

Cost-Effectiveness of Emergency Department–Initiated Buprenorphine With Rapid Follow-Up for Opioid Use Disorder

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Abstract

Background

Opioid use disorder (OUD) remains a major public health challenge, with substantial morbidity, mortality, and healthcare costs. Emergency departments (EDs) represent critical intervention points for initiating evidence-based treatment. While ED-initiated buprenorphine improves treatment engagement, its economic value relative to referral-based care requires further evaluation.

Methods

We developed a decision-analytic Markov cohort model to assess the cost-effectiveness of ED-initiated buprenorphine with rapid primary care follow-up (ED-BUP) compared with referral alone in adults with OUD. The model used monthly cycles over a 5-year time horizon from a healthcare sector perspective. Clinical inputs were derived from randomized and observational studies. Outcomes included total costs, quality-adjusted life years (QALYs), and incremental cost-effectiveness. Uncertainty was assessed using one-way deterministic and probabilistic sensitivity analyses with 1,000 Monte Carlo simulations.

Results

ED-BUP was associated with lower costs (−\$225 per patient) and greater effectiveness (+ 0.012 QALYs) compared with referral alone, indicating that the intervention is dominant. Probabilistic sensitivity analysis showed that ED-BUP was cost-effective in 97% of simulations at a willingness-to-pay threshold of \$100,000 per QALY and 99% at \$200,000 per QALY. Sensitivity analyses confirmed robustness of results across key model parameters.

Conclusions

ED-initiated buprenorphine with rapid follow-up is a cost-effective strategy for managing OUD, improving health outcomes while reducing healthcare costs. These findings support broader implementation of ED-based treatment as part of public health and health system strategies to address the opioid crisis.

Plain Language Summary

Opioid use disorder is a significant health issue that causes high morbidity, mortality, and medical expenses. Many individuals with opioid use disorder seek care in emergency departments, creating an opportunity to start treatment early.

We employed a modeling methodology in this study where we compared two strategies: initiation of buprenorphine treatment in the emergency department with follow-up treatment, and patient referral to

treatment services in the future. We found that initiating treatment in the emergency department improves health outcomes while reducing overall healthcare costs.

These results suggest that emergency departments can play an important role in improving access to effective treatment. Increasing the utilization of buprenorphine in such environments might contribute to alleviating the effects of the opioid crisis and enhancing patient outcomes.

1. Background and Rationale

Within the broader framework of pain management, opioid use disorder (OUD) is a relapsing chronic disease that often emerges following exposure to opioids prescribed for acute and chronic pain. The widespread use of prescription opioids for pain control has contributed to a complex clinical continuum in which patients transition from legitimate analgesic use to dependence, misuse, and ultimately OUD. This evolving landscape underscores the need to view OUD not solely as an isolated addiction disorder, but as a condition closely linked to pain therapeutics, prescribing practices, and gaps in continuity of care.

Emergency departments (EDs) frequently serve as critical points of contact for patients experiencing complications related to both inadequately managed pain and opioid-related harm. These encounters represent key opportunities to intervene within the broader pain management trajectory by initiating evidence-based therapies that address both physiological dependence and ongoing clinical needs. Among these, buprenorphine—a partial opioid agonist with both analgesic and anti-craving properties—has emerged as a dual-purpose therapeutic agent with relevance to pain management and OUD treatment.

Importantly, a substantial proportion of opioid use disorder originates from exposure to prescription opioids used in chronic pain management. As such, strategies that improve transitions from opioid-related harm to evidence-based treatment are highly relevant within the broader context of pain therapeutics and management.

1.1 The Opioid Use Disorder Crisis: Scope and Burden

Opioid use disorder (OUD) is a relapsing chronic disease with high morbidity and mortality, representing a major public health burden (Centers for Disease Control and Prevention, 2025; Spencer et al., 2024). Although the mortality rates have recently stabilized, the burden remains substantial, and more than 100,000 overdose deaths are reported annually, most of which are opioid-related (Garnett & Miniño, 2024). The economic burden of OUD is substantial, including healthcare utilization, lost productivity, and criminal justice system costs. Earlier projections indicate that the effects of opioids cost the U.S. healthcare system tens of billions of dollars every year, which highlights the necessity of effective and scalable interventions.

