records are improving, those filling out death certificates are not required and are not necessarily able to identify drugs involved in overdose deaths and often do not; consequently, actual deaths from opioids are underestimated (Ruhm, 2019). The degree of underestimation varies geographically. The broader alternative measure, drug overdose mortality, results from a variety of drugs besides opioids, such as methamphetamines or cocaine, so using drug overdose mortality as a proxy for opioid deaths results in some overestimating of the role of opioids. Overestimation likely would vary from place to place, depending on what other drugs are in use.

Using 2010-12 data for State rural areas, we found that the opioid prescription measure accounted for a much higher proportion of the variation in drug overdose mortality overall (40 percent) than in drug overdose mortality specifically from opioids (23 percent). Similar results were obtained for physical disability in individuals ages 21-64: 48 percent versus 33 percent. This pattern suggests that, despite the inclusion of other drugs, drug overdose mortality better reflects the opioid crisis than the opioid death measure, for which data are missing. We assume these biases have remained constant and use the opioid mortality measures only to compare trends in different types of opioids, figures 2 and 6 being examples.

Regional concentration of illicit opioid mortality

This association between areas of physical disability and rises in drug overdose mortality largely disintegrated by 2016-18. For many State rural areas, there was little change in drug overdose mortality rates between 2010-12 and 2016-18. However, for nine State rural areas in the Northeast quadrant of the United States, the rate rose by more than 20 and sometimes 30 deaths per 100,000: Connecticut (CT), Maine (ME), Maryland (MD), Massachusetts (MA), New Hampshire (NH), New York (NY), Ohio (OH), Pennsylvania (PA), and Vermont (VT).¹⁴ These rural areas, indicated by red markers in figures 5b and 5c, do not have particularly high rates of physical disability, but in 2016-18 they were among the areas with the highest rates of drug overdose mortality.

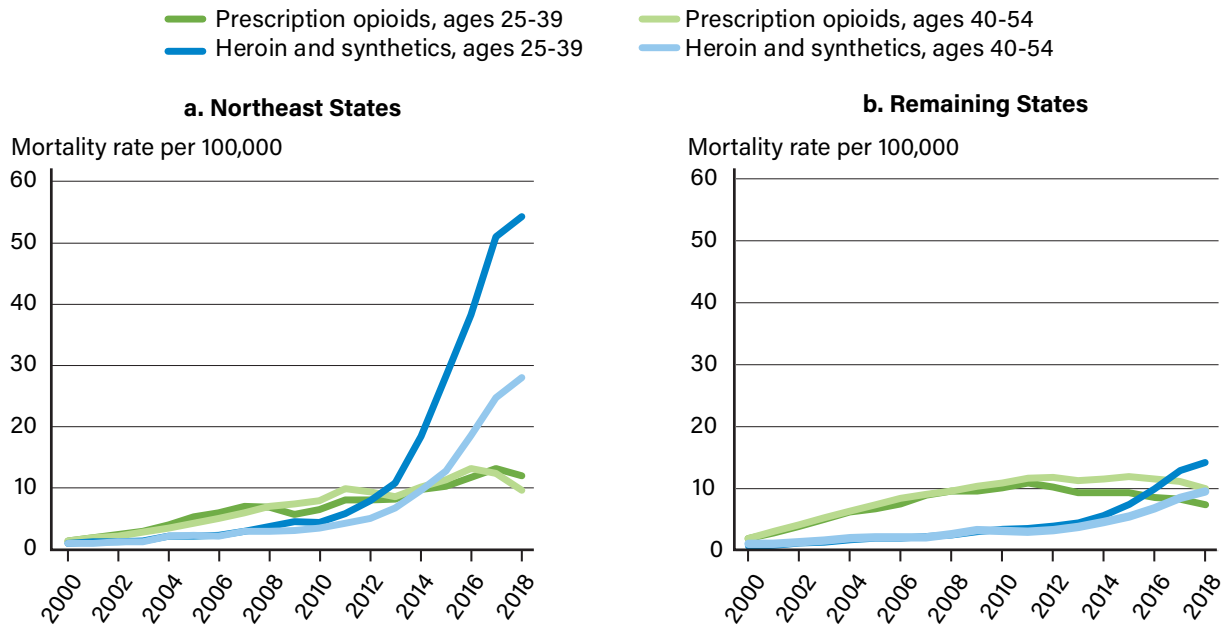
Mortality associated with heroin and synthetic opioids such as fentanyl increased at an extraordinary pace between 2010-12 and 2016-18 in these nine rural areas, especially among young adults (ages 25 to 39) (figure 6a).¹⁵ Mortality from these drugs also increased in the rural parts of other States, but generally at more modest paces among both young and middle-aged adults (figure 6b).

¹⁴We use the term “northeastern quadrant” or “Northeast” to designate this group of States, later including completely urban States: Delaware (DE) New Jersey (NJ), and Rhode Island (RI), and the District of Columbia (DC), which are contiguous. This designation should not be confused with the Census-defined Northeast Region, which does not include OH, MD, or DC.

¹⁵Improved detail on death certificates of the particular drugs involved in fatal drug overdoses may have somewhat exaggerated the rise in deaths from fentanyl-type drugs and understated the decline in other drugs over the study period. Hedegaard et al. (2018) reported that the proportion of drug overdose deaths that did not mention a particular drug or drug class declined from 22 percent in 2011 to 13 percent in 2016.

Figure 6

Rises in rural mortality from heroin and synthetics after 2011 was concentrated in the Northeast
Running 2-year average rural (nonmetropolitan) overdose mortality rates, 2000 to 2018, Northeast and remaining States, ages 25-39 and 40-54, prescription opioids and heroin and other synthetics



Note: Some of the apparent rise in mortality by opioid type reflects improvements in reporting. Northeast States with rural areas include CT, ME, MD, MA, NH, NY, OH, PA, and VT. Statistics are running 2-year averages. See figure 2 for a description of opiate categories. Mortality statistics are not age-adjusted.

Source: USDA, Economic Research Service calculations using Centers for Disease Control and Prevention Wonder data.

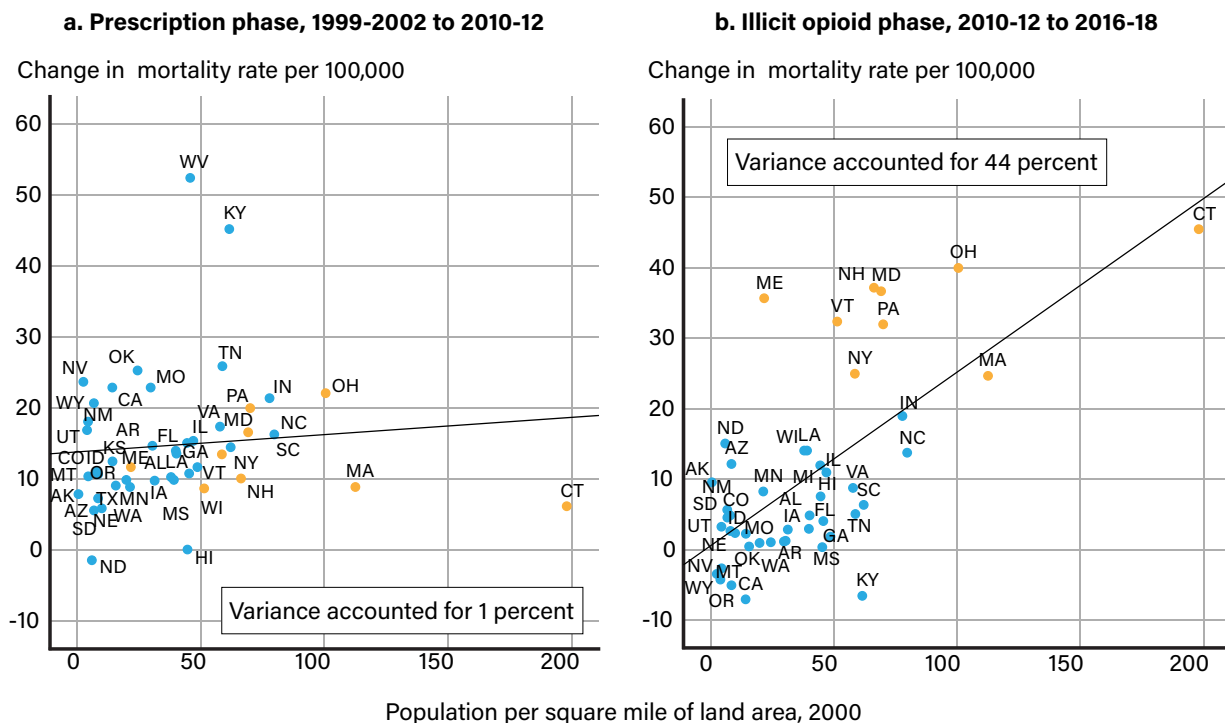
It is not immediately clear why these State rural areas had such a rapid rise in heroin and fentanyl opioid mortality in the 2010s, but the confinement to the Northeast suggests that differences in supply must be considered. To explore this issue, we made two assumptions. First, especially because they are largely imported, we assumed heroin and fentanyl tended to spill into rural areas from neighboring urban centers, making State rural availability (and mortality) somewhat dependent on urban availability (and mortality). Second, we assumed that distribution systems to rural areas would be stronger and more pervasive where population density was higher, yielding a larger increase in rural drug overdose mortality in the higher density rural areas.

Our analysis of recent changes in State rural area drug overdose mortality tends to confirm these conjectures. First, area population density had virtually no bearing on rural changes in drug overdose mortality in the 2000s when pharmacies were the source of prescription opioids, but there was a strong relationship in the 2010-12 to 2016-18 period (figure 7). Second, rural and urban changes in drug overdose mortality within the same State had a modest correlation in 1999-2002 to 2010-12 ($r=0.33$), but this correlation became much stronger in 2010-12 to 2016-18 ($r=0.72$), consistent with there being a stronger urban influence on rural drug overdose mortality in the same State during that decade.

Figure 7

Changes in rural drug overdose mortality became tied to population density in the illicit opioid phase

State rural (nonmetropolitan) area population density and changes in age-adjusted drug overdose mortality rates, ages 25-54



Note: The orange dots indicate State rural areas ranked in the top 9 for gain in drug-overdose mortality, 2010-12 to 2016-18 (CT, ME, MD, MA, NH, NY, OH, PA, and VT). Sloped lines and variances accounted for are derived from regressions. Variance accounted for is a measure of the distance of the dots from the line, and ranges from 0, when the dots do not follow a line at all, to 100 percent, when the dots are all exactly on the line.

Source: USDA, Economic Research Service calculations using data from the Centers for Disease Control and Prevention and U.S. Census Bureau.

The State rural areas of high gain in drug overdose mortality in the Northeast tended to have higher residential density ($r=0.51$) and higher urban increases in drug overdose mortality than other States ($r=0.66$). Do these qualities account for the very high increases in drug overdose mortality in the rural Northeast quadrant between 2010-12 and 2016-18, or are there other drivers? Table 1 reports the results of a multivariate analysis of the associations of these measures with changes in rural drug overdose mortality in the 2010s. Also included was the rural physical disability rate on the expectation that, because of restrictions on prescriptions and changes in the formulation of the opioid Oxycontin, disability might be associated with declines in drug overdose mortality in this period.

From equation 1 in table 1 it is apparent that all three factors—lower rates of physical disability, urban gain in drug overdose mortality, and population density—help account for the changing geography in the rural drug overdose epidemic in 2010-12 and 2016-18. When we also consider the nine Northeast States with the highest rural gains in drug overdose mortality as a group, however (equation 2), it is apparent that these three

factors do not fully account for the greater gains in these States: The sizable partial correlation of being in a northeastern State with change in mortality ($r_p = 0.67$) indicates an independent relationship.¹⁶

Table 1

Population density and State urban changes in drug mortality account for only some of the substantial increases in State rural area drug mortality in the Northeast in 2010-12 to 2016-18

Regression of changes in age-adjusted State rural (nonmetropolitan) area drug overdose mortality rates, ages 25-54, 2010-12 to 2016-18 on selected area characteristics

Area attributes	Coefficients		
	r	Equation 1 Partial r	Equation 2 Partial r
Physical disability rate, 2000	-0.37	-0.69	-0.56
Change in State urban drug overdose mortality, 2010-12 to 2015-17, ages 25-54	0.71	0.69	0.48
Population density, 2000	0.67	0.37	0.31
Northeast State	0.88		0.67
R ² (percent of variation accounted for)		76	87
N=47			

Note: Coefficients are all statistically significant ($p < .05$ level). Northeast States with rural areas include CT, ME, MD, MA, NH, NY, OH, PA, and VT. Physical disability is for ages 21-64. r = correlation coefficient. Partial r = partial correlation coefficient.

