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CAUSES AND CONSEQUENCES OF ILLICIT DRUG EPIDEMICS

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ABSTRACT

Large and rapid upswings in illicit drug use display similar properties to infectious disease epidemics. In this chapter, we review research to understand what causes drug epidemics and how they end. Drug market actors are subject to both positive and negative reinforcement that lead to rapid, nonlinear increases and decreases in drug market activity. There is evidence that drug epidemics cause serious problems, including drug overdoses, adverse birth outcomes, homicides, lower educational attainment, and migration from neighborhoods subject to intense drug market activity. Many of these costs are borne by those who do not consume or sell drugs. Given the frequency, size, and impacts of illicit drug epidemics, they deserve more attention by researchers and policy-makers.

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1. Introduction

It is estimated that more than one quarter of a billion people use illicit drugs each year (United National Office on Drug and Crime, 2020). Illicit drug use is associated with significant health, crime and personal problems, as well as broader societal impacts via the violence and organized crime connected to the production and distribution of illicit drugs. Considerable research attention in the economics, psychology, epidemiology and sociology literatures has been given to understanding why individuals begin to use illicit drugs and how addiction affects their ongoing levels of drug use. While a great deal has been learned about individual and social factors that influence individual decision-making related to illicit drugs, far less is understood about what causes rapid and widespread increases in the use of particular drugs.

Epidemics are generally associated with infectious diseases, where a disease is transmitted among individuals and quickly spreads within a local population. Growth can be exponential in its early stages, depending on the number of people with the disease and the rate at which they spread it to others. The novel coronavirus, Covid-19, displays these features, and demonstrates the substantial public health challenges associated with controlling the spread of an infectious disease.

The same nomenclature is applied to rapid surges in the number of people who use and abuse psychoactive drugs in a particular city, region or country. Although the spread of drug abuse need not be exponential, as it is not directly transmitted from one individual to another biologically, growth is often exponential due to the social nature of drug use (Jalal et al. 2018). Other features are also similar, such as how the problem begins and intensifies in particular social groups or locations before spreading to broader groups of people.

The similarities between rapid surges in drug abuse and infectious disease epidemics have long been noted. For example, the American Association for the Study and Cure of Inebriety (1893) noted that alcohol abuse has a “decided epidemic and endemic influence” (83), and a 1923 resolution at a Moscow medical conference stated that “cocaine abuse was spreading over Soviet Russia like an epidemic” (Vasilyev 2016, 184). More specific applications of the terminology of epidemics to drug abuse problems becomes evident in research in the 1950s. For example, a 1953 article titled “Epidemic of narcotic use among school children in New York City” argues that: “As is true of any epidemic disease, it is not only the noxious agent that must be studied, but also the host and the total environment” (Jacobziner 1953, 66). By the early

1970s, the approaches used to understand infectious disease epidemics began to be applied to illicit drug epidemics (e.g., DuPont 1971; DuPont and Greene 1973; Jonas 1973). The frequency and formality of these approaches increased in the late 1980s and early 1990s (e.g., Caulkins 1990; Homer 1993; Everingham and Rydell 1994). About the same time, similar methods were being applied to study several infectious diseases strongly associated with injection drug use, including Hepatitis B, Hepatitis C and HIV/AIDS (e.g., Anderson 1988; Taylor 1989; Deuffic et al. 1999).

In this chapter, we review research on the economics of illicit drug epidemics and evaluate the current state of knowledge. The first section describes major illicit drug epidemics in the United States. As each epidemic has distinctive features that require some detail, space precludes a detailed discussion of drug epidemics worldwide, although epidemics in other countries are used to deliver additional insights in a few cases. The second section covers literature that emphasizes the mechanics or dynamics of illicit drug markets, such as why supply and demand can change rapidly over time in ways that may explain the rise and decline of illicit drug epidemics. The goal is to identify likely drivers of drug epidemics, as well as the factors that contribute to their ending. In doing so, several areas are identified where additional dynamic modeling would be helpful. In the third section, the consequences of illicit drug epidemics are documented, highlighting that there are many beyond those directly related to drug use. In the final section, insights for policy makers and researchers are considered.

2. Background on illicit drug epidemics

2.1 Early drug epidemics

Detailed documentation of US drug epidemics starts with those occurring in the second half of the 19th century. The use of morphine and other opioids became fairly common over this period, especially during and after the American Civil War in the 1860s, when many injured soldiers and veterans were given opioids to treat their pain. Technological innovation had a role in this epidemic, with the availability of the modern hypodermic syringe from the 1850s onward meaning that some injured soldiers were administered opioids intravenously during the War. After the War, many veterans continued to use opioids and became addicted to them. Many women also became addicted to opioids after being given them to treat neuralgia, morning sickness, or painful menstruation. Opioid addiction also became common among physicians,

who had easy access to them (Courtwright 1983). Around the same time, opium smoking occurred at high rates among gamblers and prostitutes after the practice spread from Chinese immigrants (Courtwright 1978).

Cocaine became widely available in the 1880s, in part as a safe alternative to opioids and a way to treat opioid addictions. Sigmund Freud extolled its virtues in 1884, describing both its euphoria and the lack of compulsive desire to use it further. Cocaine or coca was available in the USA in at least 15 forms, including in cigarettes; as an inhalant; as crystals; in a solution for a hypodermic injection; and in minute amounts in the earliest version of Coca-Cola. By the late 1880s, there were stories of chronic addiction to cocaine. There was wider recognition of the dangers of cocaine by the turn of the century, and states began to attempt to regulate its use. In 1910, President Taft described cocaine as "more appalling in its effects than any other habit-forming drug used in the United States" (Musto 1989, 64).

Federal regulation of the sale and distribution of opioids and cocaine began with the 1914 Harrison Narcotic Act. Initially, many physicians continued to provide these drugs to people who were already addicted to them as a form of maintenance treatment, as it was not explicitly prohibited in the Act. The Supreme Court banned this practice in 1919, driving people addicted to opioids and cocaine first into local narcotics clinics and then into black markets as these clinics were shut down. According to historians, these measures appeared to cause the use of these drugs to wane in the 1920s and 1930s (Courtwright 1983; Musto 1989).

Since then, almost all use of opioids and cocaine has been illegal, and they have been supplied through highly developed – and often very profitable – black markets. This has generally made it difficult and expensive for people to obtain these drugs and also created consequences related to illegality, especially around criminal sanctions for drug use or possession. Economists have analyzed how legalization and depenalization might affect illicit drug markets, although in these studies the markets are typically assumed to be reasonably stable and do not focus on how a drug's legal status affects the nature of illicit drug epidemics (e.g., Miron and Zweibel 1995; Becker et al. 2006; Jacobi and Sovinsky 2016; Galenianos and Gavazza 2017).

Other drug epidemics occurred in the middle of the 20th century. There was an amphetamine epidemic that occurred between the 1930s and 1960s, when it was legal and first marketed as an over-the-counter pharmaceutical inhaler and then used as a prescribed treatment

for depression and weight loss. Widespread heavy use led to addiction and psychosis in large numbers. After the introduction of the 1970 Comprehensive Drug Abuse Prevention and Control Act, amphetamine products were included as Schedule II drugs, which made them subject to quotas, strict record-keeping by doctors and pharmacists, and the need for a new prescription each time they were filled. After these restrictions, prescription sales fell 60% (Rasmussen 2008).

A serious epidemic of heroin addiction occurred in Chicago's black community in the late 1940s and 1950s. Hughes et al. (1972) documented a rapid rise in initiation of heroin use that peaked around 1949. It was estimated that 5,000 to 10,000 people became newly addicted to heroin over this period. Through the 1950s, heroin prices increased and heroin quality decreased. New laws and an intense law enforcement response contributed to an increase in narcotics arrests, although Hughes et al. (1972) argue that initiation was declining ahead of this criminal justice response. There were other illicit drug epidemics, including a heroin epidemic among juveniles in New York City in the late 1940s and 1950s (Jacobziner 1953), and heroin epidemics in Baltimore and Washington DC in the late 1960s and early 1970s (DuPont and Greene 1973).

All of these events display rapid increases in drug initiation, with a manyfold increase in the use of a particular drug in only a few years. The increases in drug use are associated with visible problems related to addicted individuals and drug markets and a rise in drug treatment, which is followed by a rapid reduction in new drug users and market activity.

2.2 Major illicit drug epidemics in recent years

The cocaine/crack epidemic. Colombian drug cartels began supplying powder cocaine into the United States during the 1970s. Powder cocaine consumption increased across race and class, peaking around 1980 (Hamid 1992; Reuter 2013). Around that time, crack cocaine was introduced from the Caribbean into the USA. Crack cocaine is made by cooking powder cocaine with baking soda and water, and is then broken up and smoked once it cools and hardens. Crack was easier and safer to produce than other types of smokable cocaine and produced a more intense high than intra-nasally ingested powder cocaine (Agar 2003). Crack cocaine users report that smoking it yields a high lasting 20 minutes, followed by a sharp crash and an intense drive to get high again (Fagan and Chin, 1989). The drug proved to be popular with existing and new users of cocaine, who could buy a "hit" of crack for as little as five dollars (Witkin 1991).

Crack cocaine use first occurred in Miami, and soon after in Los Angeles and New York. Dealers initially sold the drug in "crack houses," which also offered a place to use the drug, and then moved to open-air sales where they used widespread violence to both establish and protect their local markets (Fagan and Chin, 1989; Reuter et al., 1990). As the markets in these initial cities became more competitive, crack cocaine markets spread to nearby cities. Traffickers steadily moved inland, and by the early 1990s crack cocaine was available throughout the United States (Evans, Garthwaite and Moore 2016).

There was a rapid increase in initiation that resulted in a cohort of users heavily addicted to crack cocaine, as well as a substantial increase in violence associated with the street markets (Fagan and Chin, 1989). Figure 1 shows some key outcomes associated with the crack cocaine epidemic. Figure 1a shows the number of deaths with a cocaine-related cause listed on the death certificate. These are from the public-use versions of the National Center for Health Statistics' Multiple Cause of Death data files. While these deaths increased throughout the 1980s and 1990s, the data show that it was never an epidemic associated with large numbers of fatal overdoses.

A far more salient association was between crack cocaine markets and gun violence, as shown through homicide rates in Figures 1b and 1c, the data for which also come from public-use versions of the Multiple Cause of Death data files. These figures are similar to those first presented in Blumstein (1995), and subsequently by Fryer et al. (2013) and Evans, Garthwaite, and Moore (2016). The annual murder rate of black males aged 15-24 increased from 66 deaths per 100,000 population in 1985 to 166 deaths per 100,000 in 1993, dwarfing the changes of other demographic groups.