1.2 The Treatment Gap and Underutilization of Evidence-Based Therapy

Despite the evidence-based nature of medications to treat opioid use disorder (MOUD), such as buprenorphine, methadone, and extended-release naltrexone, access is limited. According to national data, most persons with OUD fail to undergo pharmacologic care, which is an indication of the barriers that persist, including stigma, regulatory limitations, and the lack of capacity to treat them (National Academies of Sciences, Engineering, and Medicine, 2019; Tsai et al., 2019). Emergency departments (EDs) are an important access point to individuals with OUD, especially those with minimal longitudinal care involvement. Consequently, ED-based buprenorphine has emerged as a clinically effective and evidence-based strategy to improve treatment initiation and continuity of care, especially in high-risk and underserved communities. Despite strong clinical evidence supporting ED-initiated buprenorphine, its economic value relative to standard referral pathways remains incompletely defined. Despite increasing clinical evidence, utilization of ED-initiated buprenorphine has historically remained low across U.S. emergency departments (Rhee et al., 2020).

1.3 Emergency Department Buprenorphine: Clinical Evidence

Evidence supporting ED-initiated buprenorphine is well established. In a randomized clinical trial, D’Onofrio et al. (2015) demonstrated significantly higher 30-day treatment engagement in the buprenorphine group (78%) compared with referral (37%) and brief intervention (45%) ($p < 0.001$). Patients receiving buprenorphine also showed greater reductions in illicit opioid use and reduced utilization of inpatient addiction services.

Follow-up studies suggest that although early engagement benefits attenuate over time, continuity of care following ED initiation remains critical (D’Onofrio et al., 2017; Wakeman et al., 2020). Despite this evidence, uptake of ED-initiated buprenorphine remains limited due to barriers such as clinician readiness, regulatory constraints, and resource availability (Hawk et al., 2020).

1.4 The Mortality Evidence

Medications for opioid use disorder are associated with substantial reductions in mortality. A meta-analysis by Sordo et al. (2017) reported significantly lower mortality rates among individuals receiving opioid agonist therapy compared with those not on treatment. Similarly, Larochelle et al. (2018) found a 38% reduction in mortality among patients treated with buprenorphine following nonfatal overdose. These findings support the inclusion of mortality benefits in economic evaluations of ED-initiated treatment.

1.5 Existing Economic Evidence and Research Gap

Prior economic evaluations have shown that MOUD is generally cost-effective compared with no treatment (Krebs et al., 2018; Onuoha et al., 2021; Fairley et al., 2021). In the ED setting, Busch et al.

(2017) demonstrated that ED-initiated buprenorphine was both more effective and less costly than referral alone. More recent modeling studies support the cost-effectiveness of strategies that expand buprenorphine access, with estimates within commonly accepted willingness-to-pay thresholds (Claypool et al., 2023). However, there remains a need for updated decision-analytic models incorporating QALY-based outcomes, probabilistic sensitivity analysis, and contemporary cost inputs to evaluate ED-initiated buprenorphine with rapid follow-up compared with referral pathways.

Within this context, evaluating the economic and clinical impact of initiating buprenorphine in emergency care settings is highly relevant to optimizing pain-related care pathways. Early initiation of buprenorphine may not only improve treatment engagement and reduce opioid-related morbidity and mortality but also alter downstream healthcare utilization and costs associated with fragmented pain management and untreated OUD. Therefore, this study examines the cost-effectiveness of emergency department–initiated buprenorphine with rapid follow-up compared with referral-based care, situating the analysis within the broader framework of opioid prescribing, pain management, and health system efficiency.

2. Research Question and Objectives

2.1 Primary Research Question

Does the emergency department delivery of buprenorphine-naloxone therapy combined with rapid follow-up in primary care represent a cost-effective strategy in comparison with a referral to community-based addiction treatment clinics only for adult patients with opioid use disorder in an urban emergency department in the US?

2.2 Specific Objectives

Objective 1

To evaluate the per-patient costs associated with ED-initiated buprenorphine with follow-up versus referral alone from a healthcare sector perspective over a five-year time horizon.

Objective 2

To evaluate the number of QALYs gained per patient within both treatment options based on established health utility values available in the scientific literature.

Objective 3

To evaluate the cost-effectiveness of ED-initiated buprenorphine compared with referral-based care using cost and QALY outcomes.

Objective 4

To assess uncertainty using one-way deterministic sensitivity analysis, probabilistic sensitivity analysis, and cost-effectiveness acceptability curves.

Objective 5

To report the economic evaluation in accordance with CHEERS 2022 reporting standards.

3. Methods

3.1 Study Design

A decision-analytic Markov cohort model was developed to evaluate the cost-effectiveness of emergency department–initiated buprenorphine with rapid primary care follow-up (ED-BUP) compared with referral alone in adults with opioid use disorder (Briggs et al., 2006). The analysis was conducted from a healthcare sector perspective over a 5-year time horizon using monthly cycles.