Source: USDA, Economic Research Service, calculations based on data from Centers for Disease Control and Prevention Wonder website and the U.S. Census Bureau.

Regional concentration seems then to be a separate factor shaping the geography of the rise in illicit drug mortality. Not only were all nine States with high rural gains in the northeastern quadrant of the United States (see figure 7b), the 14 States with the highest urban area gains include all but one of the nine top States in rural gains and the completely urban (by our definition) neighboring States of Delaware (DE), New Jersey (NJ), and Rhode Island (RI), and the District of Columbia.^{17 18} This centering on the northeastern quadrant seems likely to be at least partly the result of drug ports of entry and contagion, where problems leak across State lines.

The analysis in this section has looked at the changing geography of the rural drug epidemic using State rural areas as the units of comparison. In section C below, we address some of the same questions using counties as units of comparison. That analysis allows greater attention to the role of local economic hardship in the geography of the drug epidemic within the Northeast.

¹⁶ A comparison of the correlations in this table with comparable correlation statistics for 1999-2002 to 2010-12 demonstrates the sharp differences in the geographies of change in drug overdose mortality between the two periods. Thus, the correlation of physical disability with change in drug overdose mortality went from $r = 0.65$ in the 2000s to $r = -0.37$ in the 2010s. On the other hand, correlations involving urban drug overdose mortality ($r = 0.33$), population density ($r = 0.11$), and Northeast location ($r = -0.07$) were much smaller in the 2000s than in the 2010s.

¹⁷ Kentucky and West Virginia were exceptions, with high urban gains, but perhaps because of low rural population density and isolation from urban areas, very low (West Virginia) or nonexistent (Kentucky) rural gains.

¹⁸ For another analysis of regional concentration, based on drug mortality levels rather than change but highlighting different types of drugs, see Kiang et al., 2019.

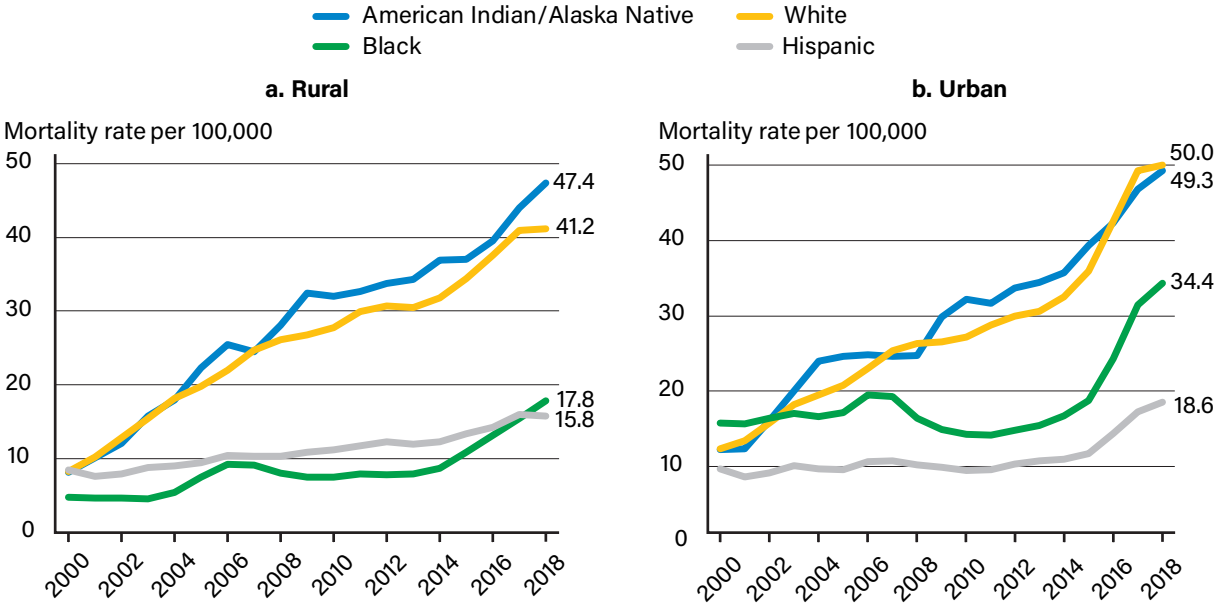
Race/Ethnicity and Drug Overdose Mortality

The opioid epidemic has not affected all racial/ethnic groups equally. Using data from 2010, Mack (2013) noted that White (non-Hispanics) and American Indian/Alaskan Native populations had much higher drug overdose mortality rates than Blacks, Hispanics, or Asian/Pacific Islanders. Figure 8 updates the information for populations ages 25-54 and distinguishes rural from urban mortality. Differences between White and American Indian/Alaskan Native populations and Hispanic, Black, and Asian/Pacific Islander populations are stark, especially in rural areas, and have only increased over time (although a substantial increase in drug overdose mortality has occurred among urban Blacks in the past few years).

Figure 8

American Indian/Alaskan Natives and Whites have been the most affected by the opioid epidemic, although this difference has become less pronounced in urban areas since the mid-2010s

Rural (nonmetropolitan) and urban (metropolitan) age-adjusted drug overdose mortality rates, ages 25-54, by race/ethnicity, 2000-18 (running 2-year averages)



Note: Racial groups are non-Hispanic; Hispanics are of any race.

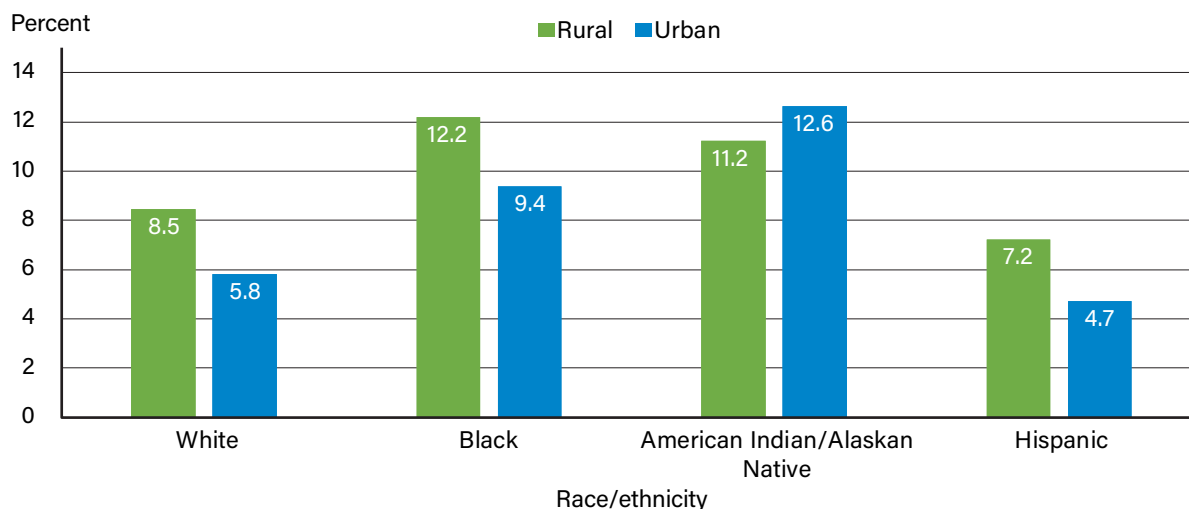
Source: USDA, Economic Research Service, calculated from Centers for Disease Control and Prevention Wonder website.

One possible explanation for the growing discrepancy through the early 2010s could be that physical disability is much more prevalent among the White and American Indian/Alaskan Native populations than among Blacks or Hispanics. This explanation is plausible for American Indian/Alaskan Native populations, who have relatively high disability rates—above 10 percent—in both rural and urban areas (figure 9). It is also credible for Hispanics in the United States, who, because of their relatively young age or through their selective immigration, have lower physical disability levels than Whites.¹⁹ The explanation does not hold for Blacks, however. Consistent with prior research on White and Black physical disability in general (Kington and Smith, 1997; Keil et al., 1989), we found disability rates among Blacks to be relatively high in both rural and urban areas. In 2000, 12.2 percent of rural Blacks (ages 21-64) and 9.4 percent of urban Blacks reported they were physically disabled, while the corresponding disability rates among Whites were 8.5 percent and 5.8 percent, respectively (figure 9).

Figure 9

Blacks and American Indian/Alaskan Native working-age populations had higher disability rates than Whites in 2000

Rural (nonmetropolitan) and urban (metropolitan) physical disability rates for ages 16-64, by race/ethnicity, 2000



Note: Race categories exclude Hispanics; the Hispanic category includes all races.

Source: USDA, Economic Research Service calculations based on U.S. Census Bureau data.

An alternative explanation—that Blacks (and, to a lesser extent, Hispanics) have been less likely to be prescribed opioids for their disabilities—has received substantial research support. Survey data suggest that compared to Whites, Blacks and Hispanics have less access to healthcare (Weinick et al., 2000). Even when healthcare was obtained, however, Blacks and Hispanics were substantially less likely to receive opioid prescriptions than Whites for many of the same reported ailments (Meghani et al., 2012; Pletcher et al., 2008).²⁰

¹⁹Using data downloaded from the Centers for Disease Control and Prevention Wonder website, we calculated for each racial/ethnic group the proportion that was age 50 or more. This proportion was about 31 percent for Whites, 25 percent for Blacks and American Indian/Alaskan Natives, and 19 percent for Hispanics.

²⁰A third possible explanation for racial differences in drug overdose mortality rates in the 2000s is differential local availability of prescription opioids. A New York City study found that pharmacies in minority neighborhoods were less likely than pharmacies elsewhere to carry a full supply of prescription opioids (Morrison, et al., 2000). We did not find any further research on this question.

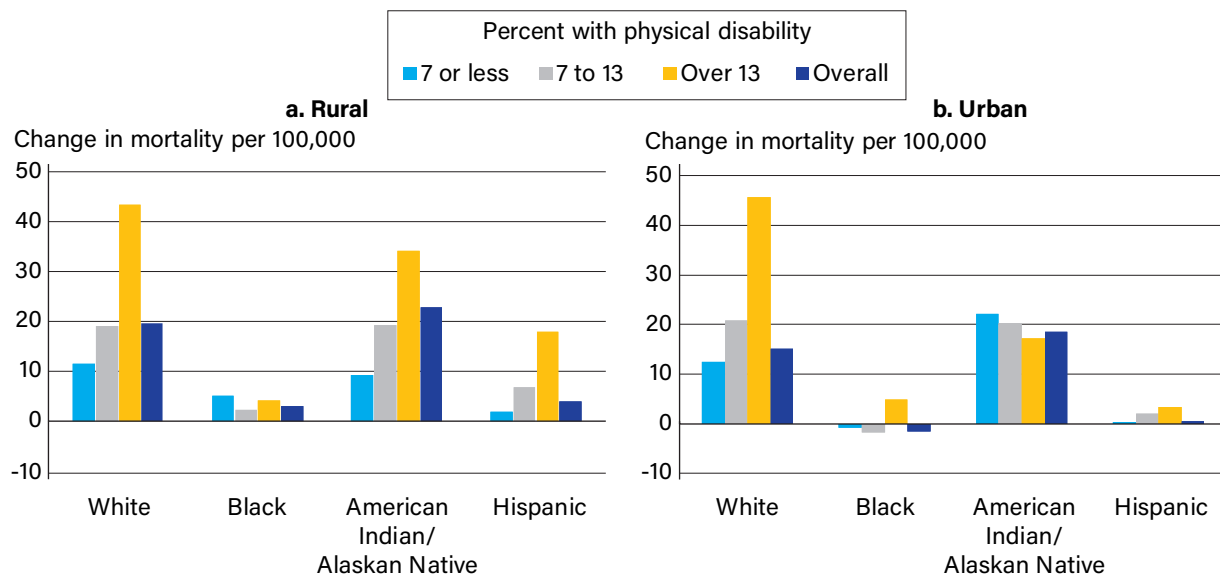
Our analysis relating physical disability rates to drug overdose mortality suggests that the strength of this relationship varied considerably across racial/ethnic groups in both rural and urban areas (figure 10). For both rural and urban Whites, the higher the rate of physical disability in 2000, the greater the increase in drug overdose mortality between 1999-2002 and 2010-12. Note that for any given physical disability level, the urban increase in White mortality is somewhat larger, arguably because of greater urban access to healthcare and prescriptions.²¹

Nevertheless, because rural physical disability rates are considerably higher, the overall increase in drug overdose mortality (ages 25-54) was greater in rural than urban areas.