This was also a period when the incarceration of black males increased substantially, although these increases are smoother than for homicide rates. Figure 1d shows the incarceration rates for black and white males over time. This is a replication of Figure 4d in Evans, Garthwaite and Moore (2016), which uses data come from the US Bureau of Justice Statistics National Corrections Reporting Program.

It has been argued that this rise in incarceration was generated by both a change in the level of criminal activity related to crack cocaine markets and a shift in national drug policy to address it (Pettit and Western 2004; Fryer et al. 2013). The epidemic stopped as quickly as it had taken off. Data from the National Household Survey on Drug Abuse show that the number of

past year cocaine users declined by nearly 50% between 1985 to 1990 (from 12.2 million to 6.2 million) as did past month prevalence (from 47.1% to 25.8%) (US General Accounting Office 1991). In Section 4 on the consequences of illicit drug epidemics, research is described that links violence and incarceration to the crack cocaine epidemic. This demonstrates the breadth of illicit drug epidemics and suggests that drug use is only one element to consider when evaluating the characteristics of illicit drug epidemics.

The Western US methamphetamine epidemic. Methamphetamine can be made from ephedrine or pseudoephedrine, the active ingredients in commonly used cold medicines. In the 1990s, large quantities of these chemicals began to be smuggled into California from Mexico and used in large laboratories in the desert. Smokable forms of d-methamphetamine hydrochloride, known as "ice" and "crystal meth," were also imported into the Western parts of the United States. Methamphetamine use and abuse grew as it became cheap and widely available. Small-scale producers began to use over-the-counter cold medications to make methamphetamine in smaller local laboratories (Maxwell and Brecht 2011).

Federal regulations were introduced in 1989, 1995 and 1997 to limit the availability of ephedrine and pseudoephedrine in forms used by large-scale producers. There were also federal efforts to tighten over-the-counter medications introduced in 1996 and 2001, and states also began to track and limit medications in 2004. DEA methamphetamine laboratory seizures between 1999 and 2016 are shown in Figure 2a. The number of labs found tripled between 1999 and 2004, and then fell rapidly through 2007 before increasing to a second, smaller peak in 2010. This second peak suggests methamphetamine producers had found new ways to access precursor chemicals or use different chemicals (Maxwell and Brecht 2011).

Methamphetamine treatment admissions per capita are shown in Figure 2b. Nationally, treatment admissions were fairly low, peaking in 2005 at around 70 admissions per 100,000 population aged 12 and older. However, the treatment rates for the three western Census divisions are much higher than the national average. The Pacific division, which consists of California, Oregon, Washington, Hawaii and Alaska, has the highest treatment rates, peaking in 2006 at around 220 treatment episodes per 100,000 residents. At this time, Oregon had the highest rate of all states at 328 episodes per 100,000 residents. Other western Census divisions had higher treatment rates than the national average as well, with their trends tracking the Pacific division until about 2010, when they started to rise. By 2013, the West North Central division

actually exceeded the Pacific division in terms of treatment entries per 100,000. Beyond 2015, methamphetamine abuse has continued to grow, and there is a recent epidemic that rivals the levels in the early 2000s.

The opioid epidemic. The current US opioid epidemic began in the late 1990s and has accounted for nearly 450,000 overdose deaths between 1999 and 2018 (Centers for Disease Control and Prevention 2020). Opioid problems are still increasing; more than 50,000 people died from opioid overdoses in 2019, according to preliminary numbers (Ahmad, Rossen and Sutton 2020). The magnitude and persistence of opioid drug overdose deaths has led to 3 years of consecutive declines in US life expectancy in recent years (Case and Deaton 2017, 2020; Woolf and Schoomaker 2019). The impacts of this crisis far exceed just overdose mortality. They include lost employment (Harris et al. 2019; Kaestner and Zieden 2019); increases in foster care placements and reductions in child welfare (Crowley et al. 2019); the spread of hepatitis C and other infectious diseases (Powell, Alpert, and Pacula 2019; Centers for Disease Control and Prevention 2017); and enormous tolls on the first response emergency management system. Figure 3 shows how the opioid epidemic has evolved over its three different phases. It started as an epidemic driven largely by prescription opioid analgesics from 1999 until 2010, then transitioned to an epidemic driven by heroin from 2010 through 2013, at which point the epidemic transitioned into its current stage, where opioid mortality is being driven by highly potent synthetic opioids, including fentanyl and fentanyl analogs.

While many who study the opioid crisis recognize that several factors have contributed to its ongoing evolution, the primary impetus for it was the overpromotion of a new long-acting opioid, OxyContin, marketed by Purdue Pharma starting in 1996 (Alpert et al. 2019; Cuéllar and Humphreys 2019; Humphreys 2017). Recent work has demonstrated how opioid analgesics became widely available on the medical market as a result of purposeful promotion to particular physician prescribers (Kiang et al., 2020; Nguyen, Bradford and Simon, 2019) and in particular states (Alpert et al., 2019). For example, Kiang et al. (2020) report that in 2017 the top 1% of physicians prescribing opioids accounted for nearly half of all opioid doses and more than one quarter of all opioid prescriptions; this was after medical boards, healthcare systems and states adopted guidelines and policies to reduce its prescribing. Other factors also contributed to the massive expansion of opioid analgesic prescribing during the 2000s, including the American Pain Society's influential campaign to recognize "pain as the fifth vital sign." This was

subsequently adopted by the Veteran's Health Administration and incorporated into published standards for pain management by the Joint Commission on Accreditation of Healthcare Organizations, ultimately affecting hospital payment reforms (Jones et al. 2018). Unprecedented insurance expansions, including the introduction of Medicare Part D, also contributed to the widespread distribution and use of these opioids (Powell, Pacula and Taylor 2020). Diversion from medical uses to the black market started occurring through healthcare fraud; doctor and pharmacy shopping, where patients obtained excess opioid doses by visiting multiple providers; "pill mills," which were pain clinics with cheap and lax dispensing; and the use of fraudulent scripts (Inciardi et al. 2009; Rigg et al. 2012; Cicero et al. 2011; Inciardi et al. 2007). Significant economic rents could be obtained by selling excess opioids on the black market (Powell and Pacula 2017).

Purdue Pharma introduced a reformulated version of its popular OxyContin in April 2010 that was designed to make the drug less easy to abuse, and by August 2010 the company stopped distributing its original non-abuse formulation to pharmacies. Several studies have shown that this supply shock led to the unintended shift of opioid-dependent users from expensive illicit prescription opioids to much cheaper heroin, thereby starting the second phase of the opioid crisis (Alpert, Powell and Pacula 2018; Evans et al. 2019). The shock was amplified by the adoption of more effective prescription-drug-monitoring programs to limit doctor and pharmacy shopping, and the closure of "pill mills." These efforts further reduced the overall supply of prescription opioids within the medical system (Kaestner and Ziedan 2019; Rutkow et al. 2015).

As the demand for heroin grew, fentanyl emerged as a cheap adulterant to heroin and then subsequently as a replacement for it (Pardo et al. 2019). Powell and Pacula (2020) show that the rise in fentanyl overdoses occurs in the same geographic locations as the early demand for OxyContin, disproportionately impacting states that had higher rates of OxyContin misuse prior to the abuse-deterrent reformulation. The substantially higher potency of fentanyl and its synthetic analogues have triggered an enormous surge in overdose deaths, which started in 2013 and has accelerated since 2015. As shown in Figure 3, fentanyl and its synthetic opioids have surpassed overdose deaths from every other type of substance since the summer of 2016 and are now the major driver of drug overdose deaths. Unlike prescription opioids, which were predominantly obtained through medical markets and diverted to the black market, the synthetic opioids are believed to be supplied from black market providers much more cheaply (Drug

Enforcement Agency 2019).

Three drugs have been at the heart of all major US drug epidemics: opioids, cocaine and methamphetamine. The forms of the drugs have changed over time, as have their potency, methods of use and supply. However, there are echoes of early drug epidemics in the most recent ones, such as the role of medical providers in supplying drugs and failing to account for the addictive potential of the drugs. Common themes from these epidemics are examined in the next section in order to understand why they occur.

3. Causes of illicit drug epidemics

Widespread drug use – as indicated by a high prevalence rate – is not indicative of an epidemic. Alcohol use has remained relatively high and stable for several decades without being described as a drug epidemic; the same is true for cigarettes prior to 1980. Epidemics occur when initiation rates increase rapidly, and "heavy" addicted users become sufficiently numerous to create substantial feedback loops that encourage further initiation and escalation. This drives the population level of use away from a stable equilibrium (Everingham and Rydell 1994; Caulkins 2001). In this section, the potential causes of illicit drug epidemics are explored. Before doing so, it is useful to outline the general determinants of demand for intoxicating substances.

3.1 General determinants of drug demand

At any point in time within a population there is a latent demand for intoxicating substances – or at least the desirable properties that the consumption of these substances provides. The demand is "latent" for two reasons. First, social norms and legal penalties discourage use of the illegal products, which both raises their price and adds non-pecuniary costs (Grossman 2005; Reuter and Kleiman 1986). Second, intoxicants are experience goods; people do not know *a priori* the value they receive from using a drug until after it is consumed (Caulkins 2007; Nelson 1970). People initiate drug use when some external factor changes their initial benefit-cost calculation (e.g., friends or family members offer drugs for free; there is a social event where they are made available; a painful injury introduces them to prescription medication). To the extent that an external factor influences the drug-use decisions of a large number of individuals within a population at the same time, there will be a rise in the overall level of initiation.

The pleasurable experience afforded to someone using an intoxicating substance is a function of individual factors, such as genetics, preferences, mental and physical health status, body mass, the amount of drug consumed, and its mode of administration. Empirical models of the demand for illegal goods generated by economists, while emphasizing the role of price, frequently consider many related individual factors that other fields have emphasized as influencing demand, including sociodemographic characteristics, differences in rates of time preference, engagement in deviance and/or truancy, religious commitment, and attitudes about health risks (Williams et al. 2004; DeSimone and Farrelly 2003; Pacula et al. 2001; Saffer and Chaloupka 1999; Chaloupka et al. 1999; Pacula 1998). However, while many of these individual characteristics are important predictors of contemporaneous use, they have little influence on cycles of demand over time (Bachman et al. 1981, 1988). Furthermore, the shifts in demand observed in drug epidemics have been too sudden to be plausibly explained by trends in underlying population characteristics (Caulkins 2001; Jacobson 2004). Indeed, two early studies examining cycles in illicit drug use found that only perceived risk of harm and perceived availability mattered for predicting trends in prevalence rates among high school seniors (Bachman et al. 1988; Bachman et al. 1981). Both factors, however, are clearly influenced by social norms and actual availability rather than individual factors *per se*.

