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# Improving Access to Medication-Assisted Treatment for Opioid Use Disorder among the Commercially-insured US Population

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## Executive Summary

The opioid crisis imposes a significant burden on the public health and the economy. Despite the value provided by Medication-Assisted Treatment (MAT) as an evidence-based treatment for Opioid Use Disorder (OUD), there are significant coverage and access barriers for patients in accessing this form of treatment.

This analysis sought to project the burden of OUD and estimate the impact of expanding adoption of MAT over the next 15 years in lowering opioid-related overdose, mortality and medical expenses among the commercially insured in the US. Our research shows the current opioid crisis is characterized by a rapid increase in the prevalence of opioid abuse combined with a decrease in the adoption of MAT. We relied on our peer reviewed and validated Markov-based microsimulation model and analysis of current trends, to project overdoses and associated mortality and costs over the next 15 years (*baseline scenario*). We also projected these outcomes in 2 alternative scenarios in which treatment with MAT was improved (*modest improvement scenario* and *aggressive improvement scenario*). Key findings are outlined below:

If the current trend continues without intervention over the next 15 years under the baseline scenario:

- Prevalence of OUD will reach 12.3 million by 2031.
- Overdoses will increase by more than 18 times reaching 1.7 million by 2031.
- Overdose deaths will reach 260,000 by 2031.
- Medical expenses associated with increases in overdoses will reach \$410 billion by 2031 and amount to a total of \$2.7 trillion over the 15-year period.

Relative to the current trajectory, preventing the projected decline in adoption of treatment with MAT over the next 15 years under the modest improvement scenario could:

- Prevent up to 3.5 million overdoses and save as many as 453,000 lives. By avoiding the costs associated with increases in overdoses, the healthcare system could save \$360 billion over the 15-year period.

Relative to the current trajectory, doubling current MAT adoption rates over the next 15 years under the aggressive improvement scenario could:

- Prevent up to 6.1 million overdoses and save as many as 805,000 lives. By avoiding costs associated with increased overdoses, the healthcare system could save \$645 billion over the 15-year period.

These findings support that even modest improvement in expanding MAT adoption rates can generate significant health, economic, and social benefits in the commercially insured population.

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## Introduction

The United States is in the midst of a public health crisis as communities across the country are struggling with the widespread devastation of opioid addiction. According to the Substance Abuse and Mental Health Services Administration (SAMHSA), approximately 2.1 million Americans have an OUD—defined as the misuse of prescription opioids or the abuse of diverted opioid medications or illicit opioids.<sup>1</sup> The Centers for Disease Control and Prevention (CDC) report between 1999 and 2017, the rate of drug overdose deaths increased by more than three-fold, and 68% of the 70,237 drug overdose deaths in 2017 were attributed to opioids (both prescription and illicit).<sup>2</sup> CDC data also show that the wide availability of synthetic opioids, including illicitly manufactured fentanyl, is driving the current increases in opioid overdose mortality at a rate increasing on average by 71% each year since 2013.

Apart from increased mortality, opioid abuse also causes substantial economic burden. A recent study of economic burden of prescription opioid overdose, abuse, and dependence in the US estimated this burden to be \$78.5 billion in 2013. More than three-quarters of these costs are attributed to nonfatal consequences, including health care spending, criminal justice costs and lost productivity due to addiction and incarceration. The remaining quarter of these costs are largely attributed to lost earnings associated with fatality.<sup>3</sup> More recent reports suggest that available estimates may have underestimated the burden of the opioid crisis as they underreport opioid overdose deaths and do not account for mortality associated with illicit sources of opioids abuse or the value of the lives lost. These estimates place the impact of the crisis closer to \$504 billion in economic burden in 2015.<sup>4</sup>

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<sup>1</sup> Substance Abuse and Mental Health Services Administration. Key substance use and mental health indicators in the United States: results from the 2015 national survey on drug use and health. 2016. Available at:

<https://www.samhsa.gov/data/sites/default/files/NSDUH-FFR1-2016/NSDUH-FFR1-2016.htm>

<sup>2</sup> Holly Hedegaard, Arialdi M. Miniño, Margaret Warner. Drug Overdose Deaths in the United States, 1999–2017. NCHS Data Brief. November 2018

<sup>3</sup> Florence, Curtis, et al. "The economic burden of prescription opioid overdose, abuse and dependence in the United States, 2013." *Medical care* 54.10 (2016): 901.