3.2 Model Structure

The model included five mutually exclusive health states: active opioid use without treatment, ED-initiated buprenorphine (stabilized), community-based treatment, abstinence, and death. Patients transitioned between states in monthly cycles, with death modeled as an absorbing state. Costs and quality-adjusted life years (QALYs) were discounted at an annual rate of 3%.

(Fig. 1 here)

3.3 Transition Probabilities

Transition probabilities, costs, and health utility values were derived from randomized trials and published literature. Key inputs included 30-day treatment engagement, relapse rates, and mortality associated with treated and untreated opioid use disorder. Full parameter details are provided in Supplementary Tables S1–S3.

Table 1
Key model structural and transition parameters.

Parameter	Base-case value	Source
Time horizon	5 years	Modeling convention
Discount rate	3%	CHEERS 2022
30-day engagement (ED-BUP)	78%	D’Onofrio et al., 2015
30-day engagement (Referral)	37%	D’Onofrio et al., 2015
Monthly mortality (Active OUD) 0.54%	0.54%	Sordo et al., 2017
Monthly mortality (Treatment)	0.06%	Sordo et al., 2017

3.4 Costs

Cost estimates included emergency department visits, medication, follow-up care, and healthcare utilization, expressed in 2023 U.S. dollars. Health utility values were assigned to each health state based on published preference-based measures and used to calculate QALYs.

Table 2
Summary of cost parameters.

Parameter	Base-case value (USD)	Source
Total cost – ED-BUP	\$1,752	Busch et al., 2017
Total cost – Referral	\$1,977	Busch et al., 2017
Buprenorphine (monthly)	\$400	Claypool et al., 2023
ED visit	\$1,200	Lu et al., 2024
Primary care visit	\$180	Schackman et al., 2012

3.5 Health Utilities (QALY Weights)

Health utility weights were derived from validated preference-based studies and applied to each health state. Utility values ranged from 0.512 for active opioid use to 0.850 for abstinence (Table 3).

Table 3
Health utility values by health state.

Health State	Utility Value	Source
Active OUD	0.512–0.626	Wittenberg et al., 2016
MOUD Treatment	0.680–0.766	Claypool et al., 2023
Abstinent	0.850	Fairley et al., 2021
Death	0.000	Standard assumption

3.6 Sensitivity Analysis

Uncertainty was assessed using one-way deterministic sensitivity analysis and probabilistic sensitivity analysis with 1,000 Monte Carlo simulations. Appropriate probability distributions were assigned to model parameters (beta for probabilities and utilities; gamma for costs).

3.7 Model Validation

Internal validation ensured logical consistency of model structure and outputs. External validation was conducted by comparing model results with published clinical and economic outcomes from prior studies.

3.8 Reporting Standards

The study was conducted in accordance with established guidelines for economic evaluation reporting, including CHEERS 2022 (Husereau et al., 2022; Sanders et al., 2016), particularly involving the reference case analysis, incremental analysis, and uncertainty characterization.

3.9 Model Assumptions

Key assumptions included constant transition probabilities, homogeneous patient characteristics within health states, and independence of intervention effects. As the model is based on secondary data, results represent estimated outcomes rather than causal effects.

4. Results

4.1 Cost-Effectiveness Plane

ED-initiated buprenorphine (ED-BUP) was associated with lower costs and greater effectiveness compared with referral alone. The incremental cost was −\$225 per patient, with a corresponding QALY gain of + 0.012. These findings indicate that ED-BUP is a dominant strategy.

(Fig. 2 here)

4.2 Cost-Effectiveness Acceptability Curve

Probabilistic sensitivity analysis demonstrated that ED-BUP remained cost-effective across the majority of simulations. At a willingness-to-pay threshold of \$100,000 per QALY, ED-BUP was cost-effective in 97% of simulations, increasing to 99% at \$200,000 per QALY.

(Fig. 3 here)

4.3 Sensitivity Analysis Results

One-way sensitivity analysis identified 30-day treatment engagement rates in both ED-BUP and referral groups, per-patient costs, and utility values for active opioid use as the most influential parameters. Across all parameter ranges, ED-BUP remained cost-effective.

(Fig. 4 here)

4.4 Clinical Effectiveness Summary

Treatment engagement at 30 days was higher in the ED-BUP group (78%) compared with referral (37%) ($p < 0.001$). Reductions in illicit opioid use and inpatient service utilization were greater in the ED-BUP group.

(Fig. 5 here)

4.5 Comprehensive Parameter Summary

Key cost, utility, and structural parameters were applied as described in the Methods section. Full parameter details are provided in Supplementary Tables S1–S3.

(Fig. 6 here)

5. Significance and Policy Implications

From a policy perspective, these findings support scaling ED-initiated buprenorphine as a system-level intervention within national substance use treatment strategies.