Illicit drug use clearly depends on social factors, including the environment in which the use occurred, the social context, and the positive or negative reinforcement surrounding that use. Manski (1995) notes that social interactions with others, whether "contextual" or "endogenous," can influence individual behavior. Indeed, there is generally consistent evidence of positive and economically significant peer effects for illicit drug use that uses a variety of different strategies to address identification and endogeneity issues (Argys and Rees 2008; Lundborg 2006; Gaviria and Raphael 2001; Case and Katz 1991). A notable exception is a study by Eisenberg et al. (2014), who use random variation in the assignment of college roommates as their source of identification. They find that roommates have no statistically significant impact on peers' use of any illicit drugs in the previous six months, although they do find that peers influence binge drinking.

Caulkins (2001) argues that the variability in the number of illicit drug users over three decades has consistently exceeded that of other social phenomena thought to be highly variable, including homicide rates, regular cigarette use, the price of crude oil, and the incidence of AIDS.

This suggests that the economic and sociodemographic factors driving each of these other phenomena are insufficient by themselves to describe the volatility in drug use.

Given that is the case, a key question is what drives broader trends that affect drug prevalence among peers. Many have argued it is the general availability of the different illicit drugs on the market, which economists usually characterize in terms of quality-adjusted prices. Research focused on cannabis shows that changes in quality-adjusted prices is indeed an important predictor in trends in use over the past several decades, in addition to trends in perceived risk (Pacula et al., 2001). As shown in Figure 4, the quality-adjusted retail prices per pure gram of the most commonly used illicit drugs – cocaine, heroin, and methamphetamine – have been declining precipitously since 1981 (the earliest year for which data is available). The persistent declines in the retail prices of these drugs have led some to conclude that prohibition and the enormous law enforcement resources dedicated to it have little impact on illicit drug prices (Pollack and Reuter 2014; Miron 2006). However, various studies have shown that targeted law enforcement, particularly methods that are able to generate unexpected supply shortages, can indeed have an impact on purity-adjusted drug prices, at least in the short run (Galenianos et al. 2012; Dobkin and Nicosia 2009; Freeborn 2009; Weatherburn et al. 2003). This suggests that the persistent decline largely reflects innovation in the illicit production process and supply chain, as well as increasing competition among suppliers (Grossman et al. 2002; Caulkins 1995, 2007).

It is important to consider one last aspect of individual demand for illicit drugs before moving on to consider the potential drivers of epidemics: addictive potential. The consumption of most illicit drugs is reinforcing, either behaviorally or through the social reinforcement received from doing it (Akerlof 1997; Becker 1996; Bikhchandani et al. 1992), or because of the physiological and neurological impacts these intoxicating substances have on the brain and body (National Institute for Drug Abuse 2020). As a result, demand is a function of past consumption due to addiction and tolerance (Backer and Murphy, 1988). Because demand is a function of past consumption, demand is susceptible to positive feedback effects through changes in use. Interestingly, this is the primary aspect of illicit drug demand dynamics that economists have modeled theoretically. Rational addiction models assume that individuals are aware of these feedback effects when making decisions about current consumption, including their impact on future use (Becker, Grossman and Murphy 1991; Grossman and Chaloupka 1998). Thus, when

the decision is made to initiate and continue drug use, it is done without regret unless there is uncertainty and learning (Orphanides and Zervos 1995). Alternative theories grounded in behavioral economics note that individuals exhibit behavioral patterns that suggest they are not fully aware or satisfied with their persistent consumption of addictive goods; for example, cue-triggered models imply that users of an addictive good will incur costs to prevent themselves from being tempted by it in the future (e.g., O'Donoghue and Rabin 1999; Bernheim and Rangel 2004; Bickel et al. 2010).

To summarize, there are a number of factors influencing the demand for illegal drugs in equilibrium, but with the exception of declining prices, none have shifted dramatically enough over time to explain how and why particular drug epidemics have recently emerged. And because the price for all three primary illicit drugs of abuse have experienced long-run declines throughout the period examined here, it must not be the case that price declines alone are sufficient to trigger an epidemic. Some of the most plausible drivers are considered next.

3.2 Supplier-induced demand

If one looks at US drug epidemics of the past, there has been a fairly consistent role played by legal suppliers of new powerful pharmaceutical products. As described already, the rise in opioid addictions during the latter part of the 19th century was primarily driven by doctors who liberally dispensed opium and morphine to their patients, starting with Civil War veterans and then other patients experiencing pain. Heroin, produced by Bayer in the 1890s, was initially developed to treat the flu and respiratory ailments and then became a pharmaceutical used to manage morphine addiction (Stobbe, 2017). Likewise, cocaine was promoted and spread through medical and related products. Cocaine and heroin both became much more expensive when they were driven underground after the Harrison Act, and historians believe that price increase was a major reason these epidemics came to a stop. A similar story could be told about the abuse of amphetamines, which began shortly after the drugs became medically available in the 1930s and then were widely prescribed from the 1940s through the 1960s before regulation again pushed them underground.

In light of this history, it is not surprising that the recent US opioid epidemic is viewed as the latest in a series of drug epidemics caused by the legal pharmaceutical industry (Herzberg et al. 2016; Stobbe 2017). The fact that doctors are understood to be the agents of their patients, not

the mouthpieces of the pharmaceutical industry, is what causes most patients to trust their physicians and take medications as prescribed. Unfortunately, the lack of awareness by the medical profession as to the true addictive nature of opioid analgesics, coupled with a mass-marketing campaign directed at doctors by the pharmaceutical industry, led to the unexpected growth in individuals escalating from casual use of a medically appropriate pain reliever to heavy and dependent use (Alpert et al. 2019; Evans et al. 2019; Finkelstein et al. 2018).

Thus, in the United States, supplier-induced demand driven by the pharmaceutical sector is an important contributor to prior drug epidemics, and something that may merit greater consideration in terms of policy solutions.

3.3 Population dynamics, demographics and socioeconomic factors

Several have noted the strong correlation between the size of a cohort and the prevalence of use of illicit substances (Jacobson 2004; Gruber 2001; Kleiman 1993). The age distribution of a population can change quickly as a result of baby booms, suggesting that population dynamics may still play a role in the development of epidemics.

It has been difficult to determine the mechanisms driving the correlation between cohort size and illicit drug prevalence (Jacobson 2004; Gaviria and Raphael 2001; Caulkins 2001). Demographers have argued that increases in the size of a youth cohort puts a strain on existing resources (Easterlin, 1978). This can mean that the risks youths face of being caught and penalized for illicit drug use fall when youth-cohort size rises amid a fixed level of enforcement (Sah 1991; Kleiman 1993; Gaviria and Raphael 2001). Kleiman (1993) describes this as "enforcement swamping," which happens whenever the frequency of an offense rises while enforcement resources remain the same. When the risk of arrest falls, it can encourage even more youth in the larger cohort to use drugs, further reducing the likelihood of arrest. Importantly, the risks to sellers also fall if enforcement resources do not rise with increases in frequency of use, which reduces drug prices. The reduction happens because a big component of the monetary price of an illicit drug lies in the legal risks associated with bringing it to the market (Kleiman 1993). Jacobson (2004) argues that there are enforcement-related "economies of scale" for drug suppliers, as an increase in supply requires a less-than-proportional increase in resources to evade law enforcement due to the "thicker" market. She examines the relative role of these different mechanisms and finds that economies of scale in the supply of drugs explain at least a

quarter of the association between cohort size and substance use, whereas the lower risk of arrest for the user explains around 10% of the relationship over time.

Prevention is another way that resources may be constrained when there are larger youth cohorts. Almeder et al. (2001) note that the initiation rate for an illicit drug over time is influenced by a constant level of initiation, which is based on latent demand, and two time-variant factors that can either reduce initiation or increase it: (1) the reputation of the drug and (2) the effectiveness of prevention programs. When limited prevention resources are stretched in an effort to reach more children, the relative effectiveness of those resources may be diminished. The authors also show that age-specific reputation effects can be important for amplifying or dampening initiation in this model. Incorporating age-specific heterogeneity into a model of the initiation of drug use enables it to mimic more key dynamics of the US cocaine epidemic.

Shifting socioeconomic factors also appear to play a role in amplifying demand. In a series of well-publicized papers, Case and Deaton (2017, 2015) have documented the declining life expectancy of white, non-Hispanics in recent years, particularly those without a college degree. This is driven primarily by drug overdoses, as well as alcohol and suicide, which has led to a series of efforts to try to explain why particular demographic groups and socioeconomic classes have been more susceptible to "deaths of despair" (e.g., Ruhm 2019a; Dow et al. 2019; Hollingsworth et al. 2017; Dasgupta et al. 2018). In their most recent book, Case and Deaton (2020) argue that a fundamental force behind both the recent opioid crisis and the previous crack epidemic is the long-term loss of available working-class jobs that provide sustainable wages and good health benefits to those without a college education. They argue that this was the case for blacks in northern cities prior to the crack epidemic, and then for less-educated whites across most of the country during the opioid epidemic. They argue that an unintended consequence of capitalism coupled with advances in technology and globalism has been a shift of power to corporations. Declines in marriage and community engagement are further indications that less-educated individuals who are unable to find jobs are using drugs – as well as alcohol – to help manage their feelings of hopelessness and despair. A recent National Academy of Sciences report reached a similar conclusion, stating that less-educated workers' lack of economic opportunities and poor working conditions have fueled the crisis (National Academies of Sciences, Engineering and Medicine, 2017).

The relevance of psychological stress, particularly when concentrated on the economically disadvantaged, has been further supported by evidence of a strong association between significant periods of mass trauma and escalation in illicit drug use. Studies have consistently shown increased misuse of prescription pain medications among US military personnel following combat from as early as the Civil War (Courtwright 2009) to the most recent wars in Afghanistan and Iraq (Pacula et al. 2016). Dasgupta et al. (2018) describe how mass-trauma events, including civilian events such as the September 11 terrorist attacks and Hurricanes Katrina and Rita, increase not only the prevalence of drugs but the amount individuals use. More individuals transition from light to heavy drug use, which creates a tipping point that reinforces epidemic dynamics (Everingham and Rydell 1994; Behrens and Tragler 2001).

3.4 Other unique features of illicit drug markets

Several unique aspects of drug demand and supply interact with factors already listed above to affect the likelihood that a shift in drug use evolves into an epidemic. On the demand side, factors such as the nature of addiction and enforcement swamping reducing the legal risk of purchasing and using drugs may encourage new users and reinforce existing drug use. On the supply side, there are production efficiencies that emerge due to enforcement swamping as well as technological advances that can reduce the cost of supplying an illicit drug, in turn lowering drug prices. Caulkins (2001) refers to these as examples of non-linear feedback loops, which are the primary explanation for why drug use is more volatile than other social phenomena. He notes that they are rarely formally modeled.