<sup>4</sup> Hagemeyer, Nicholas E. "Introduction to the opioid epidemic: the economic burden on the healthcare system and impact on quality of life." *The American journal of managed care* 24.10 Suppl (2018): S200-S206.

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MAT is an evidence-based approach to the treatment of OUD that relies on a combination of counselling, behavioral therapy and one or more medications that block the effects that opioids produce and/or mitigate the symptoms of opioid withdrawal. Methadone, buprenorphine, and naltrexone are medications currently available as a component of MAT that have been shown to successfully treat OUD. A wide body of research supports the use of MAT for OUD and in reducing the burden of the disease. Studies show that MAT can reduce overdose fatalities and significantly reduce opioid abuse compared to other treatments that do not incorporate medications.<sup>5 6 7</sup> Importantly, MAT can also reduce Emergency Department (ED) visits and hospitalizations and thereby help to avoid significant annual medical costs,

**Medications used as Part of MAT (each indicated for use along with psychosocial support/counselling):**

*Methadone* is a long-acting synthetic opioid agonist. Treatment with methadone is often referred to as methadone maintenance treatment and works by acting on the opioid receptors in the brain to reduce withdrawal symptoms and relieve drug cravings. It can only be administered for the treatment of OUD in a certified Opioid Treatment Program.

*Buprenorphine* is a partial opioid agonist and also works by acting on the opioid receptors to reduce cravings and withdrawal symptoms. Unlike methadone, buprenorphine can be prescribed in an office-based setting.

*Naltrexone* is an opioid antagonist and works by blocking the euphoric and sedative effects of opioids and is used to prevent relapse following detoxification. Unlike methadone and buprenorphine, naltrexone is not itself an opioid or controlled substance and therefore can be administered in a wider range of clinical settings.

Source: <https://www.drugabuse.gov/publications/research-reports/medications-to-treat-opioid-addiction/how-do-medications-to-treat-opioid-addiction-work>

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<sup>5</sup> Richard P. Mattick et al., "Methadone Maintenance Therapy Versus No Opioid Replacement Therapy for Opioid Dependence," Cochrane Database of Systematic Reviews 3 (2009): CD002209, <http://www.ncbi.nlm.nih.gov/pubmed/19588333>

<sup>6</sup> Sandra D. Comer et al., "Injectable, Sustained-Release Naltrexone for the Treatment of Opioid Dependence: A Randomized, Placebo-Controlled Trial," *Archives of General Psychiatry* 63, no. 2 (2006): 210–8, <http://archpsyc.jamanetwork.com/article.aspx?articleid=209312>

<sup>7</sup> Paul J. Fudala et al., "Office-Based Treatment of Opiate Addiction With a Sublingual-Tablet Formulation of Buprenorphine and Naloxone," *New England Journal of Medicine* 349, no. 10 (2003): 949–58, <http://www.ncbi.nlm.nih.gov/pubmed/12954743>

relative to those who have not been receiving treatment.<sup>8</sup>

Despite the availability of MAT and its demonstrated effectiveness for the treatment of OUD, evidence suggests there are barriers to accessing this critical treatment. In addition to the stigma that many OUD patients face, the availability of providers trained, licensed and certified to prescribe these medications is often limited, particularly in rural communities.<sup>9</sup>

There are also significant insurance restrictions that limit coverage of MAT. These include lack of coverage of all forms of MAT or high patient out of pocket costs. Utilization management tools are also frequently used, such as “fail-first” policies and prior authorization requirements which can delay access to appropriate treatment. Additionally, insurers may impose lifetime limits on MAT use, or place limits on prescription refills and dosage amounts. There are also often significant barriers and/or lack of coverage of the range of counselling and behavioural health supports that patients need as part of MAT—including for example, inpatient detoxification, residential or outpatient treatment services.<sup>10 11 12</sup>

In recognition of the significant hurdles that patient face in accessing MAT for OUD and the opportunity presented by expanding treatment, this analysis sought to project the burden of OUD and estimate the impact of expanding adoption of MAT over the next 15 years in lowering opioid-related overdose, mortality, and medical expenses among the commercially insured population in the US.

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<sup>8</sup> Mohlman, Mary Kate; Tanzman, Beth; Finison, Karl; Pinette, Melanie Jones, Craig. Impact of Medication-Assisted Treatment for Opioid Addiction on Medicaid Expenditures and Health Services Utilization Rates in Vermont. *Journal of Substance Abuse Treatment* [Internet]. 2016 May [2018 Aug 15]. 67: 9-14.