Figure 10

During the opioid epidemic's prescription phase, for rural and urban Whites and rural American Indian/Alaskan Natives, physical disability was strongly related to drug overdose mortality, but there was little or no relationship for either rural or urban Blacks

Changes in age-adjusted drug overdose mortality, ages 25-54, 1999-2002 to 2010-12, for rural (nonmetropolitan) and urban (metropolitan) racial/ethnic groups, by their respective 2000 area physical disability rates, ages 21-64



Note: Age adjustments to mortality data allow fair comparisons across groups with different age distributions. Racial groups are non-Hispanic, while Hispanics include all races.

Source: USDA, Economic Research Service calculations based on data from the Centers for Disease Control and Prevention Wonder website and U.S. Census Bureau.

The rural relationship between physical disability and drug overdose mortality for rural American Indian/Alaskan Native populations resembles the rural White pattern. However, there was no apparent link between American Indian/Alaskan Native physical disability and drug overdose mortality in urban areas, perhaps because the Indian Health Service, a likely source of prescriptions covering about half of the American Indian/Alaskan Native population overall, plays a much smaller role in urban areas than in rural ones (Indian Health Service, 2018). Among rural Hispanics, there was a relationship between physical disability and increases in drug overdose mortality, but these increases were relatively small compared with the increases among the White and American Indian/Alaskan Native populations. Urban Hispanics had little gain in drug overdose deaths, perhaps because their population is relatively young. Among Blacks, there was no appre-

²¹For instance, among rural residents in counties with disability rates between 10 and 13 percent, drug overdose mortality rose by 23 deaths per 100,000 in the population ages 25-54. The corresponding urban rise was 28 deaths per 100,000.

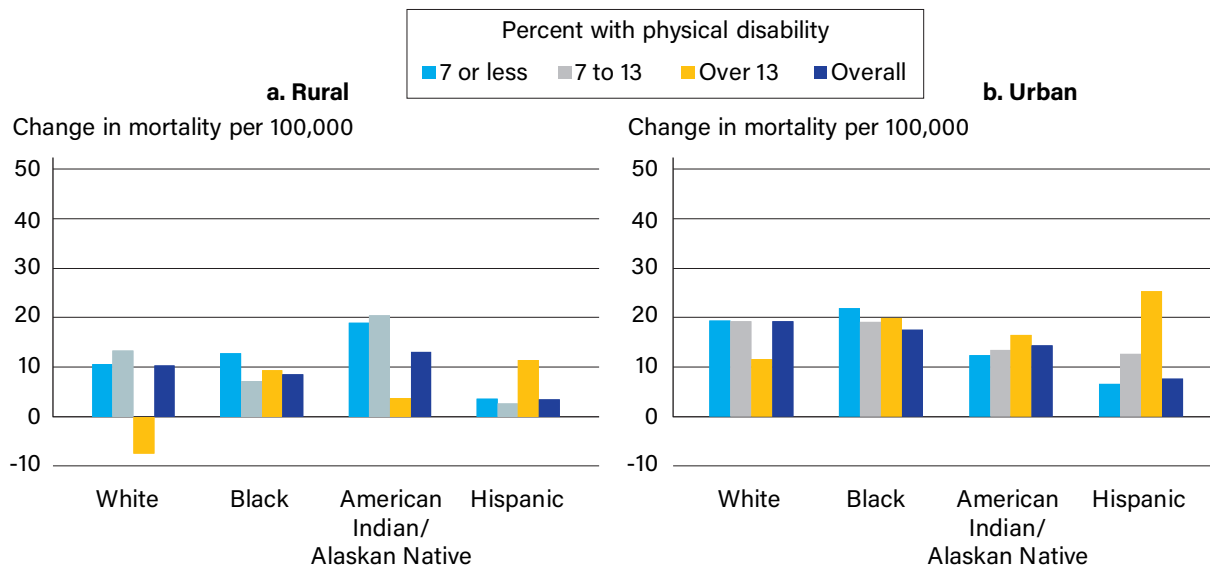
able increase in drug overdose mortality in the 2000s at any physical disability rate in either rural or urban areas.

An extension of the above graph to consider the trends in drug overdose mortality in the illicit opioid phase yields a largely disorganized pattern of results. The exceptions are the consistently greater urban than rural increases in drug overdose mortality across all racial/ethnic groups and a decline in rural drug overdose mortality among Whites with high disability (figure 11). This lower rate likely reflects a decline in drug prescriptions.

Figure 11

In a reversal from the prescription opioid phase, high physical disability was later associated with a decline in drug overdose mortality among rural Whites and relatively low gains among urban Whites and rural American Indian/Alaskan Natives

Changes in age-adjusted drug overdose mortality rates, ages 25-54, 2010-12 to 2016-18, among rural (nonmetropolitan) and urban (metropolitan) racial/ethnic groups, by their respective 2000 area physical disability rates, ages 21-64



Note: Racial groups are non-Hispanic, while Hispanic includes all races.

Source: USDA, Economic Research Service calculations from data from the Centers for Disease Control and Prevention Wonder website and U.S. Census Bureau.

This disorganization makes sense when we recall the surge in drug overdose mortality in the rural Northeast in the 2010s noted at the end of the previous section. Graphs of changes in drug overdose mortality by residence in or outside the above-defined Northeast region result in a much clearer picture of change in several ways (figure 12). First, the centering of the drug overdose mortality increase in the Northeast in the 2010s involved all the racial/ethnic groups in the study and both urban and rural areas, although the increases varied in size across the groups. Second, for each of these groups, the patterns of change in rural and urban areas have been largely the same. For instance, among rural American Indians/Alaskan Natives, increases in drug overdose mortality were greater outside the Northeast in the 2000s, but this pattern was reversed in the next decade. This essentially describes the urban changes as well—and rural changes for Whites and Hispanics. Rural-urban similarities suggest that the rural-urban distinction is less relevant for understanding the current geography of drug overdose mortality than the distinction between the Northeast and the rest of the country.

In the next section, multivariate analysis is used to explore county characteristics associated with changes in drug overdose mortality. Because the racial/ethnic groups had disparate trends in the study period, the mortality analysis is confined to non-Hispanic Whites, the largest group.

Figure 12

Drug overdose mortality increased markedly among all racial/ethnic groups in the 2010s, but only in the Northeast

Changes in age-adjusted drug overdose mortality rates, ages 25-54, among racial/ethnic populations in rural (nonmetropolitan) and urban (metropolitan) areas of the Northeast and rest of the country, 2000s (1999-2006 to 2009-13) and 2010s (2009-13 to 2016-18)



Note: Northeast includes CT, DE, DC, ME, MD, MA, NH, NJ, NY, OH, PA, RI, and VT. To avoid data suppression for rural American Indian/Alaskan Native populations in the Northeast, the beginning of the 2000s uses 1999-2006 data instead of the usual 1999-2002 average, and end of the 2000s and beginning of the 2010s uses 2009-13 instead of 2010-12 data. Because of large gains in drug overdose mortality in the 2010s, suppression was not an issue in 2016-2018. Age adjustments allow fair comparisons across areas and populations with different age distributions. Racial groups are non-Hispanic; Hispanic includes all races.

Source: USDA, Economic Research Service calculations based on data from the Centers for Disease Control and Prevention Wonder website and U.S. Census Bureau

Multivariate Analyses of County Changes in White Drug Overdose Mortality: Prescription and Illicit Opioid Phases

In the previous sections, we presented our case for physical disability as the primary shaper of the geography of the prescription phase of the opioid epidemic based on differences across State rural areas. We showed that in the 2010s, as the epidemic shifted from prescription opioids to heroin and synthetic opioids such as fentanyl, differences in local percentages of physical disability lost relevance. We also saw that the prescription phase of the opioid epidemic involved Whites and rural American Indian/Alaskan Natives primarily, while the illicit phase affected other racial/ethnic groups as well.

This section expands on these analyses to consider other possible influences on the geography of opioids. The expanded analysis involves multivariate regression using all counties instead of State rural areas as units of comparison. The county analysis permits the incorporation of a wider set of measures, but there is a cost in precision because of the small number of deaths, particularly in small counties (see Measures and methods box).

Measures and methods

The most common statistical rates relating to people (such as physical disability or poverty) are expressed in percentages, but deaths are generally expressed as per 100,000 residents. Most rural counties do not have 100,000 residents, much less 100,000 residents aged 25-54, the population of primary concern here. As numbers of observations become smaller, statistics become more unreliable or “noisy,” with random events, coding errors, and other external factors having increasing influence on calculated rates. To reduce noise problems in analyzing change over time, we pooled State rural area and county mortality data in 3 multiyear periods:

- a 4-year period, 1999-2002, which we use to represent the beginning of the opioid epidemic’s prescription phase;
- a 3-year period, 2010-12, to mark the transition between the prescription and the illicit opioid phases; and
- another 3-year period, 2016-18, to represent the most current period in the illicit phase.

In addition, for county analyses in the third section (drug overdose mortality) and the appendix (physical disability), we used population-weighted regression, which gives greater analytic importance to counties with larger populations and, therefore, less noisy statistics. The use of weighted regression is consistent with other statistics in the report, which examine overall averages across subpopulations such as age groups rather than averages across counties. Note that the State rural area analysis did not use weighted regression because the geographic units are relatively large.

Because of differences across racial/ethnic groups in both the levels of drug overdose mortality and the relationships between this mortality and physical disability, the county mortality analysis includes only White non-Hispanics. Otherwise, results are confounded by racial/ethnic differences. For example, among State rural areas, physical disability accounted for 46 percent of the variance in drug overdose mortality for the overall population aged 25-54 in 2010-12 (figure 5b). When confining the analysis to White non-Hispanics, the corresponding statistic rises to 64 percent. The age group is limited to county analysis of those between ages 25 and 54, in line with the analyses above. All told, White non-Hispanics, with 61 percent of the population in this age group, accounted for 80 percent of the drug overdose deaths in 2014-16. The disability and socioeconomic measures in the mortality analysis that follows apply to White non-Hispanics only. The community growth measures, however, apply to the entire county population.

As in the analysis of physical disability, we consider a correlation (r) or partial correlation (r_p) of ± 0.12 or more to be meaningful. In analyses containing all counties, coefficients at this level are significant at the $p < .001$ level or above. For the analysis of counties in the Northeast, where the number of counties is 333, this size correlation or partial correlation is statistically significant at the 5-percent level. This keeps the focus on the size of statistical relationships while assuring that we only consider relationships that are statistically significant at least at a minimum level.

The analysis is divided into four parts. The prescription opioid phase (1999-2002 to 2010-12) and the illicit opioid phase (2010-12 to 2016-18) are considered separately. Within each of these phases, counties in the Northeast are analyzed separately from counties in the rest of the country, although it is only in the illicit phase that we anticipated major differences between the two regions. Given the racial/ethnic differences found above (see figure 12), the analysis focuses on White non-Hispanics.²²

Of prime consideration is to what extent differences in local economic stress shaped the geography of the opioid epidemic during its illicit phase. As noted earlier, a recent international literature review found strong support for the thesis that recession and job loss lead to greater psychological distress and increased drug use (Nagelhout et al., 2017), but this proposition has received inconsistent empirical support when applied to U.S. county economic change since 1999. The 2000s comprised most of the period covered by these latter studies. Now that illicit opioids drive the opioid epidemic—at least in much of the northeastern United States—the role of local economic stress may have increased.

