Estimating the Costs of the Opioid Epidemic: Methods

Center on Society & Health
Virginia Commonwealth University
August 2023

Analytical Approach for Estimating the Costs of the Opioid Epidemic

The VCU Center on Society and Health collaborated with Altarum to estimate productivity, health care costs, and government losses from the opioid epidemic in the Commonwealth of Virginia. This builds on prior work that has measured the total burden of the opioid crisis in the United States and Ohio. The approach leverages datasets and tools previously developed to measure the costs and benefits of health and health-related interventions, including strategies developed for the Altarum Value of Health analytical model. The estimation of Virginia's county/independent city-specific losses combines the best available local data on the opioid crisis – including health care utilization data provided by the Department of Health – with data on county/independent city characteristics, while incorporating academic and grey literature on the impacts of opioid use and misuse in the United States. The newest work estimates economic costs incurred by opioid use during the year 2021, the most recent year for which key data inputs were available at the time of analysis.

The modeling process involves first calculating or estimating specific components of the opioid epidemic for the entire Commonwealth and for each county and independent city (such as the number of overdose fatalities and number of individuals suffering from an opioid use disorder). The economic costs of the productivity losses resulting from each of these opioid crisis impacts were computed using effect sizes from the academic and grey literature; local economic data on population, tax rates, and expected earnings; and models developed to estimate the impacts of lost productivity on households, the private sector, and federal/state governments, government expenditures required to address opioid abuse, and the health care costs of specific opioid-related health care utilization events. For some components, sensitivity analyses were completed on model inputs to help describe some of the uncertainty around the economic cost estimates. The following sections detail the data sources used for each major productivity cost component in this work and any specific modeling coefficients or assumptions applied in the calculations.

Productivity Losses Due to Opioid Overdose Fatalities

Estimates of the number of overdose deaths in 2021 rely on data from the Virginia Department of Health Forensic Epidemiology Fatal Overdose Tables – by locality and year. Data were collected from the Virginia Department of Health (VDH) website, and data on "All Opioid" related deaths were included in the analysis. The definition of an opioid overdose death was designed to match as closely as possible the categorization from the National Vital Statistics System data on Drug Overdose Death Counts, and includes drug categories of heroin, prescription opioids, synthetic drugs like fentanyl, and other unspecified narcotics:

> *Drug overdose deaths are identified using underlying cause-of-death codes from the Tenth Revision of ICD (ICD–10): X40–X44 (unintentional), X60–X64 (suicide), X85 (homicide), and Y10–Y14 (undetermined). Drug overdose deaths involving selected drug categories are identified by specific multiple cause-of-death codes. Drug categories presented include: heroin (T40.1); natural opioid analgesics, including morphine and codeine, and semisynthetic opioids, including drugs such as oxycodone, hydrocodone, hydromorphone, and oxymorphone (T40.2); methadone, a synthetic opioid (T40.3); synthetic opioid analgesics other than methadone, including drugs such as fentanyl and tramadol (T40.4); cocaine (T40.5); and psychostimulants with abuse potential, which includes methamphetamine (T43.6).*
>
> *Opioid overdose deaths are identified by the presence of any of the following MCOD codes: opium (T40.0); heroin (T40.1); natural opioid analgesics (T40.2); methadone (T40.3); synthetic opioid analgesics other than methadone (T40.4); or other and unspecified narcotics (T40.6).*

All county/independent city death counts were inflated by two percent, to adjust for missing data on death certificates and in the state mortality data. Virginia's adjustment was very minor compared to other states, see Ruhm (2017) Geographic Variation in Opioid and Heroin Involved Drug Poisoning Mortality Rates for an explanation and detailed data on adjustment rates by state.

The age distribution of opioid deaths in each county/independent city was also required to estimate the total lost future earnings for each fatality. We estimated the age-distribution of deaths in each county/ independent city based on the single-year age distribution of opioid overdose deaths for the entire Commonwealth for the ages most commonly accounting for opioid deaths (ages 21 to 62) and then from the age distribution for the entire United States, rescaled to match the average Virginia rate, for all other ages. Supplemental population data were required for this approach and were taken from the US Census National and State Population Estimates for 2021.