<sup>9</sup> Gale, J. A. "Rural communities in crisis: Strategies to address the opioid crisis." National Rural Health Association Policy Brief (2016).

<sup>10</sup> American Society of Addiction Medicine, *Advancing Access to Addiction Medications: Availability Without Accessibility? Report 1: "State Medicaid Coverage and Authorization Requirements for Opioid Dependence Medications,"* The Avisa Group, 2013, [https://www.asam.org/docs/default-source/advocacy/aaam\\_implications-for-opioid-addiction-treatment\\_final](https://www.asam.org/docs/default-source/advocacy/aaam_implications-for-opioid-addiction-treatment_final).

<sup>11</sup> National Center on Addiction and Substance Abuse, *Uncovering Coverage Gaps: A Review of Addiction Benefits in ACA Plans* (June 2016), <http://www.centeronaddiction.org/addiction-research/reports/uncovering-coverage-gaps-review-of-addictionbenefits-in-aca-plans>

<sup>12</sup> Christopher M. Jones et al., "National and State Treatment Need and Capacity for Opioid Agonist Medication-Assisted Treatment," *American Journal of Public Health* 105, no. 8 (2015): e55–63, <http://dx.doi.org/10.2105/AJPH.2015.302664>.

## Methodology

This analysis relied on a peer reviewed and validated Markov-based microsimulation model to estimate the effects of opioid abuse and treatments on overdoses and associated mortality and costs. The model was populated using data on commercially insured adults aged 20 to 65 from the 2007 to 2014 National Health and Nutrition Examination Survey (NHANES), a nationally representative dataset on demographic, socioeconomic, and health information for the US population. Key model parameters are described in detail as follows and summarized in Table 1. Using the model, individuals were assigned to an initial state of OUD or treatment based on gender- and age-specific opioid abuse prevalence information. Overall, 0.97% of commercially insured individuals are estimated to be diagnosed with OUD.<sup>13</sup> The annual incidence rate of OUD in 2016 was estimated to be 3.2 per 1,000 members and estimated to grow by 14% each year.<sup>14</sup>

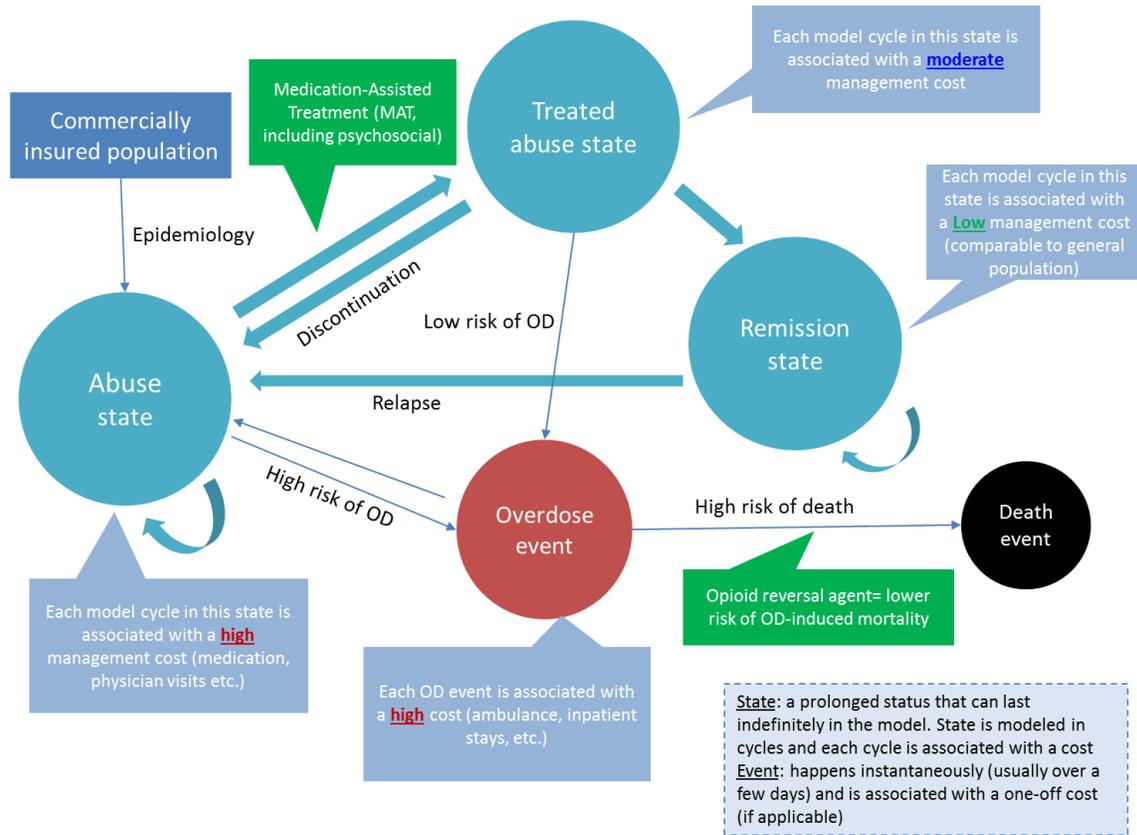
The model simulates the probability and consequences of entering one of three states of OUD and treatment – the ‘abuse’ state, the ‘treated abuse’ state, and the ‘remission’ state. Individuals in the ‘abuse’ state have either a prescription or illicit opioid use disorder but are not receiving MAT. Individuals may transition into the ‘treated abuse’ state when they receive a formal diagnosis of OUD by a health professional and receive some form of MAT. Individuals may then enter the ‘remission state’ after successfully completing MAT and are no longer opioid dependent or in need of treatment. Individuals can transition into the various OUD and treatment states as depicted in Figure 1. Each year, individuals in the ‘abuse’ state may receive treatment and transition to the ‘treated abuse’ state, and some of those in the ‘treated abuse’ state can transition to the ‘remission’ state while others will either remain in the ‘treated abuse’ state or relapse to the ‘abuse’ state.