An inherent problem in relating local economic stress to working-age drug overdose mortality is that the causal direction is difficult to untangle. Drug problems may stem from this stress, but they also may be the source of employment decline by limiting labor force participation and employability. To assess local economic stress, we included county net migration as well as employment change. Our reasoning is that local economic stress is associated with both declining employment and people leaving the area. However, while greater drug addiction may be reflected in declining employment, only in extreme cases will migration be affected by increases in drug addiction (where people worry about associated crime or their children's exposure, for instance).

We noted earlier that the introduction of fentanyl and its kindred drugs to an area tends to make existing addictions more lethal. By generating high rates of drug overdose mortality, the prescription opioid crisis of the 2000s may have overwhelmed the tendency for economic misfortune to result in higher addiction and mortality rates. However, the reformulation of OxyContin and reduced availability of prescription opioids in the 2010s, coupled with the introduction of relatively lethal synthetic opioids such as fentanyl, may have raised the overdose mortality of those who became addicts in response to economic hardship in the 2000s. Our analyses of the illicit opioid phase include measures of economic change for both the 2010s and the 2000s.

The second concern in the county multiple regression analyses is the relative importance of physical disability in relation to the central socioeconomic measures—low education, high poverty, and single-parent family structure—in shaping the geography of opioid use in the 2000s. Previous research has found one or more measures of low socioeconomic status associated with drug overdose deaths (e.g., Case and Deaton (2015, 2017); Monnat, 2018). Our analysis of physical disability showed it to be related to measures of low socioeconomic status (see appendix table 2). Given these linkages, it is plausible that low education and other socioeconomic attributes, rather than physical disability, drove the increase in drug overdose mortality. Our earlier analysis of State rural areas suggests otherwise, but the present multivariate analysis covers urban and rural areas and uses a much finer geography (counties), allowing us to doublecheck our findings. (See appendix table 2 for names and averages of measures discussed in this section.)

Gentrification, which transforms the socioeconomic characteristics of neighborhoods through in-migration of people with higher socioeconomic status, is a third consideration. While this transformation is thought of as an urban phenomenon (Zukin, 1987), it has been usefully applied to rural areas, too, in the context of people seeking pleasant climates and attractive landscapes (Winkler et al., 2009; Nelson and Nelson, 2010).

²²The prescription data were not analyzed at the county level as the data did not precede 2006, did not contain information on age or race/ethnicity, and did contain many uninterpretable zeros in rural counties. Rural and urban counties were not analyzed separately because of the small number of rural counties in the Northeast and the rural-urban similarities shown for Whites in figure 12.

Gentrification may reduce the presence of drugs by raising education and income levels, measured as change in the proportion of people age 25 and over with a college degree.

The State context is our fourth consideration. States have varied considerably in the regulation of opioid prescriptions, and other differences such as medical practices may also have varied across States (Krueger, 2017). Some States, such as Florida, strengthened their regulations to apparently good effect as their opioid epidemic developed (Rutkow et al., 2015). For State residence, we included yes-no variables (coded 1-0) for all but one State to take account of possible State differences.

We also considered the degree to which the county is rural. Residents of very rural counties generally have relatively high levels of physical disability (appendix table 2). Yet during the prescription phase of the opioid epidemic, rural areas in general had about the same increase in drug overdose mortality as urban areas (see figure 1). Rural disability may have been counterbalanced by limited access to healthcare, which reduced exposure to prescription opioids and associated addiction and mortality. Where illicit opioids are involved, rural residence may limit drug addiction and mortality rates because of difficulties in establishing drug distribution networks in sparsely settled areas. The direction of influence may not be all in rural residents' advantage, however. Treatment may be less available in rural areas, for instance, making residents with drug problems more vulnerable.

We saw in figure 7 that State rural areas with lower population density had less increase in opioid mortality in the 2010s but not in the 2000s. County-level analysis can provide a finer grade analysis. The urban-rural scale used in this analysis includes three size classifications for urban (metropolitan) areas, with lower population bounds of 1 million, 250,000, and 50,000 residents. We used two classifications for rural area residence: micropolitan (county with city of 10,000-49,999 people or where 25 percent of its workforce commutes to such a city) and completely rural (or noncore). Yes-no indicators were included for four of these five residential categories.²³

Given the concentration of the illicit opioid phase of the epidemic in the northeastern States, we analyzed their counties separately from other counties. This helped identify local geographic characteristics that shaped drug overdose mortality in areas where illicit opioids were apparently most available. Overall, drug overdose mortality rates for Whites ages 25-54 in the 2000s rose by similar amounts in the Northeast and in the rest of the country. However, the Northeast far outpaced the rest of the country in the 2010s, at least through 2016-18 (figure 12).

Multivariate results

Table 2 presents analyses of changes in drug overdose mortality during the prescription phase of the opioid epidemic. There are two equations for each area, one using net migration as a measure of community economic health (equation 1) and the other using employment change (equation 2). Similar analyses are presented in table 3 for the illicit opioid phase of the epidemic. The means and standard deviations for the measures in both tables are in appendix table 2.

²³ With the large urban type left out, coefficients for the other residence types indicate their differences from the large urban type.

Table 2

County change in drug overdose mortality rates, 1999-2002 to 2010-12, for White non-Hispanics, ages 25-54, in Northeast and remaining States

County attributes	Counties in Northeast States			Counties in remaining States		
	r	Eq. 1 Partial r	Eq. 2 Partial r	r	Eq. 1 Partial r	Eq. 2 Partial r
Urban-rural scale						
Major metro (omitted)	-0.02	-0.17
Medium metro	-0.03	-0.21	-0.23	0.07	-0.03	-0.03
Small metro	0.02	-0.11	-0.13	0.03	-0.07	-0.07
Micropolitan (rural)	0.05	-0.22	-0.24	0.06	-0.09	-0.10
Noncore (rural)	0.02	-0.14	-0.15	0.10	-0.10	-0.10
Physical disability rate, 2000	0.40	0.48	0.47	0.52	0.23	0.24
Socioeconomic characteristics, 2000						
No education beyond high school	0.40	-0.12	-0.12	0.42	-0.05	-0.05
Poverty rate (ages 25-54)	0.03	-0.38	-0.37	0.43	-0.02	-0.02
Single-parent families	0.21	-0.08	-0.07	0.26	0.05	0.04
Community change						
Net migration, 2000s (log _e)	0.03	-0.10	...	-0.01	-0.01	...
Employment change, 2000s (log _e)	-0.21	...	-0.05	-0.14	...	-0.02
Percent college graduates, 2000 to 2006-10	-0.40	-0.09	-0.08	-0.23	-0.04	-0.04
State effects (0-1)		Yes	Yes		Yes	Yes
R ² (percent of variation accounted for)		56	56		39	39
Number of counties		333	333		2,787	2,787

Note: Northeast States include CT, DE, DC, ME, MD, MA, NH, NJ, NY, OH, PA, RI, and VT. Physical disability and socioeconomic measures are for White non-Hispanics. Statistical significance at the standard 0.05 level requires a correlation or partial correlation of 0.12. We bolded coefficients of at least that size to indicate both statistical significance and substantial importance. For a fuller description of measures, see appendix table 2. Log_e denotes natural logarithm transformation. r = correlation coefficient. Partial r = partial correlation coefficient.

Source: USDA, Economic Research Service calculations based on data from the Centers for Disease Control and Prevention and the U.S. Census Bureau.

The first measure in table 2 is the urban-rural code of residence, expressed as a set of 0-1 variables. Given the similar increases in drug overdose mortality of Whites during the prescription phase of the opioid epidemic between rural and urban sectors (figure 12c), both in and outside the Northeast, we expected correlations to be small across the urban-rural scale. While correlations are small in the Northeast, once the analysis is multivariate (equations 1 and 2), the partial correlations for the included urban-rural scale categories are substantially negative. This indicates that major metropolitan areas (the omitted category) in this region had a larger jump in drug overdose mortality than expected, given their physical disability rates, socioeconomic characteristics, and community change.

Two factors suggest that this pattern represents the start of the illicit drug phase of the opioid epidemic. First, the partial correlation pattern is substantially weaker outside the Northeast region, where this phase has been slower to develop. Second, when we redid the analysis but used 2008-11 as the period end instead of 2010-12, this pattern did not show up. The jump in major urban areas was a new phenomenon. The 2010-12 transition period saw drug overdose mortality involving prescription opioids taper off while mortality involving heroin rose (figure 2). Fentanyl and related synthetic opioids were not yet a factor.

Consistent with the earlier State rural area analyses for the prime-age population overall (figure 5), partial correlations with a gain in prime-age drug overdose mortality in the 2000s are stronger for physical disability than for White socioeconomic attributes both in the Northeast and among the remaining counties.²⁴ Employment change has negative correlations with the change in drug overdose mortality, but the partial correlations are small, suggesting other factors are responsible. While there is little indication here of a substantial relationship between local economic problems and the growth in drug overdose deaths in the 2000s, our analysis of the 2010s suggests that economic problems in this period likely led to increases in drug use, which, with the arrival of fentanyl in the Northeast, led to rises in drug overdose mortality.

²⁴The substantial negative partial correlations in the Northeast equations between poverty and change in drug overdose mortality are unexpected: Normally, one would expect greater increases in drug overdose in areas of greater poverty, not decreases. The statistical source of anomaly is the negligible correlation between poverty and gains in drug mortality in the Northeast shown in table 2. High poverty is associated with physical disability in the Northeast, which in turn is related to gains in drug mortality in the 2000s. Once this indirect link is taken into account, the net relationship of poverty to mortality is negative. One possible explanation is that prescription opioids are expensive, and the cost of living is relatively high in the Northeast, which would tend to dampen the relationship between poverty and drug overdose mortality.

Table 3

County change in drug overdose mortality rates, 2010-12 to 2016-18, White non-Hispanics, ages 25-54, in Northeast and remaining States

County attributes	Counties in Northeast States					Counties in remaining States				
	r	Eq. 1 Partial r	Eq. 2 Partial r	Eq. 3 Partial r	Eq. 4 Partial r	r	Eq. 1 Partial r	Eq. 2 Partial r	Eq. 3 Partial r	Eq. 4 Partial r
Urban-rural scale										
Major metro (omitted)										
Medium metro	0.05	-0.16	-0.15	-0.19	-0.18	0.05	-0.06	-0.06	-0.06	-0.06
Small metro	0.00	-0.18	-0.17	-0.22	-0.21	-0.04	-0.13	-0.13	-0.13	-0.13
Micropolitan (rural)	-0.07	-0.27	-0.27	-0.33	-0.34	-0.07	-0.11	-0.11	-0.12	-0.12
Noncore (rural)	-0.10	-0.27	-0.27	-0.31	-0.33	-0.12	-0.11	-0.11	-0.13	-0.13
Physical disability rate, 2000	0.23	0.26	0.29	0.19	0.24	-0.09	-0.13	-0.13	-0.14	-0.14
Socioeconomic characteristics, 2006-10										
No education beyond high school	0.22	-0.12	-0.10	-0.06	-0.04	0.05	0.07	0.07	0.07	0.07
Poverty rate (ages 25-54)	0.06	-0.13	-0.17	-0.05	-0.10	-0.08	-0.08	-0.08	-0.07	-0.08
Single-parent families	0.23	0.11	0.10	0.05	0.03	0.02	0.16	0.16	0.16	0.16
Community change										
Net migration, 2000s (log _e)	-0.06		-0.15			-0.05		-0.01		
Net migration, 2010-2015 (log _e)	-0.17	-0.35	-0.21			-0.03	-0.12	-0.09		
Employment change, 2000s (log _e)	-0.25				-0.28	-0.08				-0.03
Employment change, 2010s (log _e)	-0.26			-0.37	-0.24	-0.04			-0.10	-0.08
Percent college graduates	-0.02	0.01	-0.04	0.11	0.09	0.05	-0.01	-0.01	0.00	0.00
State effects (0-1)		Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes
R ² (percent of variation accounted for)		47	48	47	51		31	31	31	31
Number of counties		333	333	333	333		2,787	2,782	2,787	2,786

Note: Northeast States include CT, DE, DC, ME, MD, MA, NH, NJ, NY, OH, PA, RI, and VT. Physical disability and socioeconomic measures are percentages for White non-Hispanics. Mortality rates have been age-adjusted to account for differences in age distribution across areas and over time. For a fuller description of county measures, see appendix table 2. Statistical significance at the standard .05 level for the Northeast counties requires a correlation or partial correlation of at least 0.12, larger than in the analysis for the remaining States. We bolded coefficients of at least that size to indicate substantive as well as statistical importance. Log_e denotes natural logarithm transformation. r = correlation coefficient. Partial r = partial correlation coefficient.