The reinforcing nature of technological innovation in the drug market warrants more explanation. Technological innovation comes in two forms: (1) innovation in how the drug is delivered to the black market, and (2) innovation in the chemical makeup and/or delivery mechanisms that increase its intoxicating properties. With respect to the first, advances in electronic communication have improved illicit suppliers' ability to deliver their product to consumers, first through the use of pagers and cell phones, and now through the internet and apps. No longer do people have to go out to street markets to procure drugs; they can be delivered directly to their door. Studies of purchases made on the darknet or through software apps indicate that the risk of detection when using these services is fairly low and, in many

instances, there is global competition among suppliers (Albridge and Askew 2017; Rhumorbarbe et al. 2016). This can lead to lower prices in the long run.

Large technological changes also occur through the identification of more powerful intoxicants, such as the introduction around 2013 of fentanyl as an adulterant to heroin, or through an innovative form that can increase potency per dose, such as the development of crack out of powder cocaine. When technological advances pertain to the drug product itself, it translates into not just a higher dose per unit of product consumed, but a potentially greater risk to naïve users and potentially greater public health harms. Whether that positively or negatively affects a drug epidemic depends on the responses of consumers. In the case of fentanyl in the United States, users were first nervous about the potential risk of fentanyl but then appeared to switch to seeking it out (Powell and Pacula 2020; Mars et al. 2019; Pardo et al. 2019).

There is one last aspect of drug markets that is important to keep in mind. It is relatively cheap and easy for individuals to become retail drug suppliers, whether selling extra medication that can be obtained from doctors, friends or family members, or delivering drugs to consumers. Barriers to entry are low and fall when a drug market gets thick, due to reduced enforcement targeting any one supplier. Indeed, Ruhm (2019a) argues that while counties experiencing relative economic decline did experience higher drug mortality, the relationship could be partially explained by factors related to the availability of opioids in the local environment, suggesting that the ease with which a drug can be supplied in a market is an important supply-side factor that can reinforce an epidemic.

To summarize, epidemics emerge because of a shift in the share of users of an illicit drug who go from occasional use to heavy use, which can in turn influence the initiation rate and other positive feedback loops. There are exogenous factors that can influence the number of individuals beginning to use drugs. These include the introduction and popularization of new pharmaceuticals and widespread trauma creating demand for new pharmaceuticals. However, it is an increase in the proportion of light users who become heavy users that creates the strongest feedback loops in the system by raising demand in the market, lowering enforcement risk, and reducing prices in the black market. Exogenous factors that can influence the transition to heavy use include more potent products, new ways of administering the drug, and prolonged stress. Increases in the number of regular users provide positive reinforcement to non-users and light users, which simply continues the dynamic upward spiral of drug use until something significant

can break the cycle and end an illicit drug epidemic. Possible factors that break these cycles are discussed next.

4. Why do drug epidemics end?

It is often difficult to understand the extent of drug use and associated problems early in a drug epidemic. Likewise, it is difficult to determine when a drug epidemic has reached its peak and begins to decline; it is often not until many years later that researchers can confidently declare an epidemic to be over. It is perhaps unsurprising that there is little definitive evidence on why drug epidemics end, although several reasons have been put forward.

4.1 Negative feedback effects.

As discussed already, there are several types of positive reinforcement that may contribute to the creation of a drug epidemic. There is also evidence that negative reinforcement may discourage individuals from trying the drug or escalating their use. At the early stages of a drug epidemic, many drugs appear benign or at least better than alternatives. Over time, more drug users become addicted and the adverse consequences of addiction become apparent. This discourages initiation by younger people, and over time this effect means that the impacts of the epidemic decline as existing users successfully address their addiction, die, or age into less harmful forms of drug use (e.g., are less violent). Musto (1989, 1999) argues that these negative reputational effects are an important reason for drug epidemics to decline over time, and several operations research papers have incorporated these feedback effects into their models (e.g., Caulkins et al., 2009; 2010).

If this effect largely flows from heavy drug users to young potential users, then it suggests that the age profile of drug users should increase over time. This has been found to be the case. For example, Hughes et al. (1972) examined a heroin epidemic in Chicago after World War II. They note the growth in offenders aged over 25 “suggests that the young people originally involved in the epidemic continued to be arrested as they grew older and were not replaced by large numbers of new adolescent addicts” (p. 997). This is also apparent in the cocaine epidemic. Figure 5 shows the average age of people entering drug treatment primarily for a cocaine/crack cocaine addiction between 1992 and 2002. This comes from the Treatment Episode Data Set, administrative data on admissions that includes all publicly funded drug

treatment admissions. There is a steady increase in the average age of people entering drug treatment for cocaine/crack cocaine, with an increase of approximately 0.6 years in the average age of entrants for every calendar year. In contrast, there is no change in the average age of individuals entering treatment for alcohol and drugs other than cocaine/crack cocaine. This suggests very strong cohort effects among addicted cocaine users over the period that crack cocaine problems declined. (Unfortunately, these data are not available before 1992 to examine trends during the rise of the crack cocaine epidemic.)

4.2 Regulation, law enforcement, and supply shocks

Supply shocks may also hasten the end of an epidemic, particularly in markets where substitutes are not cheaply or readily available. Along with increasingly negative perceptions of drug use, the epidemics of the late 19th and early 20th centuries seemed to end because prohibition decreased the availability and substantially increased the price of morphine, heroin, and cocaine (Courtwright, 2009). As availability waned, the number of new and existing users fell and the number of heavy users began to decline.

For drugs already prohibited, governments commonly respond to an epidemic by increasing drug law enforcement with the aim of reducing drug supply. They do this by increasing resources for drug interdiction and street-level policing, and increasing legal penalties for drug charges. There is limited evidence that these efforts have reduced drug epidemics; in the USA, the strongest evidence of interventions having an effect is for methamphetamine supply in the 2000s. Dobkin and Nicosia (2009) study the impact of a major disruption by federal agencies to the supply of methamphetamine precursor chemicals in California in 1995. The methamphetamine price tripled and purity declined from 90% to 20%. These effects lasted around four months. They find that hospital admissions halved and drug treatment admissions fell by 35%, but that there was no detectable effect on property or violent crime. In a series of related papers, Cunningham, Liu, and Callaghan (2003, 2005, 2009) use the introduction of laws regulating methamphetamine precursor chemicals to examine how they affected a variety of methamphetamine-related outcomes. They find that enforcement increased the price of methamphetamine, decreased its availability and reduced methamphetamine arrests for up to two years. Additional studies have examined the effects of laws restricting over-the-counter medicine on methamphetamine-related outcomes, including meth lab seizures (Dobkin, Nicosia, and

Weinberg 2014), as well as violent and property crime (d'Este 2019). In general, the evidence suggests that law enforcement has had some impact on the methamphetamine crisis, but at best temporarily slowed rather than stopped it. Any effects related to law enforcement should at least partially work by increasing methamphetamine prices, yet in Figure 4 the steady decline in methamphetamine prices is only temporarily offset by increases that coincide with the interventions studied above (around 1995 and 1998).

There is little evidence that law enforcement played an important role in reducing crack cocaine in the 1990s (Strang et al. 2012). DeSimone and Farrelly (2003) and Kuziemko and Levitt (2004) estimate that increases in cocaine arrests and imprisonment increase crack cocaine prices. These effects are quite small; Kuziemko and Levitt (2004) estimate that an increase in prisoners detained for drug-related offenses from 82,000 to 376,000 between 1985 and 1996 increased retail cocaine prices by 5-15%. Again, there is little evidence of any law enforcement actions having meaningful effects in the cocaine price series shown in Figure 4.

Likewise, there is little evidence that regulation and law enforcement have reduced the current opioid epidemic; in fact, studies suggest that efforts to reduce the use of prescription opioids have made it worse. Unlike the early epidemics of the late eighteenth and early nineteenth century, in the current opioid epidemic it is clear that users were willing to move to the black market to obtain the opioids they were seeking (Alpert, Powell and Pacula 2018; Evans, Lieber and Power 2019; Alpert et al. 2019; Powell and Pacula 2020). Heroin provided a cheap substitute and its illicit status was an insufficient deterrent, possibly because technological changes have made buying on the black market more convenient.

The best evidence of a meaningful effect of law enforcement on an illicit drug epidemic comes from Australia, where a steady increase in heroin-related problems occurred during the 1990s. By 1999, fatal opioid overdoses occurred at similar rates to traffic deaths (Lancaster et al., 2011). Then, in late 2000, there was a sharp decline in heroin availability and a large increase in its price (Moore, 2006. This change was more persistent than the methamphetamine cases mentioned above.

Figure 6a shows the price of pure heroin and the rate of opioid-related deaths in Australia. It comes from Moore and Schnepel (2021), as do the other panels in Figure 6. Between 2000 and 2001, reported retail prices for impure heroin increased by approximately 50%, while its average street-level purity declined from around 75% to 20%. The combination of

these two factors meant that there was a 400% increase in the price per pure dose of heroin, which persisted for several years. Heroin availability decreased, as did direct adverse consequences like opioid-related deaths per 100,000 population.

Degenhardt et al. (2005) evaluated possible explanations for the heroin shortage and concluded that drug law enforcement was likely to be the primary cause. Figure 6b shows that the Australian Federal Police, the primary agency responsible for drug interdiction in Australia, received large funding increases in late 1990s. Most of this funding was for overseas drug operations aimed at large suppliers (Moore, 2008). Figure 6c shows that the amount of heroin seized increased substantially in the late 1990s and early 2000s. Caulkins and Reuter (2010) describe how this also came with arrests of major drug traffickers and the dismantling of smuggling infrastructure, including shutting down a freight company that had been used to facilitate smuggling, and working out how heroin imports were concealed when entering Australia. Degenhardt et al. (2005) argue that key wholesale suppliers withdrew from Australia as a result of this intense drug interdiction, replaced by groups returning to small-scale, inefficient importation methods. Figure 6d shows that the average amount of heroin seized increased substantially at the height of the supply shock, from a fraction of a kilogram in the early 1990s to more than six kilograms per seizure around 1999 to 2001, before falling back to relatively small amounts by the mid-2000s.

Law enforcement may play a role in the end of epidemics, although Strang et al. (2012, 74) argue that law enforcement successes "often stem from a convergence of fortuitous circumstances that governments can rarely reproduce by design." Many law enforcement efforts have no detectable effects, and most that do result in temporary changes as markets adapt. The evidence suggests that it is rarely the key reason for an epidemic to end. Moreover, in the case of the opioid crisis, new regulations aimed at curtailing the abuse of prescription opioids led to the increased use of illicit opioids like heroin and fentanyl. Therefore, while law enforcement may sometimes help end epidemics, uncertainty abounds around the nature and direction of any effects.