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<sup>13</sup> America's opioid epidemic and its effect on the nation's commercially-insured population. June 29, 2017. <https://www.bcbs.com/the-health-of-america/reports/americas-opioid-epidemic-and-its-effect-on-the-nations-commercially-insured>

<sup>14</sup> Laurent, et al., Drivers of excess costs of opioid abuse among a commercially insured population. *Am J Manag Care*. 2017 May;23(5):276-282

Figure 1. Diagram of model schematic



Assumptions regarding transitions between states were derived from the following studies:

- The treatment rate among commercially insured ‘abuse’ state was estimated to be 36% in 2016.<sup>15</sup>
- Among those individuals who received MAT in the ‘treated abuse’ state, the annual relapse rate was estimated to be 81%.<sup>16</sup>
- The annual remission rate of those in the ‘treated abuse’ state was estimated to be 8%; and

<sup>15</sup> Lee JD et al. Comparative effectiveness of extended-release naltrexone versus buprenorphine-naloxone for opioid relapse prevention (X:BOT): A multicentre, open-label, randomised controlled trial. Lancet 2017 Nov 14;

<sup>16</sup> Nunes EV et al. Relapse to opioid use disorder after inpatient treatment: Protective effect of injection naltrexone. J Subst Abuse Treat. 2018 Feb;85:49-55.

- 16% of those in the ‘remission’ state who reported abstaining from opioid use, relapsed over 12 months.

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Based on data of opioid-related ED visits and mortality,<sup>18 19</sup> we derived the overall overdose rate as 0.84 per 1,000 insured members, and the probability of dying per overdose event was 15.5%. We assume that individuals in the ‘remission’ state incur a similar level of health care resource utilization as an average person in the general population (\$10,348 per year, in 2016 \$), which is considerably lower than the resource use in either the ‘abuse’ (\$32,829 per year) or ‘treated abuse’ state (\$18,392 ~ \$21,410 per year).<sup>20 21</sup> Because of the many complications and comorbidities of uncontrolled OUD, those in the ‘abuse’ state that are not undergoing treatment are assumed to incur the highest level of direct medical expenditure.

**Table 1: Summary of Key model parameters**

<b>Parameters</b>	<b>Value</b>
Model time horizon	15 years
Initial rate of opioid abuse	9.7 per 1,000 members
Initial incident rate of opioid abuse	3.2 per 1,000 members
Annual rate of opioid overdose	0.84 per 1,000 members
Mortality risk per overdose event	15.50%
Mortality risk of individuals in the treated abuse state	1.8‰
Initial treatment adoption rate	36%
<b><i>Transition rates between states</i></b>	
Abuse -> treated abuse	36% <sup>22</sup>

<sup>17</sup> Hser YI et al, A 33-Year Follow-up of Narcotics Addicts. Arch Gen Psychiatry. 2001;58(5):503-508

<sup>18</sup> HCUP Fast Stats - Opioid-Related Hospital Use, <https://www.hcup.us.ahrq.gov/faststats/OpioidUseServlet>

<sup>19</sup> The Critical Care Crisis of Opioid Overdoses in the United States. Ann Am Thorac Soc. 2017 Aug 11.