Source: USDA, Economic Research Service calculations based on data from the Centers for Disease Control and Prevention and the U.S. Census Bureau.

As noted above, table 3 largely repeats for 2010-12 to 2016-18 the analysis of the previous decade. However, there are four equations for inside the Northeast and four equivalent equations for the rest of the country. Equations 1 and 3 include migration or employment change, respectively, for the 2010s as an explanatory measure. Equations 2 and 4 include migration or employment change for the 2010s and the 2000s.

Urban-rural location had about the same relationship with change in drug overdose mortality in the 2010s as it had in the 2000s. Correlations were small in both the Northeast and elsewhere, but partial correlations were substantially negative in the Northeast. This suggests the gain in overdose mortality outside large urban areas was less than expected based on other county characteristics. This pattern was most evident in the rural micropolitan and noncore counties in the Northeast and scarcely evident at all outside the Northeast. This comports with the earlier finding that the illicit drug phase of the opioid epidemic was weaker in more sparsely settled State rural areas (figure 7 and table 1).

Despite increasing limitations on prescription opioids in the early 2010s, there were still positive partial correlations between physical disability and rises in drug overdose mortality in the Northeast over the decade. This may have been the result of people augmenting prescription opioids or switching to illicit drugs (Evans et al., 2019), an interpretation reinforced by the negative partial correlations outside the Northeast between physical disability and changes in drug overdose mortality.

While there are some modest correlations in the Northeast between socioeconomic characteristics and mortality gains in the 2010s, the partial correlations are small—essentially trivial—in the employment change equations (equations 3 and 4). Outside the Northeast, even the correlations are trivial.

In contrast to the pattern of the 2000s, local economic difficulties in the Northeast were associated with greater rises in drug overdose mortality in the region's White prime-age population in the 2010s (table 3). For employment change, partial correlations suggest rising mortality in the 2010s was more strongly related to local economic change in the prior decade than to contemporary change. Negative partial correlations for employment are larger for the 2000s than for the 2010s in equation 4 and substantial for net migration in the 2000s in equation 2. Thus for the Northeast, economic problems in the 2000s, largely unrelated to drug overdose mortality in the 2000s, were important for the fentanyl era of the 2010s.

In contrast to the Northeast, where earlier local economic misfortune was associated with rising drug overdose mortality—largely from illicit drug overdoses, according to our State rural area analysis (figure 6) and recent State-level analyses (Kiang et al., 2019; Spencer et al., 2019)—there was little such relationship in the rest of the United States. None of the economic change measures have substantial relationships with mortality in table 3 equations for remaining States. This is further evidence of the key role of fentanyl and its analogs.

Employment change and drug overdose mortality in the illicit phase of the opioid epidemic: another look

To get a more concrete picture of the relationship between long-term change in employment and recent changes in drug overdose mortality, we categorized the change in employment, 2000 to 2013-17, and examined change in drug overdose mortality across levels of employment change for both the Northeast and the rest of the country. First, however, it is useful to compare employment change in the two regions.

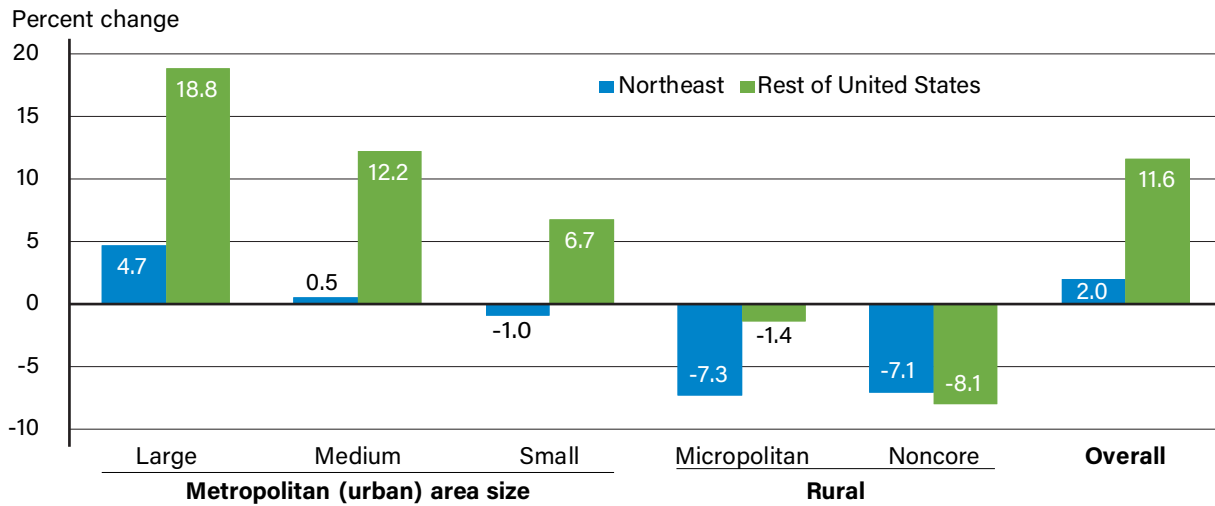
The Northeast has severely lagged the rest of the country in employment growth since 2000. The average prime-working-age White resident in the Northeast lived in a county that gained only 2 percent employment from 2000 to 2013-17. By comparison, in the rest of the country, prime-working-age Whites typically saw county employment grow by 12 percent (figure 13). In both broad territories, gains favored large metropolitan areas while employment in rural areas declined. Prime-working-age Whites in micropolitan areas in the Northeast faced an average loss in employment of 7 percent over the period, more than in completely rural counties in the region and more than the average loss of less than 2 percent in rural areas outside the region. Given that within the Northeast, less favorable county employment trends were associated with greater increases in drug overdose mortality, it is possible the widespread failure to create jobs in the region was one of the conditions that made it attractive to illicit drug distribution networks.²⁵

²⁵Another factor may be that northeastern ports serve as a conduit for drug entry. A recent cocaine shipment interception provides an example (NBC News, 2019).

Figure 13

Except in the most rural counties, working-age Whites faced much weaker local employment growth in the Northeast than in the rest of the country from 1999 to 2012-17

Employment change between 2000 and 2013-17, by urban and rural status



Note: Results are weighted by the 2012-15 average White non-Hispanic population, ages 25-54. Metropolitan areas are defined by population size in 2010: large (1 million or more), medium (250,000-999,999), and small (50,000-249,999). Micropolitan includes rural counties with cities of 10,000 residents or more and adjacent counties with substantial commuting to these counties. Noncore refers to other, more rural counties. Northeast includes: CT, DE, DC, ME, MD, MA, NH, NJ, NY, OH, PA, RI, and VT. Employment in previous year is more comparable between the 2000 Census and the American Community Survey (ACS), the data sources, as current employment in the Census is only for April, while the ACS is a survey taken over the year.

Source: USDA, Economic Research Service calculations using data from the U.S. Census Bureau.

To better gauge the strength of the relationship between this employment change and drug overdose mortality in the illicit phase of the opioid epidemic, we reran the employment change equations in table 3 for the Northeast and the rest of the United States, substituting employment change over the entire period (2000 to 2013-17) for the two employment measures in equation 4. We divided the employment variable into four categories of change and calculated the average change in drug overdose mortality within each category, holding other measures constant statistically.²⁶ These yielded estimates of drug overdose mortality change, assuming the other measured community characteristics within each region were the same across all its counties.

Consistent with table 3, the changes in employment in counties outside the Northeast were not substantially associated with differences in the spread of drug overdose mortality. Increases were relatively small, whether employment rose or fell (figure 14).

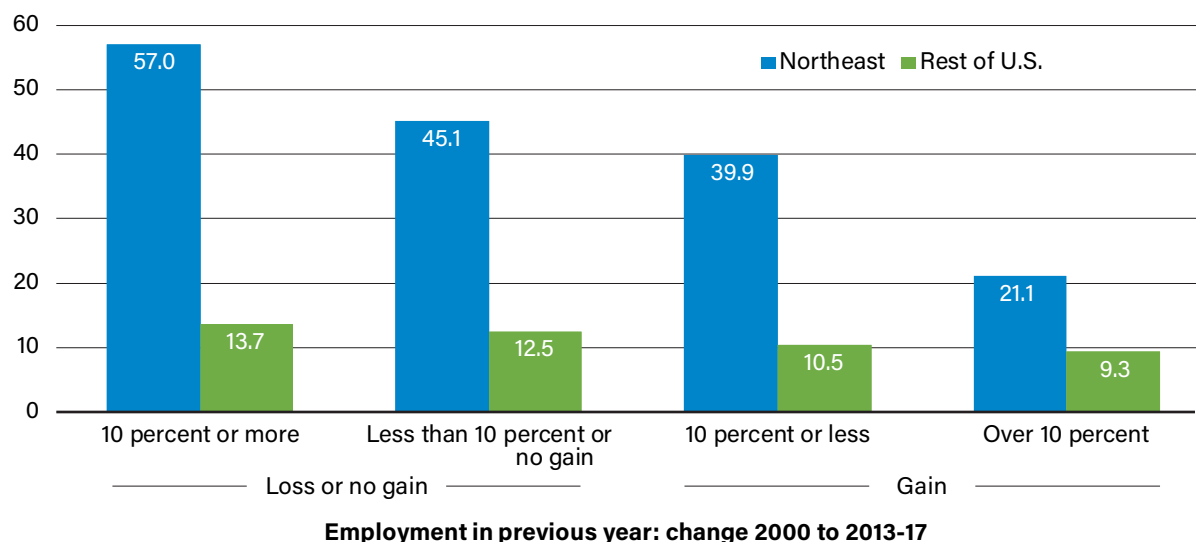
²⁶ This was accomplished using the univariate analysis of variance procedure in the SPSS Statistics program package (V. 18).

Figure 14

Drug overdose mortality rose in the Northeast during the opioid epidemic’s illicit phase, especially in areas with employment loss

Change in age-adjusted White non-Hispanic drug overdose mortality, ages 25-54, 2010-12 to 2016-18, by employment

Change in drug overdose mortality per 100,000



Note: These are results of univariate regression, repeating the two equation 4 analyses in table 3, but combining employment change into a single measure and breaking it into four categories. Estimates are based on assuming other measures in the analysis are average for the respective regions. Northeast includes: CT, DE, DC, ME, MD, MA, NH, NJ, NY, OH, PA, RI, and VT.

Source: USDA, Economic Research Service calculation based on data from the National Center for Health Statistics and the U.S. Census Bureau.

The picture is dramatically different in the Northeast, however. The drug overdose mortality rates for prime-working-age Whites rose by 57 deaths per 100,000 where this population faced an employment decline of 10 percent or more between 2000 and 2013-17, but rose by only 21 deaths per 100,000 where employment grew by more than 10 percent during that period. The partial correlation between long-term employment change and change in drug overdose mortality in the 2010s is $r_p = -0.43$ in the Northeast, which approaches in size the previous decades’ partial correlation of physical disability with change in drug overdose mortality in table 3 ($r_p = -0.47$). For the rest of the United States, the corresponding employment-drug mortality partial correlation is only $r_p = -.09$, which we consider insubstantial.

While figure 14 shows considerable differences in the increases in overdose mortality rates in the 2010s across the Northeast’s local employment change categories for the entire study period, employment loss may be the result as well as the cause of increases in local drug use. The analysis presented in table 3, however, includes separate measures of employment change for the 2000s and the 2010s. While it is quite plausible that employment change in the 2010s might have been affected by the concurrent illicit opioid phase of the epidemic, it is not plausible for employment change in the 2000s to have been affected by changes in drug use in the 2010s, especially given that the partial correlations in equations 2 and 4 for change in the 2000s take net migration and employment change in the 2010s into account.