4.3 Changes in market conditions

Price increases have been reported in some illicit drug epidemics, such as for heroin in Chicago in the 1950s (Hughes et al., 1972) and heroin in Washington DC in the early 1970s

(DuPont and Greene, 1973). Courtwright (2009) argues that drug epidemics can fade because of reduced supply, which eventually also leads to higher prices and a reduction in the number of addicts. There is a lack of detailed information in these papers around how such price rises occur, however. It is possible that inelastic supply or negative supply shocks unrelated to law enforcement lead to large price increases when there are large increases in demand. Operations research models have incorporated some of the feedback loops as well as policy responses and have matched some of the key features of certain drug epidemics (e.g., Caulkins et al. 2006; Caulkins, Tragler and Wallner 2009; Caulkins et al. 2010). They provide very little insight, however, on what real-life factors might actually cause the entry and exit of buyers and sellers into the markets in order to generate these dynamics. More detailed information around what causes the market shifts would be especially valuable, as currently data are largely available at only a high level.

Having considered why drug epidemics start and stop, their consequences are considered next. While much of the discussion around market dynamics has focused on the amounts of drugs that are consumed, many of the consequences are only loosely related to overall levels of drug use and the volume of drugs that are traded.

5. Consequences of illicit drug epidemics

There are many adverse outcomes associated with illicit drug use, including premature death, criminal activity and criminal charges, lost productivity, poor employment outcomes, relationship breakdown, and child neglect. A large literature exists that records or tracks the outcomes of persons who use illicit drugs, including studies that use policy changes or other demand-shifters – such as access to addiction-treatment programs – to determine what adverse consequences are caused by drug use rather than simply correlated with it (for reviews, see; Nicosia et al. 2009; Kilmer and Pacula 2010; Cawley and Ruhm 2012; Kenkel and Sindelar 2011).

For some outcomes, there is a direct causal relationship between illicit drug use and adverse consequences, such as drug overdoses increasing the need for medical attention and elevating mortality risk. For other outcomes, it is difficult to establish to what degree an association with illicit drug use is causal. A related literature puts dollar values on the adverse consequences to measure the aggregate consequences of illicit drug use, often at a national level

(Florence, Luo, and Rice, 2021; Reinhart et al., 2018; Nicosia et al., 2009). These provide some idea about the types of consequences associated with drug use, although they are often coarse exercises that have limited value for policy analysis (Kleiman, 1999; Reuter, 1999; Moore and Caulkins, 2006).

In this review, the focus is on consequences specifically related to drug epidemics. Epidemics have many consequences beyond those experienced by individual drug users when drug markets are stable. The following types of consequences are considered: (1) those related to intense and widespread drug use; (2) those due to illicit drug markets themselves; and (3) wider impacts affecting neighborhoods and communities or persisting in the longer term, even when epidemics subside. The next section covers policy responses, which can also have distinct effects; for example, legislation increasing drug penalties increases incarceration rates (Raphael and Stoll, 2013; Blumstein and Beck, 1999).

5.1 Effects of intense and widespread drug use

Illicit drug epidemics can amplify the effects associated with illicit drug use. This can happen in several ways. One is that illicit drug use may be more intense, either through individuals using drugs more frequently or drugs being of a higher purity than outside of an epidemic. For example, crack cocaine delivers a more intense high than powder cocaine, which is why it could be sold in small amounts. The shorter high would increase the number of times someone addicted to crack cocaine would use the drug each day (Blumstein, 1995; Agar, 2003). In other epidemics, the form of the drug stays the same but the purity increases. Heroin in Australia in the 1990s is an example of this, as average street-level heroin purity increased steadily during the 1990s and reached 75% by 1999 (Moore et al., 2005).

More intense drug use may increase the levels of addiction and the risks of overdose. Intense drug use can also affect birth outcomes. There is evidence that cocaine damages development in utero, increasing fetal death rates and decreasing birthweight and cognitive development (Frank et al. 2001; Singer et al. 2002). During the crack cocaine epidemic, there was concern that intense use among pregnant women was leading to large numbers of “crack babies.” To examine this and other outcomes, Fryer, Heaton, Levitt and Murphy (2013) construct an annual index of the severity of crack cocaine in 144 cities and all 50 states. It is composed of factors such as homicides, cocaine arrests, cocaine-related emergency department visits, cocaine

seizures by the Drug Enforcement Agency, and media mentions of crack cocaine. They find the index is positively related to increases in black babies' fetal mortality rates, which rose by more than 25% during the crack cocaine epidemic, and the fraction with low birthweight, which rose by 10% over the same period.

A related way that drug epidemics can lead to worse consequences is by stretching or overwhelming services designed to ameliorate the negative effects of drug use. Emergency response services, healthcare, and addiction treatment may not respond as effectively to large numbers of calls, potentially making overdoses more dangerous or addiction harder to treat. This channel is difficult to separate from a greater intensity of drug use but could be especially important when these services are funded by local governments. For example, Cunningham and Finlay (2013) use supply shocks to estimate the relationship between methamphetamine use and child welfare outcomes. They find an elasticity of foster care cases to methamphetamine use of 1.54, suggesting that drug use may crowd out access to these services for other reasons.

Another way that the consequences of drug use can be different in an epidemic is when consequences depend on network effects. Injecting drug users can spread blood-borne diseases like HIV/AIDS and hepatitis C through the sharing of needles. Blood-borne diseases and sexually transmitted diseases can also spread through high rates of unprotected sex with multiple partners. Risky sex has been found to be common among heavy users of drugs like crack cocaine, either because of the psychopharmacological effects of the drug or because they are exchanging sex for drugs (Forney, Inciardi, and Lockwood 1992; Booth, Kwiatkowski and Chitwood 2000). The cocaine epidemic in the USA coincided with the onset of the AIDs epidemic in the mid-1980s and may have contributed to the spread of AIDS. There has been some general modeling of the relationship between crack cocaine and AIDS (Burattini et al. 1998), although there is a lack of research that determines the extent to which crack cocaine affected the spread of AIDS. Methamphetamine use may also increase risky behaviors that heighten the risk of HIV (Marshall and Werb 2010), while the opioid crisis has increased the spread of hepatitis C (Powell, Alpert and Pacula 2019). Given the nonlinearities associated with the spread of infectious diseases and the severity of diseases like AIDS and hepatitis C, if such effects are present then they may be an extremely important consequence of drug epidemics.

5.2 Consequences related to profitable drug markets

Markets play a central role in illicit drug epidemics. As a drug becomes popular, the returns to supplying it often become extremely high. That can have consequences distinct from drug use itself, most notably violence among drug dealers to establish and maintain a share of the market, as well as income associated with selling drugs.

The importance of market-related violence was evident in the rise of crack cocaine markets. Crack cocaine's popularity and the simple technology involved in making it meant that converting powder cocaine to crack cocaine could be extremely profitable; in the late 1980s, police estimated that a $5,000 investment in cocaine could yield $125,000 in crack sales (US Government Accounting Office 1989). Only small quantities of cocaine were required to make crack, which meant that it could be locally cooked and distributed by small and decentralized organizations. As would be expected in any industry, the combination of low entry barriers and high profitability led to large amounts of entry and fierce competition (Fagan and Chin, 1989). For example, qualitative data from 1,500 crack cocaine sellers in New York suggest that the majority of low-level dealers were entrepreneurs who owned the drugs (Caulkins et al. 1999). At the same time, the relatively low price of crack cocaine made it affordable to a large number of people who would make frequent purchases, often buying one "hit" at a time (Blumstein 1995).

When crack first appeared in a new market it was distributed though "crack houses," which offered the chance to both buy and consume the drug. As crack became more popular, dealers moved to open-air markets on street corners where they used violence to deter entry and establish the local market power in order to support elevated prices (Hamid 1990). Gangs became systematically involved in distributing and selling crack cocaine (Witkin 1991; Levitt and Venkatesh 2000). The violence around crack markets was primarily perpetrated using guns, leading to many deaths. Goldstein et al. (1997) analyzed homicides in New York City in 1988 and found that almost of all of the crack-related homicides were because of crack distribution, rather than its psychopharmological effects or the need of drug users to obtain money.

The late 1980s and early 1990s was a period when many crime rates increased; as shown already in Figure 1, the homicide rate of black males in their teens and early 20s more than doubled between the mid-1980s and the early 1990s. Several studies have examined the extent to which the crime and violence associated with crack cocaine markets account for these changes. Grogger and Willis (2000) examine inner-city violence in 27 metropolitan areas, identifying the impact of crack cocaine by comparing the inner-city crime rates with suburban crime rates,

which they take to be unaffected by crack cocaine. They date the arrival of crack cocaine markets by asking police chiefs when they first became aware of crack and using Drug Abuse Warning Network data to examine when hospital emergency departments experienced an increase in admissions for smokable cocaine. The authors estimate that, in the absence of crack cocaine, the 1991 peak in inner-city crime rates would have been approximately 10% lower.

Homicides and some other types of crime rose in suburban areas as well as inner-city areas in this period, which could have been due to violence around crack cocaine markets (Levitt 2004). Other studies use variation across cities, relaxing the assumption in Grogger and Willis (2000) that suburban areas were largely unaffected by crack market violence. Cork (1999) uses sharp increases in arrests for illicit drugs and for homicides by juveniles to identify crack-related violence in cities. Using data from Uniform Crime Reports and Supplemental Homicide Reports, he identifies breaks in the drug and violence data series in 53 cities, arguing that changes in both come from crack markets. Fryer et al. (2013) use their aforementioned crack-severity index for 144 cities and the 50 states to examine the association between crack cocaine and crime rates. They find the association accounts for much of the rise in black homicide rates. Evans, Garthwaite and Moore (2016) use cocaine-related deaths in the Multiple Cause of Death data, which are shown in Figure 1a, to date the arrival of crack cocaine markets in 57 large cities and 41 states. They estimate that homicides of black males aged 15-24 more than doubled within the six years of crack markets arriving. White males aged 15-24 and black females aged 15-24, who had homicide rates that were around one-sixth the size of rates among young black males, experienced increases of approximately 50 % in the years after crack cocaine markets arrived. All of these studies suggest that crack markets were responsible for a huge amount of violence.

There is evidence of market-related violence in other illicit drug markets. For example, Mexican trafficking organizations and domestic motorcycle gangs distributing methamphetamine in the USA have used violence to establish and protect their markets (Shukla, Crump and Chrisco 2012). Half of local US law enforcement agencies surveyed about methamphetamine in the nation agreed that market competition is often violent (Brownstein et al. 2012). An interesting question is whether the increasing use of technology to sell drugs, such as cellphones and internet sites, has reduced the level of systemic violence as market territory has become less linked to physical space.