<sup>20</sup> Baser, O., Chalk, M., Fiellin, D., & Gastfriend, D. (2011). Cost and Utilization Outcomes of Opioid-Dependence Treatments. Am J Manag Care, 17, S235-S248.

<sup>21</sup> Hartman, M., Martin, A. B., Espinosa, N., Catlin, A., & Acc, T. N. (2018). National Health Care Spending In 2016: Spending And Enrollment Growth Slow After Initial Coverage Expansions. Health Affairs, 37(1), 150-160. doi:10.1377/hlthaff.2017.1299

<sup>22</sup> America's opioid epidemic and its effect on the nation's commercially-insured population. June 29, 2017. <https://www.bcbs.com/the-health-of-america/reports/americas-opioid-epidemic-and-its-effect-on-the-nations-commercially-insured>

Treated abuse -> remission	8% <sup>23,24</sup>
Treated abuse -> abuse (relapse)	81% <sup>25 26</sup>
Remission -> abuse	16% <sup>27</sup>
<b>Health care expense (2016 \$)</b>	
Individuals in the abuse state not under treatment	\$32,829
Individuals in the treated abuse state under treatment (1st year)	\$21,410
Individuals in the treated abuse state under treatment (after 1st year)	\$18,392

The baseline prevalence of MAT use is assumed to be 36% in 2016 and has decreased by 16% each year since 2010. This is reflective of a dramatic increase in prevalence of opioid abuse while uptake of MAT has not kept pace.<sup>28</sup>

The model was used to explore the impact of three potential scenarios of expanded access to MAT.

1. *Baseline scenario*: assumes the prevalence of OUD as 0.97% among the commercially insured population in 2016, with 36% of those in the abuse state transitioning to treatment with MAT. MAT adoption was assumed to decrease at the current rate (16% each year) over the next 15 years;
2. *Modest improvement scenario*: assumes that access to treatment remains stable at existing levels (rather than decreasing each year), at 36% over next 15 years;
3. *Aggressive improvement scenario*: assumes that access will improve with a treatment adoption rate gradually increasing over next 15 years until it doubles the baseline level (72%) by end of time horizon.

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<sup>23</sup> Hser YI et al, Comparing the dynamic course of heroin, cocaine, and methamphetamine use over 10 years. *Addictive Behaviors* 33 (2008) 1581–1589

<sup>24</sup> Hser YI et al, A 33-Year Follow-up of Narcotics Addicts. *Arch Gen Psychiatry*. 2001;58(5):503-508

<sup>25</sup> Lee JD et al. Comparative effectiveness of extended-release naltrexone versus buprenorphine-naloxone for opioid relapse prevention (X:BOT): A multicentre, open-label, randomised controlled trial. *Lancet* 2017 Nov 14;

<sup>26</sup> Nunes EV et al. Relapse to opioid use disorder after inpatient treatment: Protective effect of injection naltrexone. *J Subst Abuse Treat*. 2018 Feb;85:49-55.

<sup>27</sup> Hser YI et al, A 33-Year Follow-up of Narcotics Addicts. *Arch Gen Psychiatry*. 2001;58(5):503-508

<sup>28</sup> America's opioid epidemic and its effect on the nation's commercially-insured population. June 29, 2017. <https://www.bcbs.com/the-health-of-america/reports/americas-opioid-epidemic-and-its-effect-on-the-nations-commercially-insured>

Sensitivity analyses were conducted to test the impact of varying key parameters. Results can be found in appendix 2.