Our analysis indicates that, at least among prime-age Whites, job loss may have been associated with increased drug use over the past 2 decades, but it was associated with substantial rises in drug overdose mortality only in contexts such as the Northeast where fentanyl and related drugs were available. This pattern was apparent in the case of physical disability: Drug reformulation made addiction to prescription opioids less lethal except in the Northeast, where fentanyl and its analogs could serve as deadly supplements to existing addictions.

Conclusions

The opioid epidemic remains a major health issue for the United States. To better understand the underlying forces driving the epidemic, this report identifies two phases of the epidemic: an opioid prescription phase and an illicit opioid phase. The conditions associated with rising mortality in each phase have very distinct geographies.

An earlier line of research initiated by Case and Deaton in 2015 suggested that the main force behind the epidemic was the changing economic fortunes of middle-aged Whites as manufacturing jobs disappeared in the 2000s. However, with some exceptions, previous geographic research on the drug epidemic that followed this line of argument (including Case and Deaton, 2017) did not find a substantial link between local economic downturns and rising working-age mortality from an overdose of opioids or drugs in general (Ruhm, 2019). Our analysis of change in drug mortality in the 2000s is generally consistent with this research: We found little association with concurrent local economic change in this period.

We explored an alternative story—that the supply of opioid painkiller prescriptions drove the epidemic of the 2000s. Several factors shifted in the late 1990s to make prescription opioids more readily dispensed and abused:

- The medical community came to believe that pain alone was a treatable health issue;
- There was a belief that opioid medicines were not highly addictive;
- New, supposedly easier to manage time-release opioid medicines proved easy to abuse (Quinones, 2015).

We found the geography of the prescription painkiller phase of the opioid epidemic during the 2000s to be largely shaped by State rural area and county differences in physical disability rates, which we took to be a measure of the prevalence of chronic pain. Whatever difficulties physical disability entails, the prescription phase brought more difficulties, as addiction grew and prescriptions proved eventually unable to quell the pain, resulting in rising opioid deaths.

In the early 2010s, prescription regulation and opioid reformulation began to slow and, in some places, reverse the rise in prescription overdose mortality. With the introduction of new forms of heroin and new illegal synthetic opioids, however, these years also marked the beginning of the illicit drug phase of the opioid epidemic. With the arrival of new illicit opioids in the early 2010s, local economic health appears to have become relevant to the opioid mortality epidemic. Analyzing changes in drug overdose mortality rates in the 2010s among working-age Whites in the fentanyl-plagued Northeast, we found strong negative county-level relationships with employment change, especially with employment change in the 2000s. We believe that local employment decline in the 2000s was likely associated with increased drug addiction, but that any effect on mortality was largely outweighed by the tremendous increase in prescription opioids, their link with physical pain and disability, and their ultimate inability to safely ease chronic pain.

Fentanyl and its analogs have no such link, and their arrival has resulted in a geographic shift in the opioid epidemic toward the northeastern quadrant of the country. In this region, drug overdose mortality in the 2010s tended to concentrate in counties with a history of employment loss and outmigration—and this drug problem may now be contributing to the region's inability to attract jobs and people. Earlier conclusions about the weak link between local employment change and drug overdose mortality during the prescription phase of the epidemic are not pertinent to the illicit opioid phase of the epidemic in the Northeast.

Does the rise in drug overdose mortality in the Northeast represent a rise in despair or a rise in the lethality of the drug supply? County loss of employment in the region is associated with rises in drug overdose mortality for White prime-working-age adults in the 2010s, but to ascribe that rise to despair leaves no explanation as to why similar changes in county employment in the rest of the country had a minor association with this population's change in drug overdose mortality. It also raises the question of why a similar pattern was not found in the 2000s in either the Northeast or the rest of the country.

There is no doubt that the economic trends over the past 20 years have placed tremendous stress on the prime-working-age population whose schooling did not extend beyond high school. But the rises in drug overdose mortality that have characterized, first, the prescription opioid phase of the epidemic and, more recently, the illicit opioid phase, seem to have reflected more the increasing availability of more dangerous opioids than growing stress or despair.

References

- Adler, N.E., and J. Stewart. 2010. "Health Disparities Across the Lifespan: Meaning, Methods, and Mechanisms," *Annals of the New York Academy of Sciences* 1186:5-23.
- American Medical Association Advocacy Resource Center. 2020. "Issue Brief: Reports of Increases in Opioid-Related Overdose and Other Concerns during COVID Pandemic." Updated, June 8.
- Autor, D.H., D. Dorn, and G.H. Hanson. 2013. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review* 103(6):2121-2168.
- Autor, D., D. Dorn, and G. Hanson. 2018. "When Work Disappears: Manufacturing Decline and the Falling Marriage Market Value of Young Men," CESifo Working Paper #7010.
- Beale, C.L. 2004. "Anatomy of Nonmetro High-Poverty Areas: Common in Plight, Distinctive in Nature," *Amber Waves*, February 1.
- Betz, M.R., and L.E. Jones. 2018. "Wage and Employment Growth in America's Drug Epidemic: Is All Growth Created Equal?" *American Journal of Agricultural Economics* 100(5): 1357-1374.
- Bowen, M.E., and H.M. González. 2010. "Childhood Socioeconomic Position and Disability in Later Life: Results of the Health and Retirement Study," *American Journal of Public Health* 100 Supplement 1: S197-S203.
- Case, A., A. Fertig, and C. Paxson. 2005. "The Lasting Impact of Childhood Health and Circumstance," *Journal of Health Economics* 24: 365-389.
- Case, A., and A. Deaton. 2015. "Rising Morbidity and Mortality in Midlife Among White Non-Hispanic Americans in the 21st Century." *Proceedings of the National Academy of Sciences* 112 (49): 15078-15083.
- Case, A., and A. Deaton. 2017. "Mortality and Morbidity in the 21st century: Final Post-Conference Version," *Brookings Papers on Economic Activity*, Washington, DC: Brookings.
- Case, A., and A. Deaton. 2020. *Deaths of Despair and the Future of Capitalism*. Princeton University Press, Princeton, NJ.
- Case, A., D. Lubotsky, and C. Paxson. 2002. "Economic Status and Health in Childhood: The Origins of the Gradient," *The American Economic Review* 92(5):1308-1334.
- Chou, R., J.A. Turner, E.B. Devine, R.N. Hansen, S.D. Sullivan, I. Blazina, T. Dana, C. Bougatsos, and R.A. Deyo. 2015. "The Effectiveness and Risks of Long-Term Opioid Therapy for Chronic Pain: A Systematic Review for a National Institutes of Health Pathways to Prevention Workshop," *Annals of Internal Medicine* 162(4):276-286.
- Cohen, S., and D. Janicki-Deverts, E. Chen, and K.A. Matthews. 2010. "Childhood Socioeconomic Status and Adult Health," *Annals of the New York Academy of Sciences* 1186:37-55.
- Currie, J., J.Y. Jin, and M. Schnell. 2018. "U.S. Employment and Opioids: Is There a Connection?" National Bureau of Economic Research, Working Paper #24440.

- Cutler, D.M., and A. Lleras-Muney. 2011. "Socioeconomic Status and Health: Dimensions and Mechanisms," in *The Oxford Handbook of Health Economics* (S. Glied and P.C. Smith, Eds.) Oxford, UK: Oxford University Press.
- Cutler, D.M., W. Huang, and A. Lleras-Muney. 2016. "Economic Conditions and Mortality: Evidence from 200 Years of Data," National Bureau of Economic Research, Working Paper #22690.
- Dowell, D., T.M. Haegerich, and R. Chou. 2016. "CDC Guideline for Prescribing Opioids for Chronic Pain—United States," *Journal of the American Medical Association* 315(15):1624-1645.
- Evans, W.N., E.M.J. Lieber, and P. Power. 2019. "How the Reformulation of OxyContin Ignited the Heroin Epidemic," *The Review of Economics and Statistics* 101(1):1-15.
- Fried, L.P., and J.M. Guralnik. 1997. "Disability in Older Adults: Evidence Regarding Significance, Etiology, and Risk," *Journal of the American Geriatrics Society* 45(1):92-100.
- Guy, G.P., K. Zhang, M.K. Bohm, J. Losby, B. Lewis, R. Young, L.B. Murphy, and D. Dowell. 2017. "Vital Signs: Changes in Opioid Prescribing in the United States, 2006–2015," *MMWR Morb. Mortal. Wkly. Report* 66:697–704.
- Hedegaard, H., B.A. Bastian, J.P. Trinidad, M. Spencer, and M. Warner. 2018. "Drugs Most Frequently Involved in Drug Overdose Deaths: United States, 2011-2016," National Vital Statistics Reports 67:9:2-13.
- Indian Health Service website. 2018. Urban Indian Health Program Factsheet, October 2018.
- Keil, J.E., P.C. Gazes, S.E. Sutherland, P.F. Rust, L.G. Branch, and H.A. Tyroler. 1989. "Predictors of Physical Disability in Elderly Blacks and Whites of the Charleston Heart Study," *Journal of Clinical Epidemiology* 42(6):521-529.
- Kiang, M.V., S. Basu, J. Chen, and M.J. Alexander. 2019. "Assessment of Changes in the Geographical Distribution of Opioid-Related Mortality Across the United States by Opioid Type, 1999-2016," *JAMA Network Open* 2019.0040.
- Kington, R.S., and J.P. Smith. 1997. "Socioeconomic Status and Racial and Ethnic Differences in Functional Status Associated with Chronic Diseases," *American Journal of Public Health* 87(5):805-810.
- Krebs, E.E., A. Gravely, S. Nugent, A.C. Jensen, B. DeRonne, E.S. Goldsmith, K. Kroenke, M.J. Bair, and S. Noorbaloochi. 2018. "Effect of Opioid vs. Nonopioid Medications on Pain-Related Function in Patients With Chronic Back Pain or Hip or Knee Osteoarthritis Pain: The SPACE Randomized Clinical Trial," *Journal of the American Medical Association* 319(9):872-882.
- Krueger, A.B. 2017. "Where Have All the Workers Gone? An Inquiry into the Decline of the U.S. Labor Force Participation Rate," *Brookings Papers on Economic Activity*, Washington, DC: Brookings.
- Lee, H., M. Hubscher, G.L. Moseley, S.J. Kamper, A.C. Traeger, G. Mansell, and J.H. McAuley. 2015. "How Does Pain Lead to Disability? A Systematic Review and Meta-Analysis of Mediation Studies in People with Back and Neck Pain," *PAIN* 156(6):988-997.
- LLeras-Muney, A. 2005. "The Relationship Between Education and Adult Mortality in the United States," *The Review of Economic Studies* 72(1):189-221.

- Macy, B. 2018. *Dopesick: Dealers, Doctors, and the Drug Company that Addicted America*. New York, NY: Little, Brown, and Company.
- Mack, K.A. 2013. “Drug Overdose Deaths — United States, 1999-2010,” *Morbidity and Mortality Weekly Report, Supplement* 62(3):161-163.
- Mack, K.A., C.M. Jones, and M.F. Ballesteros. 2017. Illicit Drug Use, Illicit Drug Use Disorders, and Drug Overdose Deaths in Metropolitan and Nonmetropolitan Areas — United States,” *Morbidity and Mortality Weekly Report, Surveillance Summary* 66:19.
- McDonald, D. C., K. Carlson, and D. Izrael. 2012. “Geographic Variation in Opioid Prescribing in the U.S.,” *Journal of Pain* 13:988-996.
- McGreal, C. 2018. *American Overdose: The Opioid Tragedy in Three Acts*. New York, NY: Public Affairs.
- Meghani, S.H., E. Byun, and R.M. Gallagher. 2012. “Time to Take Stock: A Meta-Analysis and Systematic Review of Analgesic Treatment Disparities for Pain in the United States,” *Pain Medicine* 13:150-174.
- Meier, B. *Pain Killer: An Empire of Deceit and the Origin of America’s Opioid Epidemic*. New York, NY: Random House.
- Monnat, S.M. 2018. “Factors Associated with County-Level Differences in U.S. Drug-Related Mortality Rates,” *American Journal of Preventive Medicine*, 54(5): 611-619.
- Monnat, S.M. 2019. “The Contributions of Socioeconomic and Opioid Supply Factors to U.S. Drug Mortality Rates: Urban-Rural and within-Rural Differences,” *Journal of Rural Studies*, 68 (May): 319-335.
- Monnat, S.M., and R.F. Chandler. 2015. “Long-Term Physical Health Consequences of Adverse Childhood Experiences,” *The Sociological Quarterly* 56(4):723-752.
- Monnat, S.M., D.J. Peters, M.T. Berg, and A. Hochstetler. 2019. “Using Census Data to Understand County-Level Differences in Overall Drug Mortality and Opioid-Related Mortality by Opioid Type.” *American Journal of Public Health*, 109:1084-1091.
- Montez, J.K., and M.D. Hayward. 2013. “Cumulative Childhood Adversity, Educational Attainment, and Active Life Expectancy Among U.S. Adults,” *Demography* 51(2):413-435.
- Morrison, R.S., S. Wallenstein, D.K. Natale, R.S. Senzel, and L.-L. Huang. 2000. “‘We Don’t Carry That’— Failure of Pharmacies in Predominantly Nonwhite Neighborhoods to Stock Opioid Analgesics,” *New England Journal of Medicine* 342:1023-1026.
- Nagelhout, G.E., K. Hummel, M.C.M. de Goeij, H. de Vries, E. Kaner, and P. Lemmens. 2017. “How Economic Recessions and Unemployment Affect Illegal Drug Use: A Systematic Realist Literature Review,” *International Journal of Drug Policy* 44:69-83.
- National Center for Health Statistics. Detailed Mortality file (1999-2018), as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program.
- NBC News website, March 11, 2019. “Authorities Make Largest Cocaine Seizure at N.Y.-Area Port in 25 Years.”