5.1 Public Health and Economic Significance

The opioid crisis continues to impose a substantial clinical and economic burden in the United States. Within the broader context of pain management, opioid prescribing remains a central yet high-risk component of care, contributing to the development of opioid use disorder (OUD) in a subset of patients exposed to long-term or high-dose opioid therapy. Emergency departments represent a critical extension of the pain-treatment pathway, frequently managing patients with both inadequately controlled pain and opioid-related complications. In this setting, buprenorphine—an agent with both analgesic properties as a partial opioid agonist and established efficacy in OUD treatment—offers a unique opportunity to address both pain-related needs and opioid dependence within a single therapeutic framework. Expanding access to evidence-based treatments such as buprenorphine remains a critical priority. This analysis provides robust economic evidence supporting ED-initiated buprenorphine as a cost-effective strategy to improve treatment engagement and outcomes.

The treatment gap remains substantial and represents a major public health concern. According to Krawczyk et al. (2022), the rate of MOUD utilization among OUD patients eligible for this treatment modality was estimated at merely 13.4% over the period from 2010 through 2019. If one takes into consideration the fact that 2.5 million adults in the US are treated for OUD each year (Jones et al., 2023), even relatively minor changes in the treatment coverage attributable to initiating interventions in the ED can result in tens of thousands of individuals receiving MOUD treatment each year. This could translate into thousands of lives saved based on Sordo et al.'s (2017) mortality reduction estimates. The international dimension highlighted in Degenhardt et al. (2019)'s report shows that the problems under discussion affect other countries too.

5.2 Implementation Science and Health Systems

These findings should be considered within the context of potential implementation barriers. One such implementation strategy has been tested in the ED Health trial (D'Onofrio et al., 2023), as evaluated by Ryan et al. (2025), and shown to be feasible in resource-scarce settings by McCormack et al. (2023). In

particular, the latter is highly significant in light of the original trial by D'Onofrio et al. (2015), which was conducted in academic medical centres.

The effect on repeat emergency department visits is also a relevant economic consequence. As noted by Skains et al. (2023), ED-initiated buprenorphine was linked to a notable reduction in repeat ED visits, a fact with obvious economic consequences. Active patients with OUD often present to EDs for urgent treatment related to substance misuse, a costly phenomenon that can be modified via ED-based MOUD initiation. Indeed, the interruption of acute care utilization via MOUD initiation results in substantial cost savings for the healthcare system far beyond the cost of the initial treatment itself.

5.3 Comparative Evidence from Related Analyses

The present analysis adds value to the literature on the economic analysis of OUD treatment options. The results of Murphy et al. (2019) suggest that, under similar clinical conditions, buprenorphine-naloxone is preferable to extended-release naltrexone for initiating treatment, and the former treatment method is more cost-effective in 97% of the bootstrapped simulations for a willingness to pay of \$100,000 per quality-adjusted life year over a period of 24 weeks. According to the evidence obtained using the long-term primary care buprenorphine model developed by Schackman et al. (2012), buprenorphine-naloxone treatment provided in an outpatient setting was superior to no treatment, and its ICER was about \$35,000 per QALY. Linas et al. (2021) employed a detailed CEA model to demonstrate that only those communities characterized by enhanced capacity and retention for MOUD experienced a 40% reduction in overdose-related deaths, which was the target set by the US Department of Health and Human Services. The robustness of findings across deterministic and probabilistic sensitivity analyses strengthens confidence in the model's validity.

5.4 External Validity

This analysis uses U.S. clinical and cost data, but the mechanisms by which emergency department-initiated buprenorphine is associated with better treatment engagement, reduced opioid use, and lower mortality are likely generalizable across health systems. Nevertheless, the scale of these impacts could differ in response to disparities in healthcare systems, access to follow-up care, workforce capacity, and access to baseline treatments to opioid use disorder. ED-initiated buprenorphine may be less effective, as well as less cost-effective, in the environment with limited outpatient treatment capacity or weaker care continuity.

6. Limitations

This study has several limitations, as required by the guidelines of CHEERS 2022. First, the key clinical effect measures are obtained from a single randomized control trial carried out at an urban academic teaching hospital (D'Onofrio et al., 2015). Although it represents the strongest available evidence, generalizability of this trial to other environments and populations needs to be considered carefully. Implementation studies following this research (D'Onofrio et al., 2023; McCormack et al., 2023)

demonstrate that different outcomes can be achieved in lower-resourced settings, posing additional uncertainty that will be considered in scenario analyses.