In order to estimate the economic and productivity losses from each opioid overdose fatality, we applied methods used in Altarum's Value of Health modeling using data on earnings, tax rates, and non-opioid related mortality rates. Non-opioid mortality rate estimates were downloaded from CDC WONDER. Estimated effective tax rates were taken from outputs of the NBER TAXSIM model for the state of Virginia and were applied evenly to each county and independent city. Lost future earnings by age were estimated for each locality by applying individual annual earnings by age from 2017 American Community Survey 1-year microdata, smoothed using a 5-year moving average, and adjusted to each Virginia locality using data on the median income for an individual with a high-school diploma relative to the state and national average of this statistic for 2021. The median county/independent city income was based on American Community Survey data accessed from the U.S. Census Bureau's Data Portal.

To estimate the 2021 economic impact of lost future productivity, we applied the following assumptions to the earnings data: a 1% annual real growth rate in future earnings for all individuals and a 3% annual discount rate to all earnings in future years. Lost productivity costs were apportioned to households and the private sector, the federal government and state government using the tax rate data from above and Altarum Value of Health tool methods.

Productivity Losses Due to Nonfatal Opioid Use Disorders

Productivity losses due to nonfatal opioid misuse were calculated from the estimated count of individuals suffering from an opioid use disorder (OUD), county/independent city incomes, and the estimated impact each OUD has on productivity and earnings.

The counts of opioid use disorders were previously estimated using data from the National Survey on Drug Use and Health (NSDUH) alone, but our approaches were updated in this new 2021 analysis. For this year's data update, we incorporated findings from Keyes et al. that NSDUH data may undercount the true population prevalence of Opioid Use Disorder (OUD). As a result, we used an approach described in Section 2.4 of that paper that estimates OUD counts based on a multiplier of observed opioid mortality counts, by locality. This multiplier takes into account changes in the prevalence of more deadly, synthetic opioid use over time, and we used data collected from calendar year 2021 in Virginia from CDC Provisional Drug Overdose Deaths to estimate the share of opioid deaths in Virginia that occurred due to the use of synthetic opioids such as fentanyl. For the few counties and localities that had "0" overdose deaths (and by this approach would have estimated "0" individuals with OUD), we instead use the prior method of estimating county/independent city-level OUD rates based on the statewide estimate from NSDUH and the locality's share of ED Opioid Overdose visits from VDH data, described below.

It is important to note that both these approaches represent a change from our prior estimates of OUD in Virginia and substantially increase the estimates of OUD from prior calculations. For data from NSDUH, estimates of OUD were higher in 2021 because it was the first year Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) criteria were used to estimate rates and also because, "beginning with the 2021 NSDUH, questions on prescription drug use disorder were asked of all past year users of prescription drugs, regardless of whether they misused prescription drugs", increasing the overall estimated rates of OUD. Further, our departure this year in using the Keyes et al. work to estimate county/independent city-level OUD rates further increased estimated rates as this approach attempts to correct for undercounting of OUD in NSDUH data using

multiplier approaches. A secondary advantage of the Keyes et al. approach is that it allows for greater specificity of OUD rates, based on actual county/independent city-level mortality data (whereas prior data apportioned state-level OUD count estimates based on the state population).

The total productivity loss and economic impact of this opioid misuse and OUD was computed by applying data from prior research on the impact of substance use disorders on labor force participation and wages and the county/independent city-level earnings data from above. These costs were then apportioned by payer using the methods of the Value of Health tool described above.