An important dimension of market-related violence is the violence that occurs in countries that produce or traffic illicit drugs. The profitability that leads to violence in domestic markets also creates conditions for substantial violence in the source countries. There is a small but growing body of research that is documenting the factors affecting drug market violence in these countries, especially the violence in recent decades in Mexico and Colombia. For example, Dell (2015) shows that local enforcement crackdowns weaken incumbent traffickers and increase violence as rivals attempt to take over their territories. Lindo and Padilla-Romo (2018) find that capturing Mexican drug "kingpins" also destabilizes drug trafficking markets and increases violence. Castillo, Mejía, and Restrepo (2020) find that cocaine scarcity in Mexico increases violence, especially close to the United States and in localities where competition among traffickers is more intense.

Profitable markets also create opportunities for income from drug dealing, which potentially increases the opportunity cost of formal employment and education. A small number of studies have attempted to understand the returns to drug dealing and its consequences during drug epidemics; for example, studies of dealing crack cocaine have used data from criminal justice records and school-based surveys (Reuter et al. 1990); financial records from a gang selling crack cocaine (Levitt and Venkatesh 2000); and ethnographic observations of drug markets (Johnson et al. 2000).

Such studies suggest that, for most individuals involved in supplying drugs, pecuniary returns are low. Levitt and Venkatesh (2000) find that members of a Chicago gang selling crack cocaine who worked as low-level drug dealers make roughly the minimum wage, while facing large risks in terms of death, violence and incarceration. The authors argue that participation can be viewed as a tournament, where these dealers are motivated by the possibility of moving up in the gang and making a lot of money in the future, rather than by current returns.

These studies also suggest that drug dealing is predominantly a part-time activity. Johnson et al. (2000) observed 300 participants in crack markets in New York and found most used it as a sporadic way to earn income. Levitt and Venkatesh (2000) reported that most gang members commonly worked four times a week for four hours each time, and that many held legitimate jobs. Reuter et al. (1990) examined arrest records in Washington DC between 1987 and 1989 and found the employment rates of individuals arrested for drug selling were similar to

those arrested for non-drug offenses. In a follow-up survey, they found that individuals working more intensively in the formal labor market were more active in selling crack cocaine.

It is clear that drug dealing and other types of involvement in illicit drug supply is a source of income for both people using the drug and some others, such as members of gangs. However, there is little evidence that the opportunities are lucrative or widespread enough to have meaningful effects on educational choices or overall levels of employment.

There are potentially other market-based consequences. Production processes can create health and environmental problems. Methamphetamine is often produced in local clandestine laboratories. The manufacturing process is highly volatile and can lead to toxic fumes, fires, explosions, and burn injuries. These labs created widespread health risks to those making the drugs, their neighbors and law enforcement personnel, as well as creating hazardous waste that had to be cleaned up once discovered (Shukla et al. 2012). Nicosia et al. (2009) estimate that these costs summed to between $40 million and $90 million in the USA in 2005 (in 2005 dollars).

5.3 Wider impacts

Active drug markets and a large number of users can affect local communities or broader groups of people. Although these can be difficult to quantify, some studies have linked such consequences to illicit drug epidemics.

Local government finances. Local police agencies, emergency medical services, coronial services, and child and family welfare services help deal with the consequences of illicit drug epidemics. Although research is limited, there is anecdotal evidence that drug epidemics stress the budgets of many local governments (e.g., Seligson and Reid 2017). There is also recent research that local communities with high levels of drug abuse experience higher government funding costs. Li and Zhu (2019) and Cornaggia et al. (2021) look at the relationship between measures of the US opioid crisis and municipal bond markets, finding that the opioid epidemic increases debt funding costs and reduces credit ratings and bond issuances. Both papers use instrumental variables strategies based on proximity to opioid supply and, interestingly, both find that Prescription Drug Monitoring Programs partially ameliorate these effects on local government financing.

Migration effects. An important and potentially permanent effect of drug epidemics is migration away from neighborhoods dealing with violence and other problems. Cullen and Levitt (1999) find that rising crime rates in cities lead households to leave inner-city areas, with most moving to suburbs in the same Metropolitan Statistical Area. The households that are most sensitive to changes in crime rates are high-income households and those with children, which has important implications for the tax base, schools, and future economic and social prospects of affected neighborhoods. Kamada (2020) uses city-level measures of the intensity of the crack cocaine epidemic and 1980 and 1990 Census data to examine the degree to which the crack cocaine epidemic drove this movement. He finds that crack led to migration out of inner-city areas by black and Hispanic households, but not white ones. In line with the findings of Cullen and Levitt (1999), he finds that higher-income black households were most likely to move.

Education effects. Widespread impacts on education have also been found. Evans, Garthwaite and Moore (2016) examine the impact of the crack cocaine epidemic on black males' high school graduation rates. They argue that the effects of the crack cocaine epidemic could have affected young black males' expectations of the risks of death or incarceration, given that their mortality increases were similar to those that occurred in South Africa as a result of the AIDS epidemic. They examine whether this affected human capital investment and find that black males' high school graduate rates declined after crack cocaine markets arrived in a city or state. They argue that it is a key reason for the decline in black high school graduation rates in the late 1980s and early 1990s, and a widening in the white-black educational achievement gap. Monteiro and Rocha (2017) find that there are also direct effects of drug-related violence on education in Brazil. They use variation in gang-related drug violence in Rio de Janeiro's favelas to examine how it affects student achievement. They find drug market violence reduces math test scores and observe direct effects on schools and teachers: Violence increases teacher absenteeism, principal turnover, and temporary school closings.

Longer-term violence. Much of the violence associated with illicit drug epidemics subsides with the maturing or reduction of drug market activity. However, Blumstein (1995) argues that during the crack cocaine epidemic, drug dealers arming themselves led to young people not directly involved in drug markets to use guns for self-protection. This created a cycle of gun violence that went well beyond drug markets, and potentially persisted even as crack cocaine markets became less violent. Evans, Garthwaite and Moore (2018) test this using cross-

city variation in the emergence of crack cocaine markets. They find that murder rates were elevated among young black males when compared with older black males, even 17 years after crack cocaine markets emerged. They attribute this to gun availability and argue that these elevated murder rates can explain approximately one-tenth of the current gap in life expectancy between black and white males.

Many of the consequences of illicit drug epidemics are large. For example, there is evidence that the crack cocaine epidemic by itself increased homicides, led to worse birth outcomes, reduced educational attainment, increased migration out of affected communities, and spread serious communicable diseases. Such effects are either permanent or long-lasting. If governments are going to commission "cost of illness" studies to value the costs of alcohol and drug use in "normal" times, then it would be useful to extend the analysis to epidemics (noting the caveats expressed about their utility). It is likely that the value of policy resources devoted to addressing drug epidemics are dwarfed by the cost of such consequences.

6. Summary/Conclusion

The United States has experienced numerous illicit drug epidemics. They are becoming increasingly national in nature, as improved communication technologies and high potency means that many drugs can be supplied in locations that range from small towns to large cities. The damage caused by these epidemics, as measured in terms of fatal drug overdoses, is growing exponentially through each iteration (Jalal et al., 2018).

While economists have not contributed broadly to the study of drug epidemics, they have offered some keen insights through their studies of demand and supply. This review of the literature suggests that the primary drivers of drug epidemics today are factors leading to supplier-induced demand of novel intoxicants, which is still possible through medical markets; positive feedback loops related to the initiation and escalation of drug use; declining enforcement risks combined with supply-side innovations, such as more potent drugs, production enhancements, and delivery efficiencies; and, to some degree, population dynamics primarily related to the relative size of the youth cohort as well as changes in the levels of stress and trauma in a community. Shifting socioeconomic factors may play a role in amplifying demand, but they alone seem insufficient to cause an epidemic.

Factors contributing to the end of epidemics include escalating negative feedback loops caused by the negative experiences of heavily addicted drug users; supply shocks affecting the targeted drug and its close substitutes; and changes in market conditions. Law enforcement is only occasionally effective when tried alone, but may support other dynamics already in play to resolve an epidemic more quickly.

Demand for intoxicating substances seems to continue, regardless of the consequences or harms of previous drug epidemics. Today, as the USA struggles through one of the deadliest drug epidemics in history in the opioid epidemic, demand for intoxicating substances continues to shift to new intoxicants despite the deaths of tens of thousands of individuals and the greatest availability of treatment to date. Microeconomic work tells us little about how to address such epidemics. The complex dynamics and rapid changes associated with illicit drug epidemics do not always lend themselves to clean empirical identification. Ruhm (2019b) uses the current opioid drug epidemic as an example of where methods should accommodate the importance of the research questions, and shows that the current tradeoffs in the economics profession between rigor and importance can be tilted too far toward rigor. More research that improves even the basic understanding of the characteristics of drug epidemics is important, and economists are well placed to do it. Relatedly, new models are needed that can consider more explicitly the complicated positive and negative feedback loops. There are some recent economics papers modeling "harder" illicit drug markets (e.g., Galenianos, Pacula and Persico 2012; Galenianos and Gavazza 2017). However, further development is required before epidemics can be incorporated; at the moment, operations research has contributed nearly all tractable models of illicit drug epidemics, some of which are referenced here. Given the current state of knowledge, it is unsurprising that it is not possible to fully anticipate or consider the dynamic consequences of potential policy interventions.

Economists have contributed several insights to measuring the consequences of illicit drug epidemics. They have also identified consequences that are widespread and beyond those that can be measured through observing or surveying drug users. Again, empirical identification can be difficult, but these papers do highlight that illicit drug epidemics have effects that are large and persistent. Consequences associated with recent epidemics like the cocaine epidemic and the opioid crisis further reinforce that the traditional drug policy settings likely represent an under-investment of policy resources to address them (Reuter 2013). Likewise, data collection

relevant to understanding and quantifying the costs of illicit drug epidemics remain sparse, and greater investment in those data would be a promising step toward improved understanding of drug epidemics.