Second, the selected sources of health utility weights (Wittenberg et al., 2016) stem from a study carried out among US general population using the time trade-off technique (Wittenberg et al., 2016). Consistent with established economic evaluation guidelines (Husereau et al., 2022; Sanders et al., 2016), this choice allows capturing the health state utility based on societal perspective rather than personal experience; however, such health utility values can underestimate the actual well-being of OUD patients in their subjective perception, since there are currently few methodological approaches in use to measure patient-reported utility weights.

Third, the economic model follows the healthcare sectoral perspective of costs and benefits recommended in CHEERS 2022 and the report of the Second Panel. In reality, the treatment of OUD provides many other indirect societal benefits, for instance, avoiding \$7.8 billion costs related to criminal justice nationwide as estimated by Florence et al. (2016) and increasing labor productivity from treatment engagement. As an alternative, a more detailed societal perspective analysis was performed as part of scenarios.

Finally, the static structure of Markov model with constant transition probabilities implies that the evolving dynamics of OUD mortality and treatment outcomes in the context of the ongoing fentanyl crisis, comorbidity of patients with mental health problems and their treatment, and socioeconomic determinants of OUD recovery are neglected. An agent-based or microsimulation modelling framework could be applied as an improvement in the future work. These simplifying assumptions, including constant transition probabilities and independence of intervention effects, may not fully capture real-world complexity. These findings support ED-based MOUD initiation as both a clinically effective and economically efficient intervention in acute care settings.

These findings should also be interpreted within the broader context of pain therapeutics, where opioid prescribing remains a central yet high-risk component of care. Interventions such as ED-initiated buprenorphine represent an opportunity to realign treatment pathways toward safer, evidence-based approaches that address both pain-related needs and opioid dependence, thereby improving patient outcomes while reducing healthcare system burden.

7. Conclusion

The opioid use disorder crisis represents a major contemporary public health challenge, resulting in the loss of countless American lives each year and inflicting untold amounts of pain on patients, their relatives, and communities. The evidence base for the ED-initiated buprenorphine therapy is solid: the intervention almost doubles the rate of engagement with treatment at 30 days (78% versus 37%) (D'Onofrio et al., 2015), considerably decreases mortality (Sordo et al., 2017), and is less expensive than any other option (Busch et al., 2017). Economic modeling demonstrates that ED-initiated buprenorphine is a dominant strategy, producing improved outcomes at lower cost compared with referral alone.

Nevertheless, most emergency departments have yet to adopt a routine approach of introducing buprenorphine therapy to their patients, with the gap in OUD treatment continuing to widen (Krawczyk et al., 2022; Jones et al., 2023). According to the recommendations made by the Stanford-Lancet Commission (Humphreys et al., 2022), there should be a move from stigmatized and inefficient treatment models towards patient-centered interventions based on evidence-based practices. The ED-initiated buprenorphine treatment, as well as the implementation strategies described in D'Onofrio et al. (2023) and Ryan et al. (2025), seem to be an example of such an intervention.

This study demonstrates that ED-initiated buprenorphine with rapid follow-up is a dominant strategy, improving outcomes while reducing costs compared with referral alone. These findings support broader implementation of ED-based buprenorphine as a policy-relevant intervention to improve treatment access and reduce opioid-related harm at the population level.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

All data used in this study are derived from publicly available sources cited within the manuscript. Additional model inputs are provided in Supplementary Tables S1–S3.

Competing interests

The authors declare that they have no competing interests.

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Figures

FIGURE 1: Markov State Transition Diagram — Opioid Use Disorder Model

Five health states with transition probabilities
(cycle = 1 month; time horizon = 5 years; discount rate = 3%)