Productivity Losses Due to Incarceration

The final component of opioid productivity impacts was estimated for the population of state residents incarcerated due to drug crimes related to opioids. While small, this component estimated the impact of lost workforce participation and earnings for 2021 from those incarcerated. Estimates of the state incarcerated population were taken from Bureau of Justice Statistics Prisoners reports and the number of those imprisoned for drug crimes was estimated by applying the national percentage of inmates incarcerated for drug-related crimes to the total state incarcerated population. The percentage of these drug crimes related to opioids was estimated using the ratio of estimated opioid drug arrests to total drug arrests in the Commonwealth, taken from the 2021 data from the Virginia Department of Criminal Justice Services (DCJS). Because the DCJS data only reported on drug arrests by the "primary drug type", we estimated the ratio of opioid associated arrests to all arrests incorporating all opioid arrests in the numerator, plus 50% of simulant and barbiturate arrests, due to the increasing prevalence of opioids in these other drug supplies. Total earnings lost were estimated using the median earnings data described above. Our estimates of lost productivity due to incarceration do not include the costs of criminal justice or government contributions to prison costs but were solely the lost potential earnings of individuals who have been incarcerated.

Health Care Costs Due to Overdoses and Health Crises Involving Opioids

The total direct health care cost in each locality was estimated as the sum of costs from emergency visits for opioid overdose, emergency department treat-and-release visits for other opioid-related visits, inpatient stays for overdose, and inpatient stays for other opioid-related visits. For these four categories of events, we estimated hospital, ambulance, and Naloxone costs, and quantified and monetized health-care utilization by locality. Best-available imputation methods were used to address missing data based on federal-, state-, and local-level evidence. To estimate the cost of each of the health care use cases, a brief literature scan was conducted to identify the most recent estimates of opioid health care costs, such as costs of an overdose hospitalization. Altarum's Health Spending Economic Indicators were used to adjust costs and payments for inflation over time where necessary.

Hospitalizations

For each Virginia locality, the number of opioid-attributable inpatient hospital stays for opioid-related acute health complications was estimated. Costs and payments associated with these stays were estimated by locality, as well. Commonwealth data provided by VDH on overdose hospitalizations were first incorporated to generate estimates, and this was combined with federal data to identify non-overdose opioid stays.

Estimates of the number of overdose hospitalizations in 2021 were from data provided by VDH describing hospitalizations opioid-related discharges, summarized by county/independent city and by each of the 35 VDH districts. These claims-based records were from the Virginia All-Payer Claims Database (APCD). For hospital costs, national estimates of opioid-poisoning inpatient stay costs provided by Inocencio et al. (2013) were used.

The overall count of opioid-related inpatient stays is published at a state level by the Agency for Health Research and Quality's (AHRQ) Healthcare Costs and Utilization Project (HCUP). HCUP's encounter-based data also capture overdose

inpatient stays, so the estimated overdose stays were subtracted from the estimated overall inpatient stays at the locality level to avoid double-counting. The HCUP Fast Stats report on Opioid-Related Hospital Use gave estimated 2021 inpatient stays with opioids mentioned in the diagnostic codes. The number of inpatient visits per locality was estimated from the HCUP state data, by using the VDH provided proportion of emergency department visits in each locality from the state total (ED data discussed in the next section). For 2021, HCUP data on opioid inpatient hospitalizations have not yet been published, therefore we estimated this required data point based on the historical ratio of opioid overdose ED Visits to inpatient hospitalizations.

Emergency Department Visits

Tallies of overdose visits to the emergency department (ED) were provided by VDH and supplemented by state-level HCUP data on opioid-related "treat-and-release" (T&R) visits.

Surveilled overdose ED visits were counted from the VDH's public *Emergency Department Visits for Unintentional Drug Overdose Among Virginia Residents* statistics, which provided annual counts for ED visits for opioid overdoses by the patient's locality of residence. For overdose ED costs, the average cost per visit was applied from estimates by Inocencio et al. (2013), which we adjusted for national inflation in hospital outpatient care. Payments were estimated by applying a payment-to-cost ratio, already calculated for overdose inpatient stays, to the estimated ED cost.