7. References

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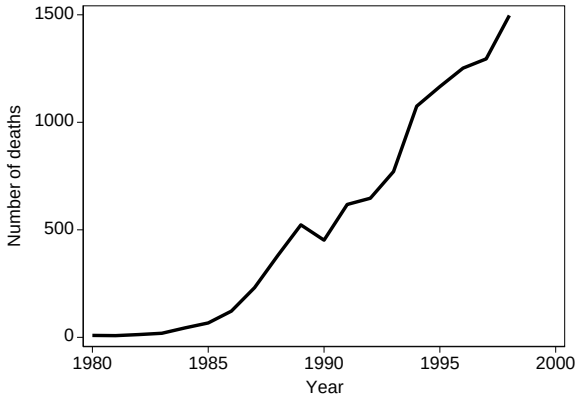
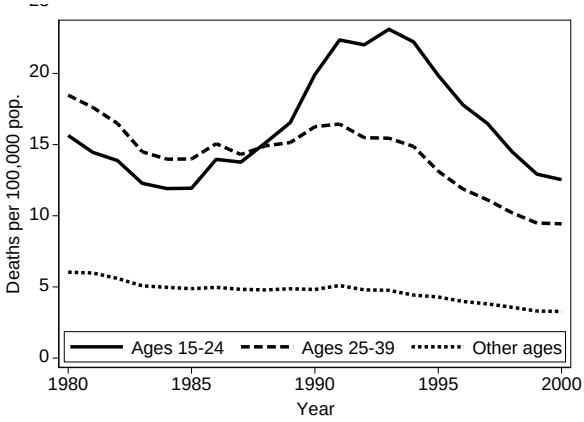
Figure 1 Crack cocaine-related outcomes, 1980-2000

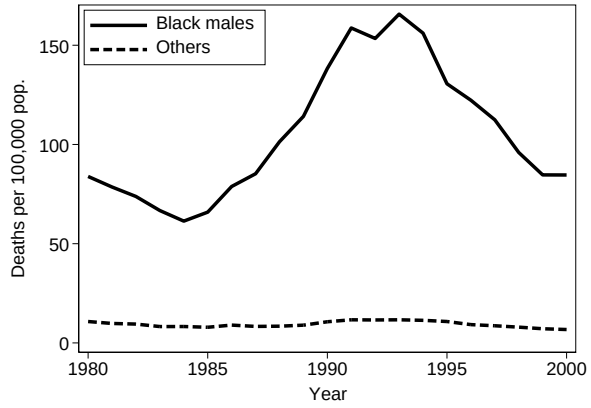
A: Cocaine-related deaths



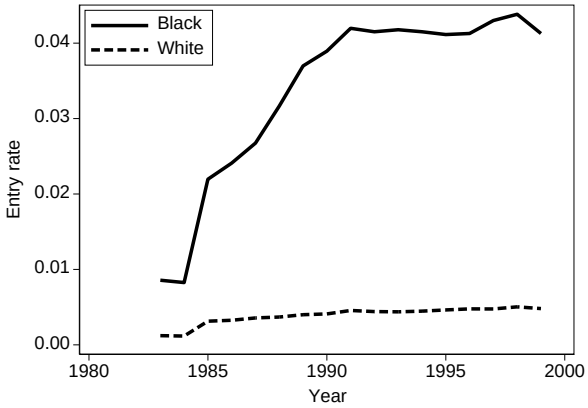
B: Murder rates by age



C: Murders for ages 15-24, black males cf. rest



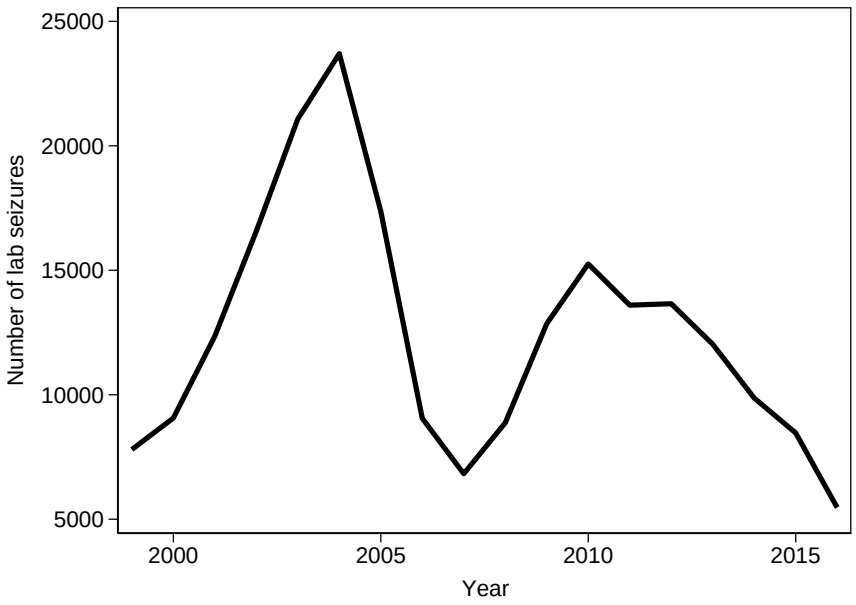
D: Male incarceration rates, by race



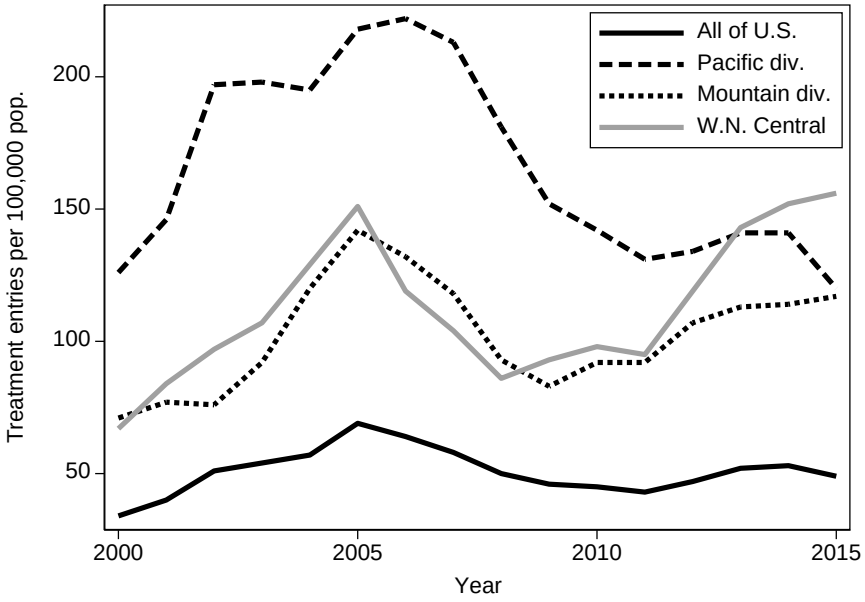
Notes: These figures are adapted from those in Evans, Garthwaite and Moore (2016). Panels A-C use data from public-use versions of the National Center for Health Statistics' Multiple Cause of Death data files. For Panel A, cocaine-related deaths are defined according to the 9th Revision of the International Classification of Diseases system system; the codes are 304.2 (Cocaine dependence) and 305.6 (Cocaine abuse). Panel D replicates Figure 4D in Evans, Garthwaite and Moore (2016), using restricted data from the US Bureau of Justice Statistics National Corrections Reporting Program.