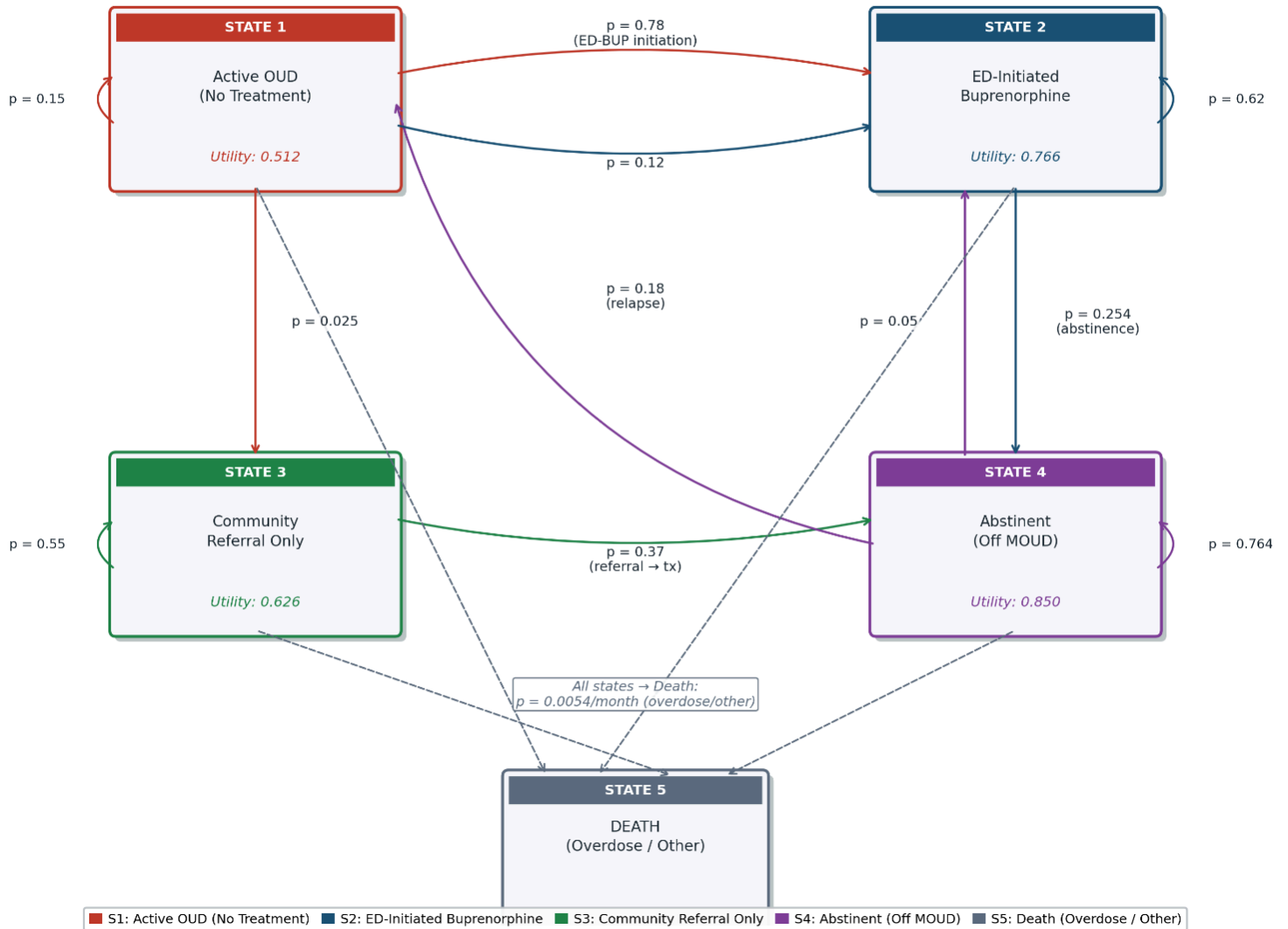


Figure 1 Note: Markov model structure adapted from Busch et al. (2017) and Claypool et al. (2023).
Utility weights from Wittenberg et al. (2016) and Fairley et al. (2021). All costs in 2023 USD.

Figure 1

Markov state transition diagram illustrating health states and transitions for opioid use disorder, including active use, treatment states, abstinence, and death.