While some of these overlapped with ED visits for overdose, some were non-overdose, and thus important to include in the model. To estimate ED T&R visits by locality, each locality's estimated opioid inpatient stays was multiplied by the national ratio of opioid-related ED T&R visits to inpatient stays. These values were reported in the same Fast Stats tables that estimated sub-state inpatient stays. To avoid double counting ED visits for overdose, we subtracted the locality's overdose ED T&R visits. (We approximated the number of overdose ED visits that were T&R and assumed all overdose inpatient stays began as an ED visit, so we subtracted inpatient stays from surveilled ED visits for overdose.) This produced

estimates of ED T&R visits for non-overdose by locality. To these, we applied costs from Inocencio et al. (2013) and adjusted for inflation to get total costs per locality. Payments were approximated by multiplying these ED T&R costs by the payment-to-cost ratio already calculated for overdose inpatient stays.

Ambulance and Naloxone Costs

Ambulance costs for ED visits for overdose, ED T&R visits for non-overdose, and non-overdose inpatient stays were calculated. (Overdose inpatient stays were assumed to be captured by the overdose ED visit data, whereas non-overdose cases could only be ED T&R or inpatient, but not both.) We multiplied our estimate of non-overdose inpatient stays by 71%, the share of opioid-related inpatient stays that originated as ED visits in the Mid-Atlantic region (Mallow et al., 2018). The overdose ED, non-overdose ED T&R, and non-overdose inpatient stays were assumed to provide mutually exclusive, comprehensively exhaustive groups of ED cases, any of which may have involved an ambulance call. Ambulances were assumed to be used in 75% of all ED cases, and ambulance costs were taken from Inocencio et al. (2013) national estimates, adjusted for inflation in general hospital-care prices from 2011 to the year of study. One naloxone dose was assumed used in all ambulance cases for overdose, multiplied by an estimated average $60 per dose.

Primary Payer of Direct Health Care Costs

Data provided by VDH on the breakdown of overdose charges by payer was used to estimate the primary payment source for each direct opioid-related overdose or other health care utilization event. Costs were then attributed to the private sector, federal government, and state government totals using data on the proportion of each coverage type paid for by each major insurer. Medicare costs were attributed to the federal government, private insurance costs to the private sector and Medicaid costs split between the state and federal government based on the fiscal year Federal Medical Assistance Percentage (FMAP) for 2021.

Indirect Health Care Costs of Chronic Disease Caused by Opioid Misuse and Abuse

Based on the prevalence of opioid use disorder, injection drug use, and on VDH surveillance data of new cases of chronic diseases with known opioid-related health risks, the costs of illness attributable to opioid use were estimated. Neonatal abstinence syndrome, human immunodeficiency virus, hepatitis C and B viruses, and tuberculosis – diseases modeled by Jiang et al. (2017) – were considered.

Neonatal Abstinence Syndrome (NAS)

NAS is a suite of birth and development complications due to in-utero opioid exposure. NAS-afflicted babies born were identified using locality-level data published by VDH. Costs associated with birth were applied from Corr & Hollenbeak (2017), while non-birth costs associated with the first 8 years of life were taken by applying Liu et al.'s (2019) NAS-attributable spending multipliers to national health spending per capita for children ages 0-8. Birth and postpartum costs were separated out using estimates from Bui et al. (2017). Age-specific spending data for 2016 from the Institute for Health Metrics and Evaluation Disease Expenditure project database (received by request from Joseph Dieleman, Ph.D.), and Child Trends population estimates by age for 2016 gave a denominator for per capita costs were also used.