## Study findings

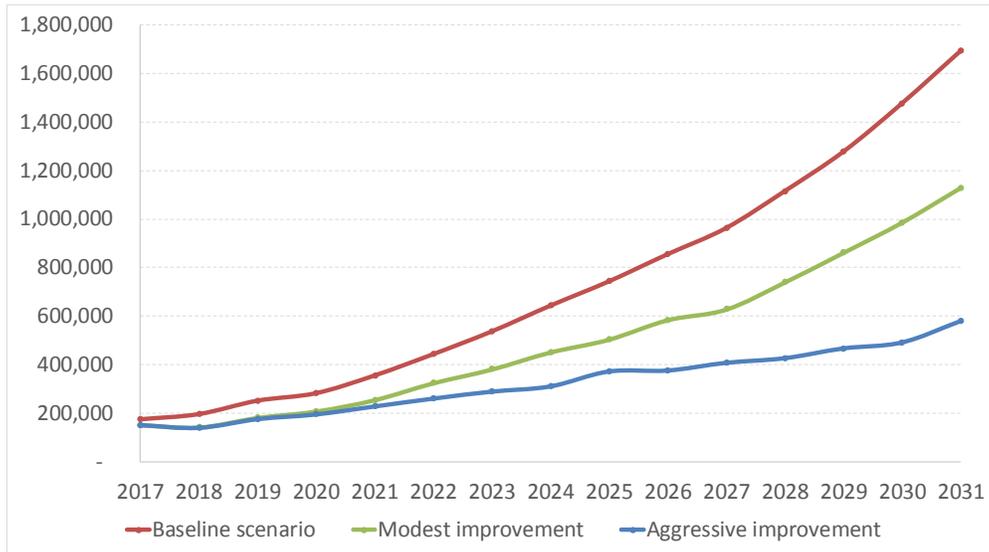
### 1. Projected prevalence of OUD patients receiving MAT over the next 15 years

The prevalence of opioid abuse among the commercially-insured population is projected to keep rising over next 15 years, increasing from 1.2 million in 2016 to 12.3 million by 2031. Compared to the baseline scenario, we estimated about 4.8 and 8.8 million more OUD patients could receive MAT under the modest and aggressive treatment scenarios.

### 2. Projected rates of opioid overdose and related mortality over the next 15 years

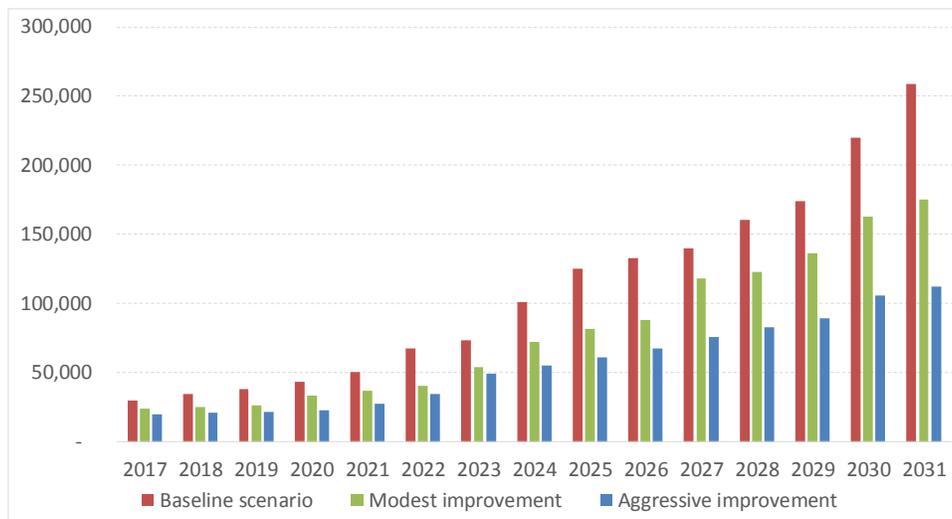
Under the *baseline scenario*, the estimated annual incidence of opioid overdose among the commercially insured population is projected to increase by more than 18 times over 15 years, from 132,000 in 2016 to 1.7 million in 2031, amounting to nearly 11 million overdoses over 15 years (Figure 2). In the *modest* and *aggressive improvement scenarios*, improving adoption of MAT could reduce the total numbers of overdoses by 3.5 million (32%) and 6.1 million (56%), respectively (See Figure 2).

**Figure 2. Projection of total number of opioid overdose among commercially insured, under three scenarios**



Similarly, the estimated opioid-related mortality is also expected to rise dramatically under the *baseline scenario*, from 30,000 deaths in 2017 to almost 260,000 deaths in 2031 among the commercially insured population (Figure 3). Alternatively, the mortality is expected to reach 175,000 and 112,000 by the same time in the *modest* and *aggressive improvement scenarios*. In total, the simulation shows the two improved scenarios are expected to help avoid 453,000 (27%) and 805,000 (49%) deaths due to opioid abuse, respectively, over 15 years (See Figure 3).