- Nelson, P.B., and J.D. Nelson. 2018. "Rural Gentrification and Networks of Capital Accumulation—A Case Study of Jackson, Wyoming," *Environment and Planning A: Economy and Space*, Sage Journals website.
- NPR/Robert Wood Johnson Foundation/Harvard T.H. Chan School of Public Health. 2018. Life in Rural America (October), Robert Wood Johnson Foundation website.
- Paolozzi, L.J., C.M. Jones, K.A. Mack, and R.A. Rudd. 2011. "Vital Signs: Overdoses of Prescription Opioid Pain Relievers – United States, 1999-2008," *Morbidity and Mortality Weekly Report*, 60(43), 1487–1492.
- Paolozzi, L.J., K.A. Mack, and J.M. Hockenberry. 2012. "Variation among States in Prescribing of Opioid Pain Relievers and Benzodiazepines — United States, 2012," *Journal of Safety Research* 51:125-129.
- Pletcher, M.J., S.G. Kertesz, M.A. Kohn, and R. Gonzales. 2008. "Trends in Opioid Prescribing by Race/Ethnicity for Patients Seeking Care in US Emergency Departments," *Journal of the American Medical Association* 299(1):70-78.
- Quinones, S. 2015. *Dreamland: The True Tale of America's Opiate Epidemic*. New York, NY: Bloomsbury Press.
- Ruhm, C.J. 2019. "Drivers of the Fatal Drug Epidemic," *Journal of Health Economics* 64:25-42.
- Rutkow, L., H.-Y. Chang, M. Daubresse, D.W. Webster, E.A. Stuart, and G.C. Alexander. 2015. "Effect of Florida's Prescription Drug Monitoring Program and Pill Mill Laws on Opioid Prescribing and Use," *Journal of the American Medical Association: Internal Medicine* 175(10):1642-1649.
- Scudds, R.J., and J.M. Robertson. 2000. "Pain Factors Associated with Physical Disability in a Sample of Community-Dwelling Senior Citizens," *Journal of Gerontology: Medical Sciences* 55A:M393-M399.
- Spencer M.R., M. Warner, B.A. Bastian, J.P. Trinidad, and H. Hedegaard. 2019. "Drug Overdose Deaths Involving Fentanyl, 2011–2016," *National Vital Statistics Reports* 68: 3. Hyattsville, MD: National Center for Health Statistics. 2019.
- U.S. Census Bureau. 2003. *Census 2000 Summary File 4 Technical Documentation*. Washington, DC.
- Van Zee, A. 2009. "The Promotion and Marketing of OxyContin: Commercial Triumph, Public Health Tragedy," *American Journal of Public Health* 99(2): 221-227.
- Venkataramani, A.S., E.F. Bair, R.L. O'Brien, and A.C. Tsai. 2019. "Association Between Automotive Assembly Plant Closures and Opioid Overdose Mortality in the United States: A Difference-in-Differences Analysis," *Journal of the American Medical Association Internal Medicine*, Published online, doi:10.1001/jamainternmed.2019.5686.
- Winkler, R., D.R. Field, A.E. Luloff, R.S. Krannich, and T. Williams. 2007. "Social Landscapes of the Inter-mountain West: A Comparison of 'Old West' and 'New West' Communities," *Rural Sociology* 72(3):303-327.
- Zukin, S. 1987. "Gentrification: Culture and Capital in the Urban Core," *Annual Review of Sociology* 13:129-147.

Appendix 1: Supplemental Analysis of County Adult Physical Disability Rate

This supplement provides three explorations of the validity of our measure of physical disability. The first is a multivariate county-level analysis testing whether there was a link between adult physical disability in 2000 and child poverty in 1970. Research on health over an individual's life shows that health problems later in life are often linked to health, economic, or other difficulties in childhood. Early difficulties tend to make people less resilient to health problems as adults, resulting in higher rates of chronic disease and shorter lives than might otherwise be expected by their adult socioeconomic status. Moreover, low socioeconomic status in adulthood also can be a result of childhood difficulties (Cohen et al., 2010; Montez and Hayward, 2014). In the context of the present study, if physical disability in a county's working-age population in 2000 reflects long-term health issues, we would expect that, independent of current county poverty levels and educational attainment, physical disability in 2000 might be related to county child poverty in 1970 (Bowen and Gonzalez, 2010). We examine this issue here using county multivariate analysis so we can consider several possible influences on physical disability rates at the same time.

The second exploration, in the same multivariate analysis, is a test of the relationship between county employment change in the 1990s and reported physical disability in 2000. Specifically, we consider five other possible sources of a county's high rate of physical disability besides child poverty:

- First, we include a rural-urban scale. Rural areas tend to lose population as young people leave for college, the armed forces, or city lights, and only some return (McGranahan et al., 2010). People with disabilities seem less likely to leave, making disability levels relatively high among those left behind. We used the National Center for Health Statistics' five-category urban-rural code to indicate how rural a county was.²⁷
- Second, to consider possible racial/ethnic differences, we included measures of the proportions of the population that were Black, American Indian/Alaskan Native, Asian/Pacific Islander, and Hispanic, leaving Whites as the omitted category.
- Third, because physical disability is likely to increase with age, and areas differ in their age structure, we included the proportion of the population in 2000 that was age 50 or over. We expected that, other things being equal, the higher this proportion, the higher the disability rate was likely to be.
- Fourth, to allow for industry differences in physical risk, we included the proportions employed in agriculture (including forestry and fishing), mining, and manufacturing in 2000. These industries make more physical demands than most service sector jobs.
- Fifth, we considered socioeconomic status in 2000—the percentage of those ages 25-64 who completed schooling beyond high school, the poverty rate (ages 25-54), and the proportion of single-parent families with children. Child poverty in 1970 and schooling completed were socioeconomic background measures, and 2000 adult poverty and single parenthood among families with children were the final measures. We expected that physical disability would be related not only to low socioeconomic levels in 2000 but also to 1970 child poverty as well.

In line with other county analyses in this study, equations were weighted by the relevant population, in this case, county residents who were aged 21-64 in 2000. Weighted regression gives more significance to counties with larger populations, assuming these estimates are more precise. Lest this weighting scheme result in esti-

²⁷For a more detailed description of these and other measures used in this study, see appendix table 1.1.

mates that apply to urban but not rural areas, the analysis was done for all counties and rural counties only. The rural and overall averages for the measures are in appendix table 1.1.

Appendix table 1.1

Physical disability county level analysis variable means and standard deviations

County measures	All counties		Rural counties	
	Mean	Std. dev.	Mean	Std. dev.
Physical disability percentage rate, population ages 21-64, 2000	6.9	1.7	9.4	3.3
Urban-rural categories, 2013 (each coded yes=1, else=0)				
Large metro area (population 1 million plus)	0.55	0.36		
Medium metro area (population 250,000–999,999)	0.21	0.29		
Small metro area (urbanized area, 50,000-249,999)	0.09	0.20		
Micropolitan area (urban cluster of 10,000-49,999)	0.09	0.20	0.58	0.49
Noncore (other rural)	0.06	0.18	0.42	0.49
Race/ethnicity (percent of population), 2000				
Black	12.2	9.3	8.4	14.5
American Indian/Alaskan Native	0.8	2.1	1.8	6.6
Asian/Pacific Island	12.2	10.3	5.3	11.1
Hispanic	4.9	4.4	0.8	1.8
Population ages 50-64 as percent of population ages 21-64, 2000	25.9	2.5	29.3	3.7
Percent employment by industry, 2000				
Agriculture, forestry, and fishing	1.5	1.9	4.7	4.2
Mining	0.4	1.0	1.2	2.7
Manufacturing	14.1	5.0	18.5	9.6
Socioeconomic background				
Child (0-17) poverty rate, 1970	14.8	6.8	22.0	13.5
Employment change, 1990-2000 (log _e)	0.122	0.096	0.121	0.111
Socioeconomic conditions, 2000 (percentages)				
No school completed beyond high school, ages 25-64	43.8	11	55.5	10.5
Poverty rate, ages 25-54	9.6	4.6	11.9	5.5
Single-parent families as percent of all families with children	29.1	7.9	27.7	6.9

Note: All measures weighted by 2000 county population ages 21-64. Log_e denotes natural logarithm transformation.

Source: USDA, Economic Research Service calculations based on data from the U.S. Census Bureau and, for 1970 child poverty, U.S. Census Bureau data from Integrated Public Use Microdata Series: National Historical Geographic Information System.

We present the results of the analysis in terms of correlations and partial correlations. A correlation (r) represents both the strength and direction of a relationship. Thus, it might be negative, such as between poverty and education, or positive, such as between height and weight. Mathematically, a correlation may be as strongly negative as -1 or as positive as +1, but socioeconomic measures tend to be imperfectly related and correlations are typically much smaller. Partial correlations reflect relationships remaining after taking the other measures in the analysis into account statistically.

Correlational statistics are not causal in one direction. For instance, county physical disability rates tend to be associated with relatively high poverty rates. Physical disability could cause poverty by limiting employment opportunities. But, through a lack of healthcare resources, poverty could make physical disability more likely. Correlations and partial correlations represent the degree that measures account for one another without presuming a direction of causation. An additional consideration is that, with about 2,000 rural counties and more than 3,000 overall, relationships may be statistically significant without having substantive impor-

tance. We consider correlations and partial correlations larger than ± 0.12 to be substantive in this study. For the rural, regional, and overall county analyses, correlations of this or larger size are always statistically significant.²⁸

The results show, first, that high physical disability rates correlate with highly rural areas, indicating that working-age residents in more rural areas tend to have higher physical disability rates than their more urban counterparts.²⁹ These differences, however, may be attributed to rural-urban differences in socioeconomic and other characteristics included in the study, as the partial correlations are all near zero.

²⁸Except in the Northeast, correlations and partial correlations of ± 0.12 are significant at the $p < .001$ level, meaning that the chances of finding a correlation of this size when there is not an actual relationship is less than 1 in 1,000. In the Northeast, with only 333 counties, correlations and partial correlations of this size are significant at the $p < .05$ level, the usual level accepted for statistical significance.

²⁹Separate calculations show that the physical disability rates for this age group are 5.9 percent in large metro areas and 10.2 percent in noncore rural areas.