HIV, HCV, HBV, and Tuberculosis

Infections of HIV, Hepatitis C (HCV), Hepatitis B (HBV), and Tuberculosis all have lasting effects that require high medical costs to treat symptoms upon their onset. The contagious diseases spread via injection drug use, such as with heroin. We used the model provided by Jiang et al. (2017), and incorporate estimates of injection drug use rates among opioid misusers, to estimate the state's total future healthcare costs owing to new, injection drug use infections during 2021. Having estimated the population of opioid injection drug users estimated by locality, the probabilities and costs gathered by Jiang et al. to model HIV, HCV, HBV, and Tuberculosis costs in that injection drug-user group at the locality level were

applied. It is important to note this is an update from prior analyses that used heroin use as a proxy for injection drug use and previously used estimates heroin drug use from NSDUH. As a result of the changing Opioid epidemic (and the declining prevalence of heroin use alone, alongside an increasing prevalence of other synthetic opioids), we believe this new approach better estimates true risks to HIV, HCV, HBV, and Tuberculosis. This change increases the expected rates of these conditions, above and beyond the increase already expected due to higher OUD rate estimates in the 2021 findings.

For HIV and HCV, observed new cases were used to adjust the distribution of the total costs among localities without changing the Virginia total. This helps reflect that areas with higher prevalence of either disease will bear disproportionately high costs due to greater likelihood of contagion, locally. HIV and HCV are especially well tracked in publicly available data, including at the locality level, by the Virginia Department of Health. Locality-level data on HIV new diagnoses were received via a data request from VDH, whereas HCV new diagnoses data were downloaded from the VDH website. Using the costs in Jiang et al.'s model, these new diagnoses were monetized; national estimates suggest 9.4% of new HIV cases and 60% of new HCV cases are linked to injection drug use, so these shares of the disease costs were applied to each locality to estimate the opioid-attributable cost from documented new cases. The remainders of the Virginia cost of illness from HIV and HCV, as modeled based on Jiang et al., were then distributed among localities according to the size of localities' estimated heroin user populations. Where applicable, costs of treatment were adjusted by Altarum's all-item measure of health-care price inflation to reflect 2021 dollars.

Criminal Justice and Other Costs

Criminal Justice

To estimate the costs of opioid misuse and OUD to the Criminal Justice System in Virginia, we incorporated data on the estimated number of opioid-related drug arrests and opioid-related drug incarcerations in the Commonwealth, by locality in 2021. The number of opioid-related arrests by locality were estimated based on

county/independent city-level arrest rates data provided by the Virginia Department of Criminal Justice Services in their 2012-2021 Drug Arrest Trends report and the methods described above in the 'Productivity Losses due to Incarceration' section that determined the number of opioid-related arrests in 2021. To estimate the additional criminal justice costs, we applied an estimated cost per arrest accruing from combined police protection and court system costs, based on a per-drug-related arrest cost value from a 2013 Justice Policy Institute analysis, adjusted for inflation to 2021 dollars. An additional cost per drug-related incarceration in Virginia was taken from a 2012 Vera Institute of Justice report on the average cost per inmate in Virginia, applied to the estimated number of opioid-related incarcerations in 2021.

Child / Family Assistance

To estimate the costs of opioid misuse and OUD to Child and Family Services we used data from a 2019 paper in the American Journal of Managed Care, by Crowley et al. Their estimates for the 2016 costs nationally to the child welfare system (including Child Protective Services, in-home services, and foster care services) were applied to our own estimates of the national case count of OUD in that year using the Keyes et al. approach. This was used to compute an estimated cost per OUD case to the Child Welfare System (inflated to 2021 dollars), which we applied to the 2021 counts of OUD in Virginia to estimate a statewide cost to Child and Family Services. To estimate the cost burden for each county/independent city in 2021, we used data on the number of child referrals to Child Welfare Services by locality from 2021 data provided by the Virginia Department of Social Services. The total state cost was apportioned to each county and independent city, based on each locality's share of the overall number of referrals across the state.

K-12 Education System

We estimated additional direct expenditures on the K-12 education system due to OUD using methods from previous work by the National Center on Addiction and Substance Abuse (CASA) that estimated the national cost to the K-12 education system due to substance use disorders. The cost per SUD per year to the

education system was estimated by dividing this total value by the total number of SUD conditions in 2016 from NSDUH. This value was inflated to 2021 dollars and applied to the county/independent city-level data on the number of individuals suffering from OUD in 2021 for Virginia.