Figure 2 Methamphetamine-related outcomes, 1999-2016

A: Methamphetamine lab seizures

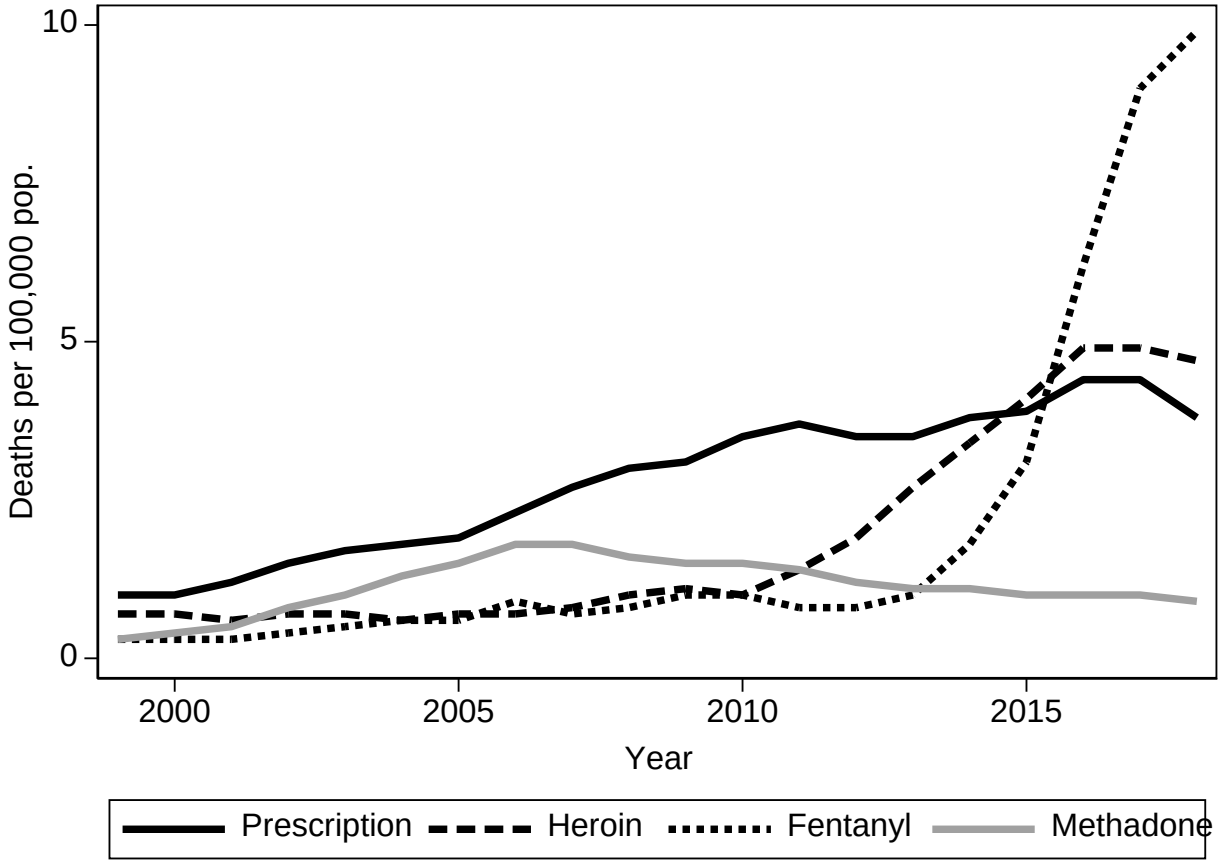


B: Treatment admissions for amphetamine/methamphetamine



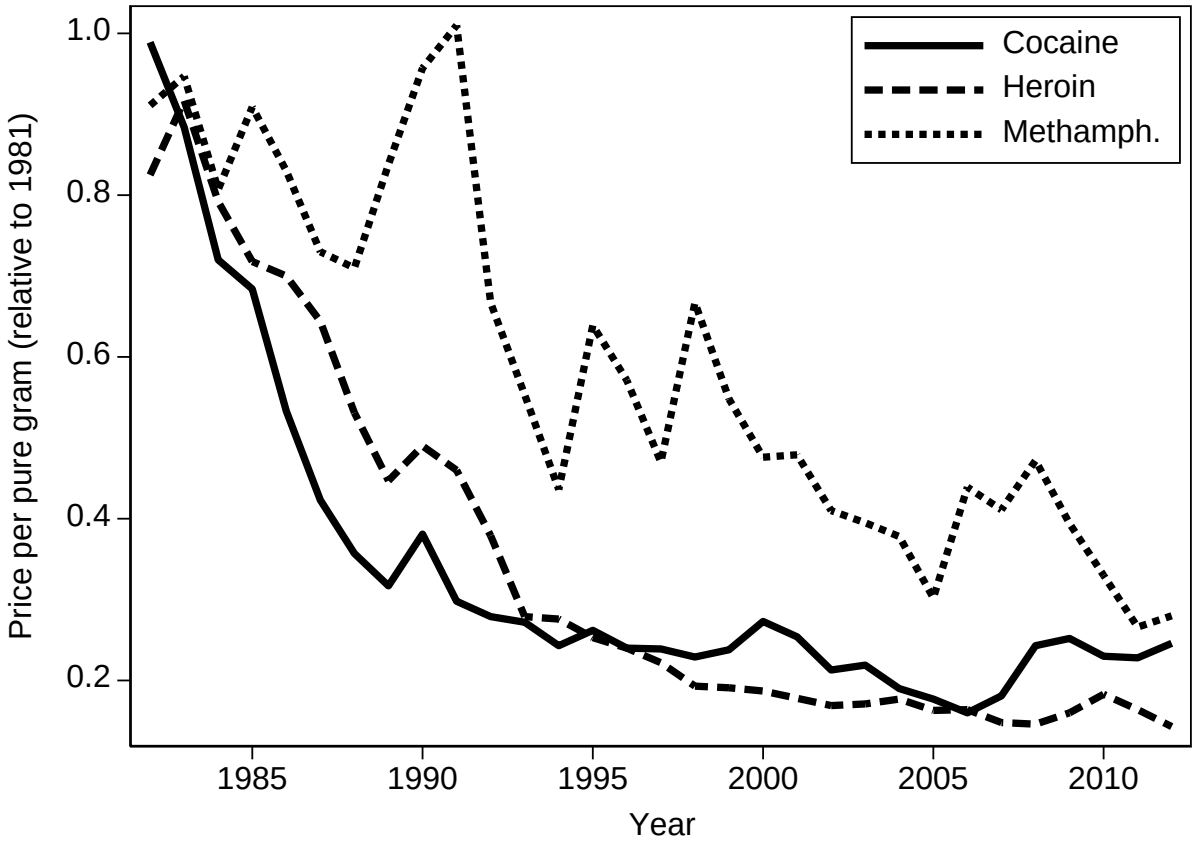
Notes: Panel A shows the number of methamphetamine clandestine laboratories found, taken from the National Clandestine Laboratory Database and National Forensic Laboratory Information System. Panel B shows treatment admissions for all of the USA, and for three Census divisions: Pacific (Alaska, California, Hawaii, Oregon, Washington); Mountain (Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, Wyoming); and West North Central (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota). The data in Panel B are from the Treatment Episode Data Set, which is taken from Substance Abuse and Mental Health Services Administration (2012, 2017).

Figure 3 Opioid drug overdose deaths in the United States, 1999-2018



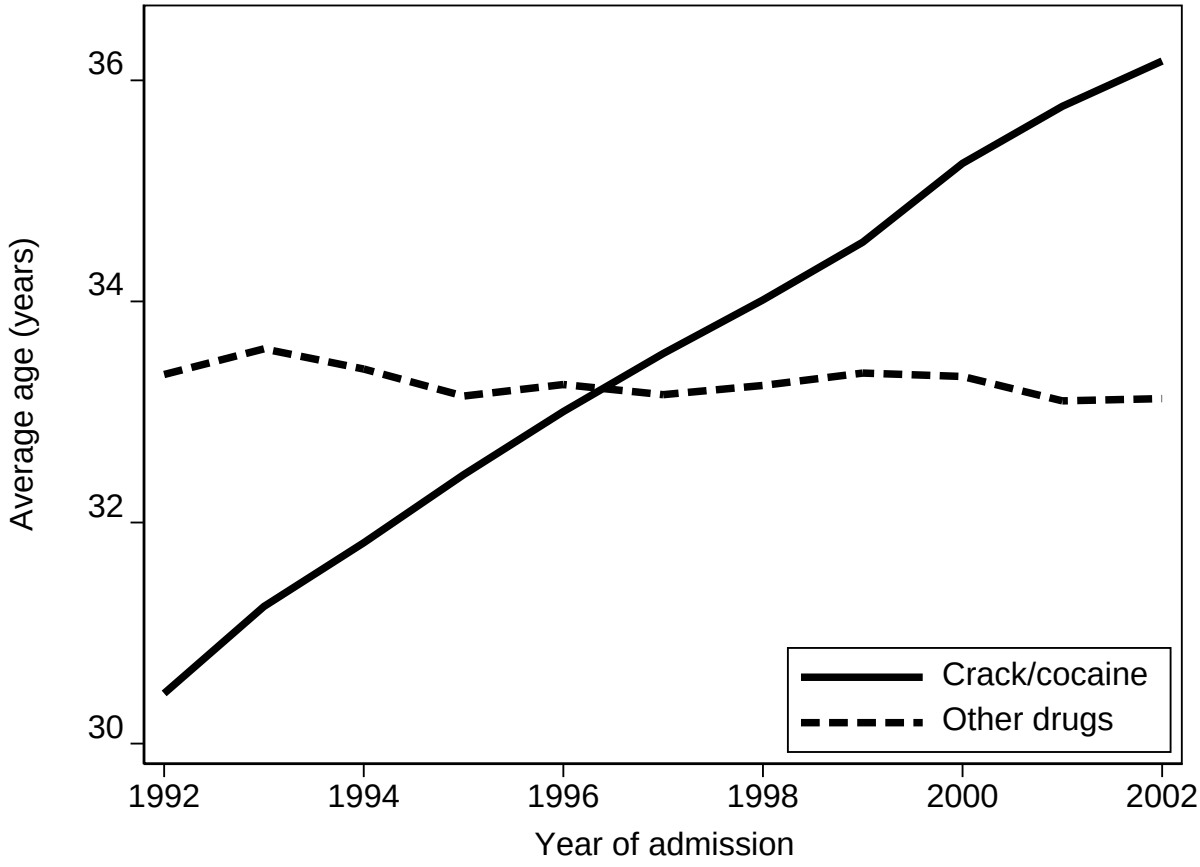
Notes: This shows the rate of opioid-related drug overdoses per 100,000 population, broken down by the type of opioids involved. It is using National Center for Health Statistics data, and is taken from Hedegaard, Miniño, and Margaret Warner (2020).

Figure 4 Purity-adjusted retail prices of cocaine, heroin and methamphetamine, relative to 1981



Notes: These data are from the System to Retrieve Information from Drug Evidence (STRIDE) database, which includes information from drug seizures, such as the type of drug, the purity, and the price. There are adjustments for purity similar to Alpert, Powell and Pacula (2018).

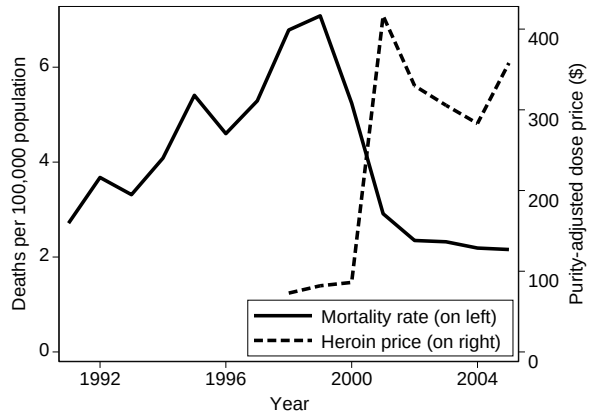
Figure 5 Average age at drug treatment admissions, crack/cocaine versus other drugs



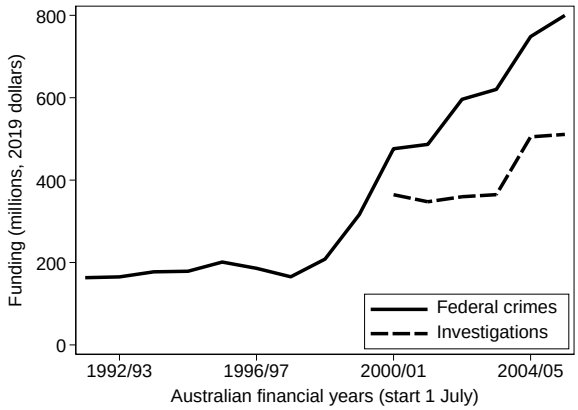
Notes: This figure shows the average age for entrants to drug treatment for individuals identifying cocaine as their primary drug of concern versus entrants who report no problematic cocaine use, but treatment for some other drugs or for alcohol. It is based on Treatment Episode Data Set microdata from the Inter-university Consortium for Political and Social Research (ICPSR 25221).

Figure 6 Australian heroin outcomes and federal drug interdiction

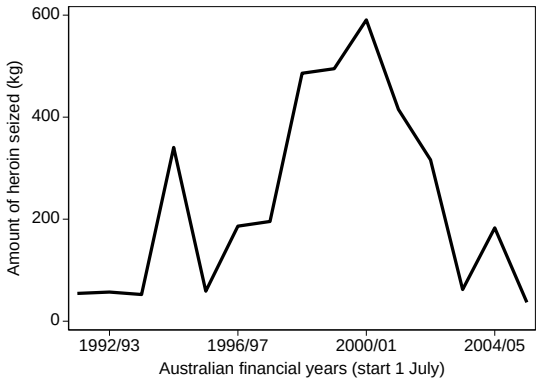
A: Opioid deaths and the price of heroin



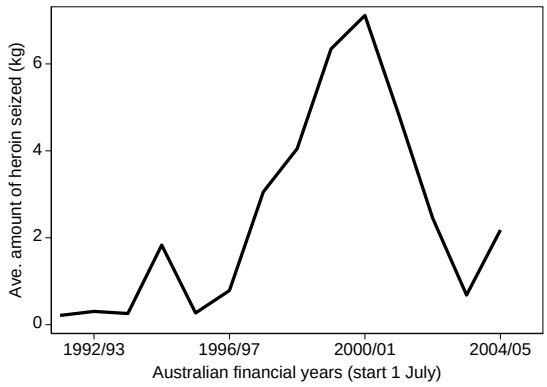
B: Funding for policing federal crimes



B: Amount of heroin seized (kilograms)



D: Average weight per seizure (kilograms)



Notes: These figures are based on Moore and Schnepel (2021). For Panel A, the opioid-related mortality rate is for the state of New South Wales, while the purity-adjusted price for a dose of heroin is constructed by dividing retail prices for heroin (from a survey of regular injecting drug users) by the average heroin purity (from police forensic analyses of retail-level quantities). Panels B-D are based on Australian financial years, which run from July 1 to June 30 of the following year. They are based on data constructed from annual reports from the Australia Federal Police. For Panel B, funding for federal crimes is different to funding for federal investigations after 2000/01 because the Australian Federal Police took on extra responsibilities related to terrorism.