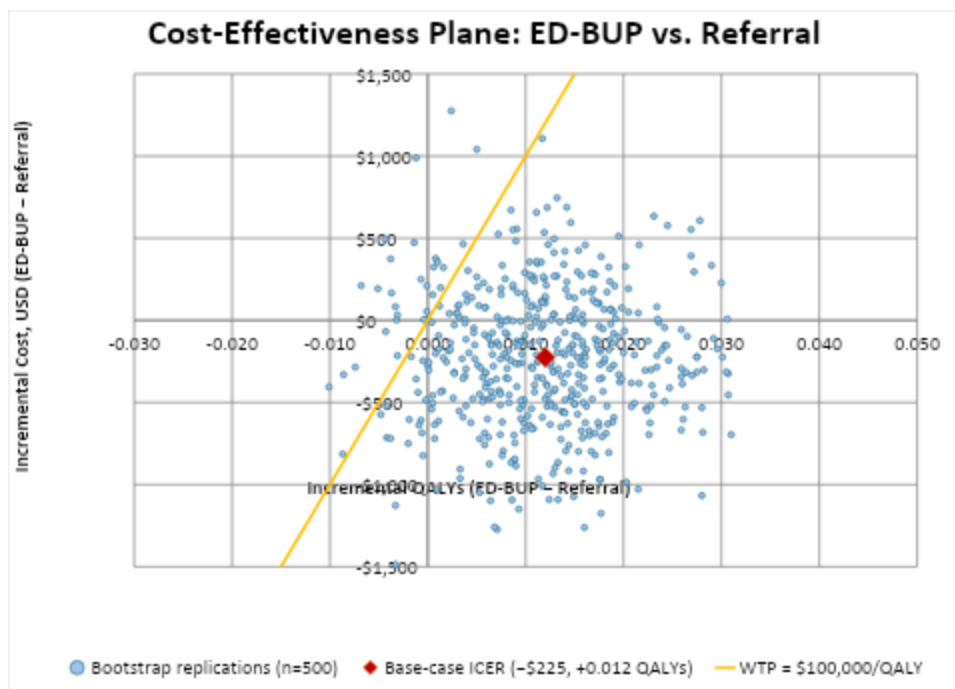


Figure 2

Cost-effectiveness plane showing incremental costs and QALYs for ED-initiated buprenorphine versus referral alone based on probabilistic sensitivity analysis.

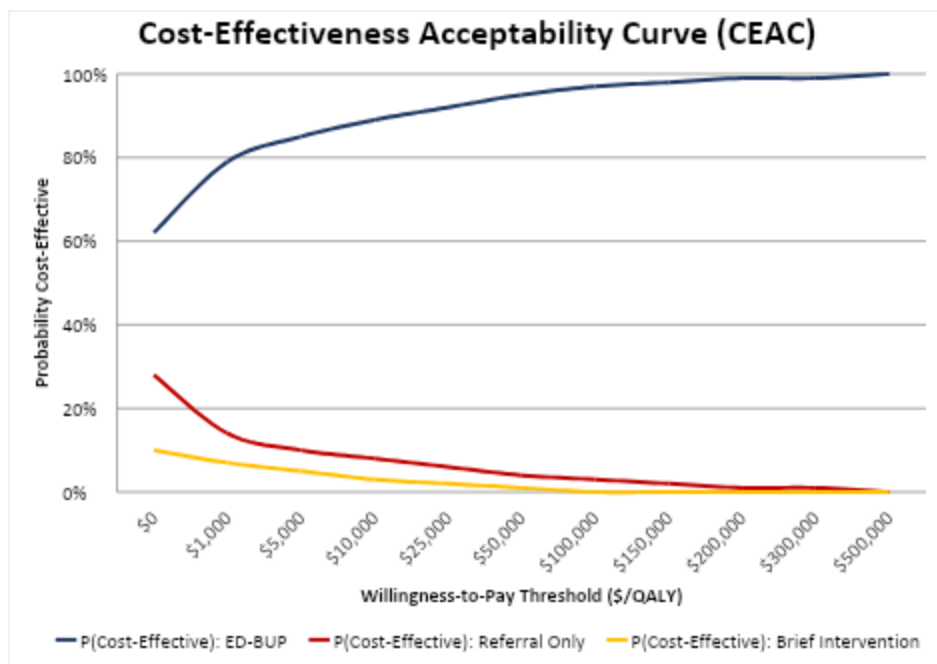


Figure 3

Cost-effectiveness acceptability curve showing the probability that ED-initiated buprenorphine is cost-effective across willingness-to-pay thresholds.

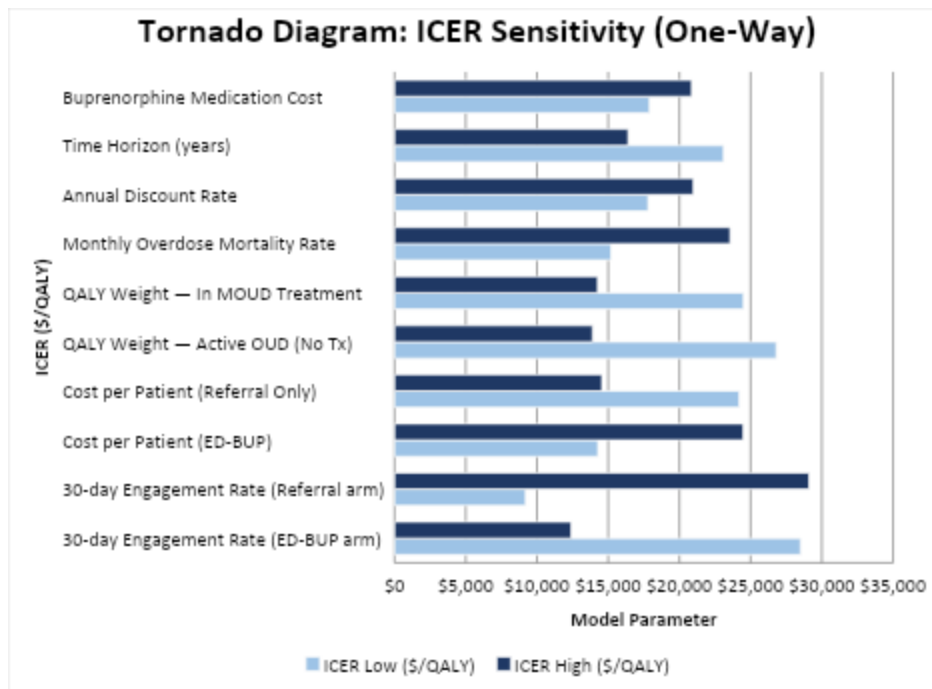


Figure 4

Tornado diagram showing the impact of key parameters on the incremental cost-effectiveness ratio.