Appendix table 1.2

County physical disability rate (ages 21-64), 2000, regressed on industry structure, socioeconomic background, current conditions, and control measures

County measures	All counties		Rural counties	
	r	Equation Partial r	r	Equation Partial r
Urban-rural scale				
Large metro area		...		
Medium metro area	0.08	0.05		
Small metro area	0.12	0.00		
Micropolitan area (rural)	0.25	0.00		...
Noncore (rural)	0.36	0.02	0.22	-0.04
Race/ethnicity (percent of population), 2000				
Black	0.12	-0.31	0.20	-0.37
American Indian/Alaskan Native	0.13	-0.11	0.05	-0.33
Asian/Pacific Islander	-0.43	-0.09	-0.15	-0.07
Hispanic	-0.19	-0.45	0.12	-0.31
Population ages 50-64 as percent of population ages 21-64, 2000	0.48	0.24	0.48	0.24
Percent employment by industry, 2000				
Agriculture, forestry, and fishing	0.30	-0.12	-0.14	-0.24
Mining	0.31	0.17	0.29	0.20
Manufacturing	0.16	-0.01	-0.03	-0.02
Socioeconomic background and change				
Child (0-17) poverty rate, 1970	0.62	0.23	0.59	0.25
Employment change, 1990-2000 (log _e)	-0.03	0.09	-0.11	-0.01
Socioeconomic conditions, 2000 (percentages)				
No schooling completed beyond high school, ages 25-64	0.71	0.32	0.56	0.25
Poverty rate, ages 25-54	0.57	0.32	0.67	0.42
Single-parent families as percent of all families with children	0.33	0.21	0.34	0.19
R ² (percent of variance accounted for)		78		74
Sample size (N)		3,067		1,935

Notes: Regression weighted by county 2000 population, ages 21-64. Appendix table 1.1 includes a fuller description of the measures. "Large metro area" and "Micropolitan area" are omitted variables in the overall and rural analyses, respectively. Log_e denotes natural logarithm transformation. r = correlation coefficient. Partial r = partial correlation coefficient.

Source: USDA Economic Research Service calculations based on U.S. Census Bureau data.

Second, the racial/ethnic composition of the population has some bearing on the physical disability rate. Areas with relatively high proportions of Blacks and/or American Indian/Alaskan Natives tend to have somewhat higher physical disability rates than elsewhere—but, given the negative partial correlations, substantially lower rates than one would expect based on other population characteristics. When taking other characteristics into account, areas with larger Hispanic populations tend to have much less physical disability than would be expected. Hispanics are a relatively young population in the United States, but this does not appear to be the only explanation as the age of the population is already included in the analysis.

Overall, counties with higher proportions employed in agriculture, mining, and manufacturing tend to have relatively high physical disability rates, but among the partial correlations of the three, only mining has a clear relationship with physical disability. In rural areas, the negative partial correlation for agriculture suggests that farming areas generally have low physical disability rates once other factors are taken into

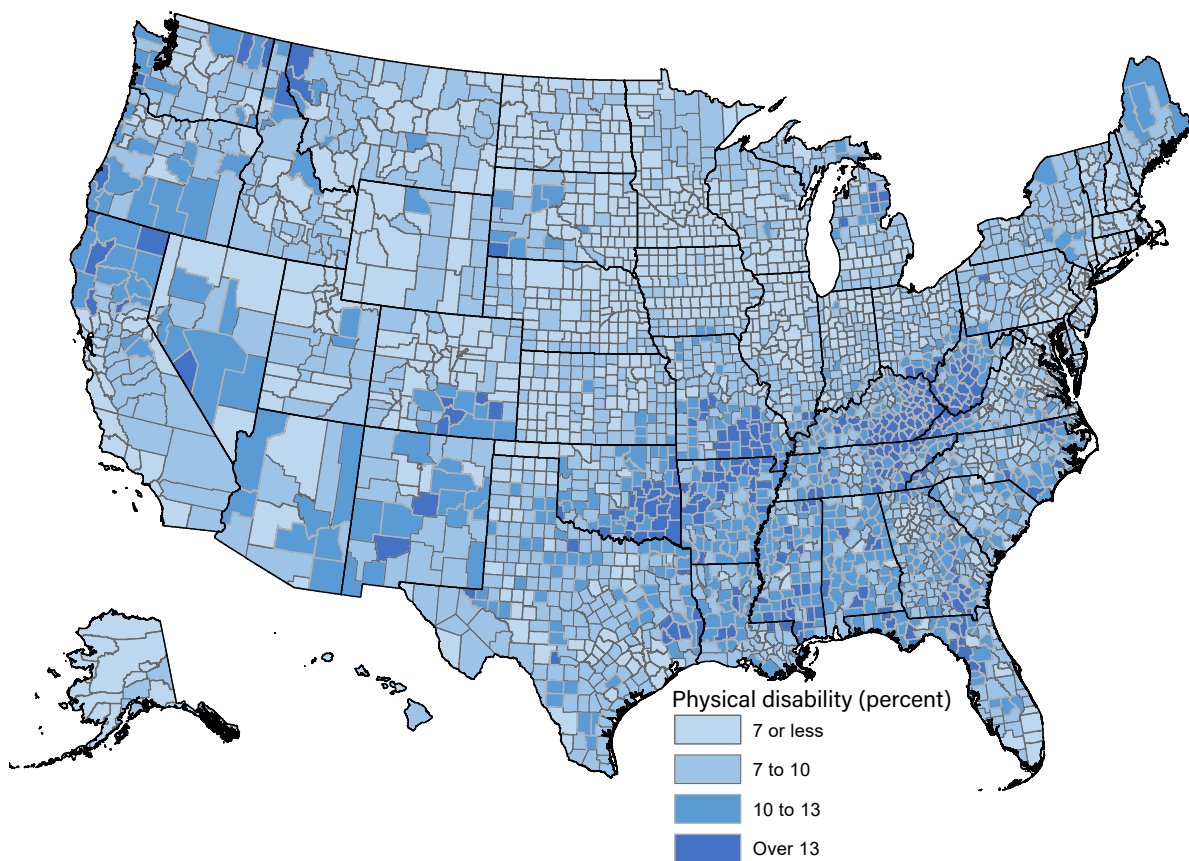
consideration. Rural mining areas usually have relatively high physical disability rates. This could partly be a legacy from a time when mining was more prevalent.

While socioeconomic measures were highly associated with physical disability in 2000, child poverty in 1970 correlated as well. The corresponding partial correlation was smaller than the overall correlation but still substantial overall and in rural areas, supporting the conjecture that high rates of physical disability stem in part from long-term economic and health difficulties. The results fit the life course approach, which locates the genesis of much chronic disease in childhood distress.

Finally, there is no indication that county employment change over 1990-2000 had a substantial influence on self-reports of physical disability in 2000 overall or in rural areas. The results may be different when there is widespread job loss, but that was not the situation in the 1990s in rural or urban areas.

Appendix figure 1

Physical disability rate by county for ages 21-64, 2000



Note: Census respondents with a physical disability reported having a long-lasting condition that substantially limited one or more basic physical activities, such as walking, climbing stairs, reaching, lifting, or carrying.

Source: USDA, Economic Research Service calculations using data from the Census Bureau, 2000 Census, Summary File 4.

A county map of physical disability in 2000 shows high disability rates concentrated in the Southern Highlands, including the Appalachian areas of West Virginia, Kentucky, and parts of Tennessee, the Ozarks of southern Missouri and northern Arkansas, and the Ouachita mountains of eastern Oklahoma and parts of Arkansas. Coal mining dominated parts of West Virginia and Kentucky but has been rare in the rest of the Southern Highlands. These areas are largely populated by Whites and often have had high poverty rates (Beale, 2004).

Other areas with high rates of physical disability in 2000 tended to be more scattered but included northern California, southern Oregon, and a cluster of northern Michigan counties, as well as several counties dispersed across the South. In contrast, counties in the agricultural Northern Plains tended to have among the lowest rates of physical disability.

Appendix table 1.3

Age-adjusted mortality rates from natural causes in 1999-2002, Whites non-Hispanics, ages 25-54, regressed on physical disability rate, education, and poverty in 2000, State rural areas and counties

Area population characteristics (percentages)	A. State rural areas Coefficients		B. Rural counties Coefficients		C. All counties Coefficients	
	r	Partial r	r	Partial r	r	Partial r
Physical disability rate (ages 21-64)	0.87	0.75	0.68	0.42	0.69	0.32
No education beyond high school (ages 25-64)	0.73	0.43	0.50	0.19	0.50	0.02
Poverty rate (ages 25-54)	0.60	-0.36	0.54	-0.08	0.62	0.10
R ² (percent of variance accounted for)		83		48		48
Sample size (N)		47		1,764		3,128

Notes: Natural causes are all causes except those classified as "external" (ICD-10 codes V01-Y89), such as accidental deaths, homicide, and suicide. All measures are for White non-Hispanics. County analyses are weighted by White non-Hispanic population, ages 25-54 in 1999-2002. r = correlation coefficient. Partial r = partial correlation coefficient.

Source: USDA, Economic Research Service calculations based on data from the U.S. Census Bureau and the Centers for Disease Control and Prevention and National Center for Health Statistics.

Appendix 2: County Analyses of Drug Overdose Mortality in the Northeast and Remaining States: Means and Standard Deviations

Appendix table 2
County analyses of changes in drug overdose mortality, Northeast and remaining States: Means and standard deviations

County measures	Counties in Northeast States		Counties in remaining States	
	Mean	Std. Dev.	Mean	Std. Dev.
1. Change in age-adjusted drug overdose mortality rates per 100,000, 1999-2002 to 2010-12, White non-Hispanics, ages 25-54	16.7	10.8	16.7	14.1
Urban-rural categories, 2013 (each coded yes=1, else=0)				
Large metro area (population 1 million plus)(omitted metro category)	0.60	0.49	0.47	0.50
Medium metro area (population 250,000-999,999)	0.22	0.41	0.22	0.42
Small metro area (urbanized area, 50,000-249,999)	0.06	0.24	0.12	0.32
Micropolitan area (urban cluster of 10,000-49,999)	0.09	0.28	0.10	0.31
Noncore (other rural)	0.03	0.18	0.08	0.27
Percent reporting physical disability, White non-Hispanics, ages 21-64, 2000	5.9	1.7	6.9	2.7
Socioeconomic characteristics, White non-Hispanics, 2000				
Percent with no school completed beyond high school, ages 25-64	40.6	12.2	38.2	13.4
Poverty rate, ages 25-54	5.7	2.7	6.5	3.3
One-parent families as a percent of all families with related children	21.0	4.3	22.1	3.9
Community change				
Change in overall population due to net migration, 2000-2010 (log_e)	-0.017	0.062	0.041	0.129
Number employed in previous year, ages 16-64, ratio 2007-11 to 2000 (log_e)	0.002	0.05	0.049	0.099
Percent with a college degree, change 2000 to 2006-10, White non-Hispanics, ages 25 and over	4.7	2.0	4.0	2.0
2. Change in age-adjusted drug-induced mortality rates per 100,000, 2010-12 to 2016-18, White non-Hispanics, ages 25-54	40.4	20.5	10.7	20.5
Socioeconomic characteristics, White non-Hispanics, 2006-2010				
Percent with no school completed beyond high school, ages 25 and over	35.8	11.4	34.1	12.5
Poverty rate, ages 25-54	7.1	3.2	8.3	3.7
One-parent families as a percent of all families with related children	23.6	6.3	24.9	5.3
Community change				
Change in overall population due to net migration, 2000 to 2005 (log_e)	0.004	0.021	0.029	0.051
Number employed in previous year, ages 16-64, ratio 2013-17 to 2007-11 (log_e)	-0.004	0.04	0.021	0.067
Change in percent with a college degree, 2006-10 to 2013-17, White non-Hispanics, ages 25 and over	4.0	1.7	3.3	1.9

Notes: Statistics weighted by White non-Hispanic population, ages 25-54, 2009-12. Northeast States include: CT, DE, DC, ME, MD, MA, NH, NJ, NY, OH, PA, RI, and VT. Measures included in both tables 2 and 3 are not repeated in this list. County measures of socioeconomic status and employment post-2000 are only available for 5-year periods from the U.S. Census Bureau's American Community Survey. Differences between the Northeast and the rest of the country are bolded where they are at least 0.12, signifying both statistical and substantive differences. Log_e denotes natural logarithm transformation.

Source: USDA, Economic Research Service calculations based on data from the National Center for Health Statistics and standardized to the 2014 population using 5-year age groups. Net migration statistics are from the University of Wisconsin, while the 2010-15 migration data are U.S. Census Bureau estimates.