**Figure 3. Projection of total number of opioid-related mortality among commercially insured, under three scenarios**

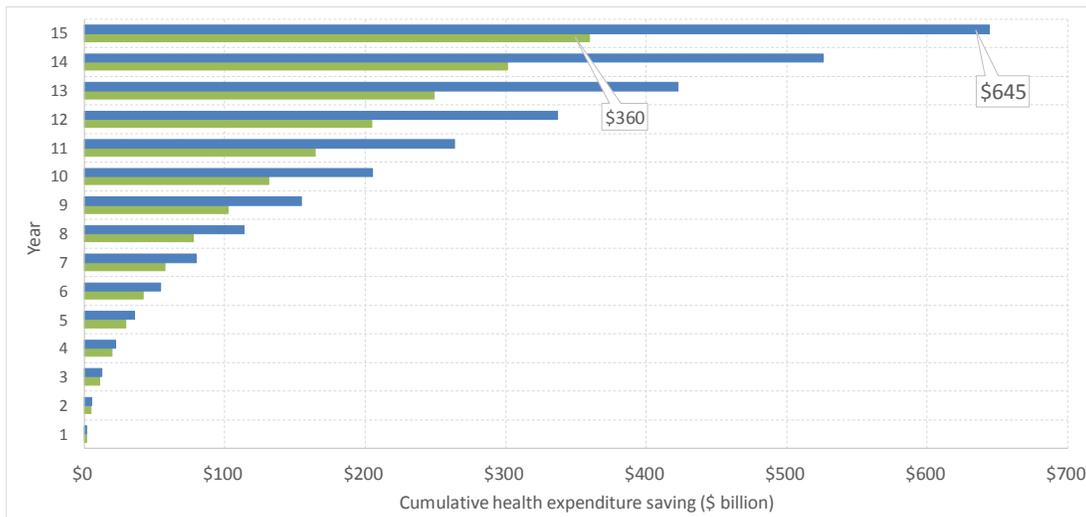


### 3. Projected impact of opioid abuse on total health care expenditure

Under the *baseline scenario*, the annual health care costs incurred by opioid abuse is expected to increase from \$35 billion in 2017 to \$410 billion in 2031, summing to \$2.7 trillion over 15 years.

Through the improvement in MAT adoption under the *modest improvement scenario* on average \$24 billion can be saved in health care expenditures each year due to reduced healthcare utilization, resulting in a total savings of \$360 billion (13%) over 15 years. Alternatively, if we can double the treatment adoption rate by 2031 under the *aggressive improvement scenario*, on average \$43 billion can be saved each year and a total of \$645 billion (24%) can be saved over the next 15 years (Figure 4).

**Figure 4. Projection of cumulative savings in health expenditure under modest and aggressive improvement scenarios**



## Results in context

This study is the first to use advanced microsimulation techniques to project the potential health and economic benefits of improving access to various opioid addiction treatments among the commercially insured population. Our research shows the current opioid crisis is characterized by a rapid increase in the prevalence of opioid abuse and a decrease in the adoption of MAT. If this trend continues the annual number of overdose, mortality, and direct medical costs associated with opioid abuse will increase by more than 10-fold over the next 15 years. By improving access to MAT over the same time frame, there is potential to avoid up to 6.1 million

overdoses and save as many as 805,000 lives over the next 15 years. By avoiding the costs associated with increased overdoses, the healthcare system also could save up to \$645 billion over the next 15 years.<sup>29</sup>

These findings represent remarkable opportunity to stem the tide of this devastating public health crisis by improving access to MAT. However, they are likely an understatement as they do account for the many additional benefits that could be achieved that were not explored here but contribute to the significant economic burden of OUD, such as lost productivity and criminal justice costs. Additionally, though there are a number of secondary clinical consequences associated with opioid abuse and addiction that will likely be avoided as a result of expanded MAT delivery these were also not included in this analysis. For example, MAT is associated with a reduction in Hepatitis C and HIV infection among injection drug users.<sup>30 31</sup> Avoidance of costly infectious diseases as well as associated health care expenditures are also likely to contribute significantly to reduced economic burden in alternative scenarios in which MAT adoption is expanded.

In recognition of the role MAT provides in addressing the opioid crisis, policymakers are increasingly taking steps to remove barriers that impede expanded access to this evidence-based treatment. These steps include policies to expand the types of healthcare professionals that can seek the licensing to prescribe certain MATs as well as policies to increase the number of patients that clinicians can treat with these medications. Additionally, a broad range of federal grant programs are providing much-needed resources to states to help improve and expand treatment capacity for the delivery of MAT, including in rural areas where accessing licensed providers is often limited. States are also exploring innovative approaches such as expanding the use of telehealth services and demonstration projects aimed to break down silos in the delivery of addiction treatment and recovery services, including MAT. There have also been recent policies to improve coverage and access to all forms of MATs in

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<sup>29</sup> MAT can reduce the rate of overdose or help transition the treated population into a state of remission. Previous efforts in modeling the effectiveness of opioid addiction interventions have largely focused on single agents over a relatively short follow-up period. ## The application of such studies in a policy context may be limited due to the substantial difference in population characteristics, multi-modal treatment regimen, drug efficacy, patient behavior, as well as the lack of any ‘endpoints’ in real life.