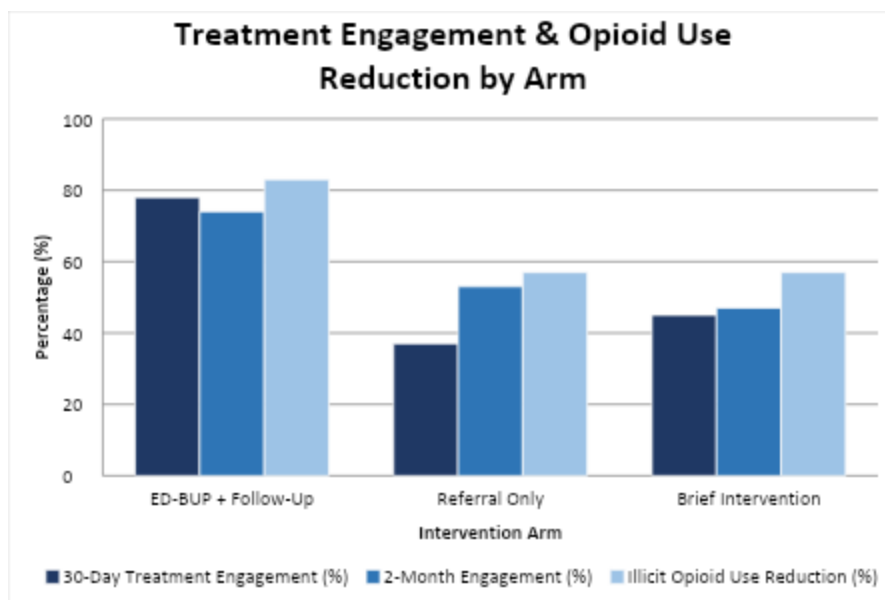


Figure 5

Treatment engagement and clinical outcomes by intervention arm based on D’Onofrio et al. (2015).

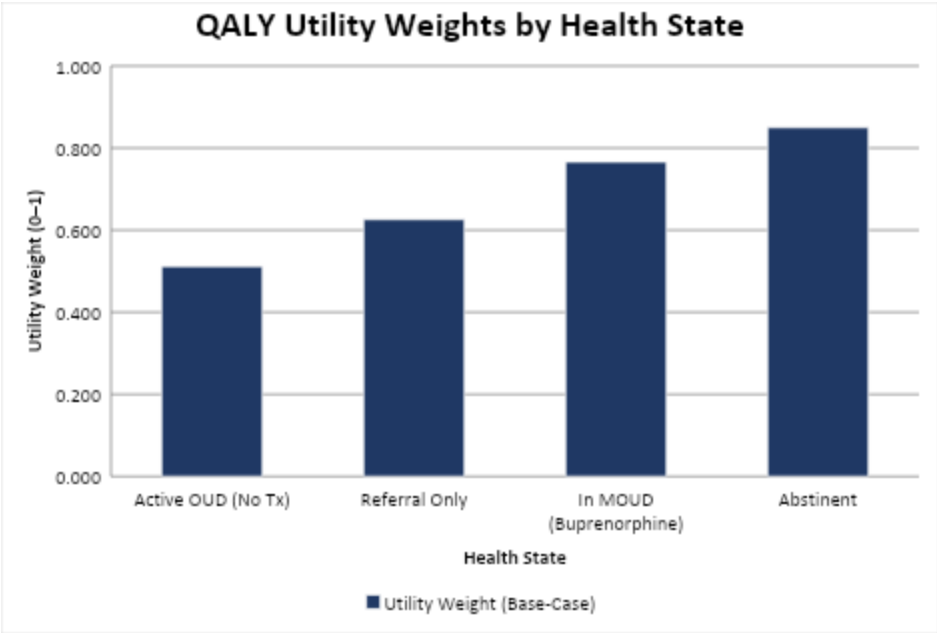


Figure 6

Summary of cost, utility, and structural parameters used in the decision-analytic model.

Supplementary Files

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