<sup>30</sup> Judith I. Tsui et al., “Association of Opioid Agonist Therapy With Lower Incidence of Hepatitis C Virus Infection in Young Adult Injection Drug Users,” *JAMA Internal Medicine* 174, no. 12 (2014): 1974–81, <http://archinte.jamanetwork.com/article.aspx?articleid=1918926>

<sup>31</sup> David S. Metzger et al., “Human Immunodeficiency Virus Seroconversion Among Intravenous Drug Users In-and-Out-of-Treatment: An 18-Month Prospective Follow-Up,” *Journal of Acquired Immune Deficiency Syndromes* 6, no. 9 (1993): 1049–56, <http://www.ncbi.nlm.nih.gov/pubmed/8340896>

publicly funded programs, including Medicare and Medicaid.<sup>32</sup> And importantly, four of the nation’s largest commercial insurers have announced the removal of prior authorization requirements for MAT, evidencing positive steps forward in removing hurdles to treatment.<sup>33</sup>

Improving access to MAT can generate significant health, economic, and social benefits, particularly when implemented in combination with other policies aiming at prevention of opioid abuse. Moving forward, additional research to assess the broad range of potential benefits associated with improving access to MAT, including in Medicaid and Medicare, can further help to inform a comprehensive strategy to addressing the opioid crisis.

## Acknowledgement

The authors thank the Pharmaceutical Research and Manufacturers of America (PhRMA) for providing funding to support this research.

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<sup>32</sup> H.R.6 – 115<sup>th</sup> Congress: SUPPORT for Patients and Communities Act; S.524 – 114<sup>th</sup> Congress: Comprehensive Addiction and Recovery Act of 2016.

<sup>33</sup> Livingston S, “Access denied: insurers slowly removing barriers to addiction treatment” Modern Healthcare, April 14, 2017. <https://www.modernhealthcare.com/special/opioid-addiction>

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## Appendix 1: Key Model Assumptions

- State transition
    - People who abuse opioids cannot go to remission directly without any treatment/intervention
  - Prevalence
    - The prevalence of illegal synthetic opioids use is derived from the SKIP (Survey of Key Informants' Patients) program, which consists of > 150 publicly and privately funded treatment centers, balanced geographically with coverage in 48 states. It is assumed that it is representative of the US on the use of illegal synthetic opioids.
  - Incidence
    - The same trend in the incidence of opioid abuse between 2010 and 2014 would continue until 2030
  - Anti-addiction treatment
    - The same trend in treatment adoption rate between 2010 and 2016 (derived from Blue Cross Blue Shield data) would continue until 2030
  - Overdose
    - Mortality
      - The trend of opioid OD mortality between 2010-2016 would continue until 2030
      - Even though the risk of OD is dependent on the type of opioids being abused (heroin, Rx opioid, & synthetic opioids), once an OD event has occurred the risk of death remains the same regardless of which type of opioids caused the OD in the first place
    - ED visit
      - Assume all opioid related ED visits are due to opioid overdose
      - Each OD event will lead to one ED visit
  - Direct Health Care Expenditure
    - Pre-treatment (abuse) health management cost stays constant between the first and second half of a year
    - Health management cost for those in remission is the same as the average health management cost for general, commercially insured population
    - Assume the cost of treatment on subsequent years would be constant
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## Appendix 2: Sensitivity Analysis for 15-year Cumulative Health Expenditure Saving

Sensitivity analysis was conducted to test the influence of +/-10% variation in transition rates to the cumulative health expenditure saving estimated by our simulation model. Default transition rates and their ranges of variation tested in this analysis are shown in Table 1; The tornado diagram (Figure 1) shows the simulated health expenditure saving varied by 3~17% as result of fluctuation in default transition rates.

**Table 2. Default transition rates and range of variation**

Transition rates	Decrease by 10%	Default rate	Increase by 10%
Abuser -> treated abuser	32%	36%	40%
Treated abuser -> remission	7%	8%	9%
Treated abuser -> abuser (relapse)	73%	81%	89%
Remission -> abuser	14%	16%	18%

**Figure 5. Percentage change in cumulative saving of health expenditure over 15 years**

