

Modeling the Impact of a Long-term Horizon and Multiple Treatment Episodes on Estimations of the Cost-effectiveness of Alcohol Treatment in the United States

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Background



Alcohol Consumption in the United States

- **About 10%** of the U.S. population age 12 and older meets the criteria for alcohol use disorder (AUD)¹
- AUD and excessive drinking
 - More than **200 diseases** and **injury-related** health conditions²
 - **90,000 deaths annually** 2015-2019³
 - **\$250 billion in costs** to society in 2010⁴
 - Excess health care utilization
 - Lost productivity
 - Criminal justice

Treatment for AUD



Treatment for AUD, including behavioral and pharmacologic interventions, is effective^{5,6,7}



Despite its effectiveness, alcohol treatment is underutilized; less than 7% of people with AUD received any treatment.⁸

Clinicians and patients perceive treatment as ineffective^{9,10}

Narrow definition of treatment success = abstinence¹¹



Most clinical studies examine the effectiveness of **a single episode of treatment over a short period of time.**

Does not capture long-term benefits of treatment, or cumulative effect of multiple treatment episodes

Study Aims

Aim 1: Assess the impact of a **long-term horizon** on estimations of cost-effectiveness of alcohol treatment

Aim 2: Assess the impact of **multiple treatment episodes** on estimations of the cost-effectiveness of alcohol treatment





Methods

Lifetime simulation model

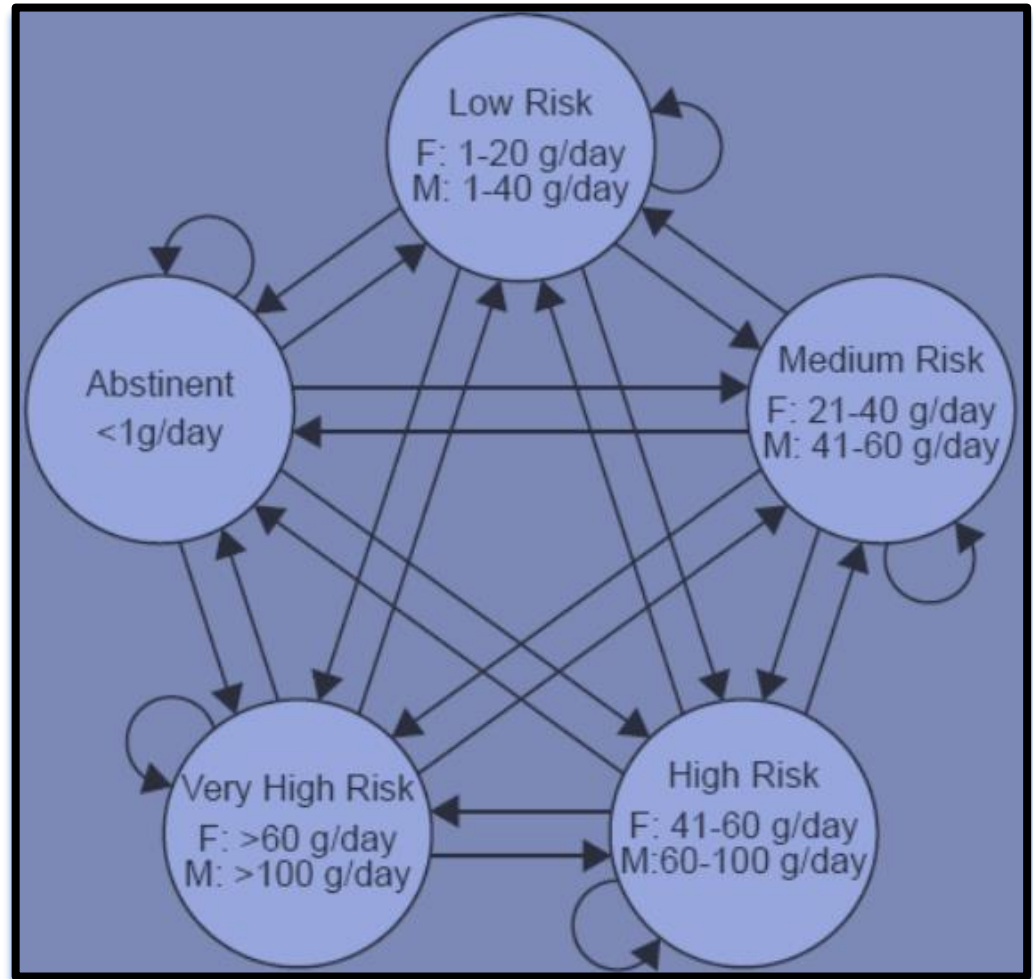
Track individuals' drinking trajectories; hospitalizations for 28 alcohol-related conditions; other hospitalizations; crimes committed; treatment, hospitalization, and crime costs; productivity; life expectancy; quality-adjusted life years (QALYs); and death for alcohol related conditions or other causes.

- **Base-case:** no additional treatment episode, uses **long-term drinking trajectories** validated for people with AUD in the United States.¹²
- **Scenarios involving treatment** use data from the COMBINE study^{13,14}—a three-year trial of behavioral and pharmacologic treatment—to inform drinking trajectories during treatment.



Drinking Trajectories

- Starting distribution: COMBINE study
- Annual probabilities of transition among five drinking states
- Transitions estimated separately for 24 groups defined by sex (male/female), age (18-35, 36-50, 51+) and race/ethnicity (American Indian or Alaska Native, Asian or Pacific Islander, non-Hispanic Black, non-Hispanic White, or Hispanic).



Cost-Effectiveness Analysis

Incremental cost-effectiveness ratio (ICER)¹⁵ to compare a strategy to its next most expensive alternative

- $ICER = \frac{C_a - C_b}{E_a - E_b}$, where C and E represent average cost and QALYs, respectively, accumulated over the analysis period for strategies *a* and *b*, and adjusted for present value
- ICERs are compared to a society's willingness to pay for an additional QALY, often \$50,000-\$100,000

Healthcare perspective: hospitalization costs and costs of treatment only

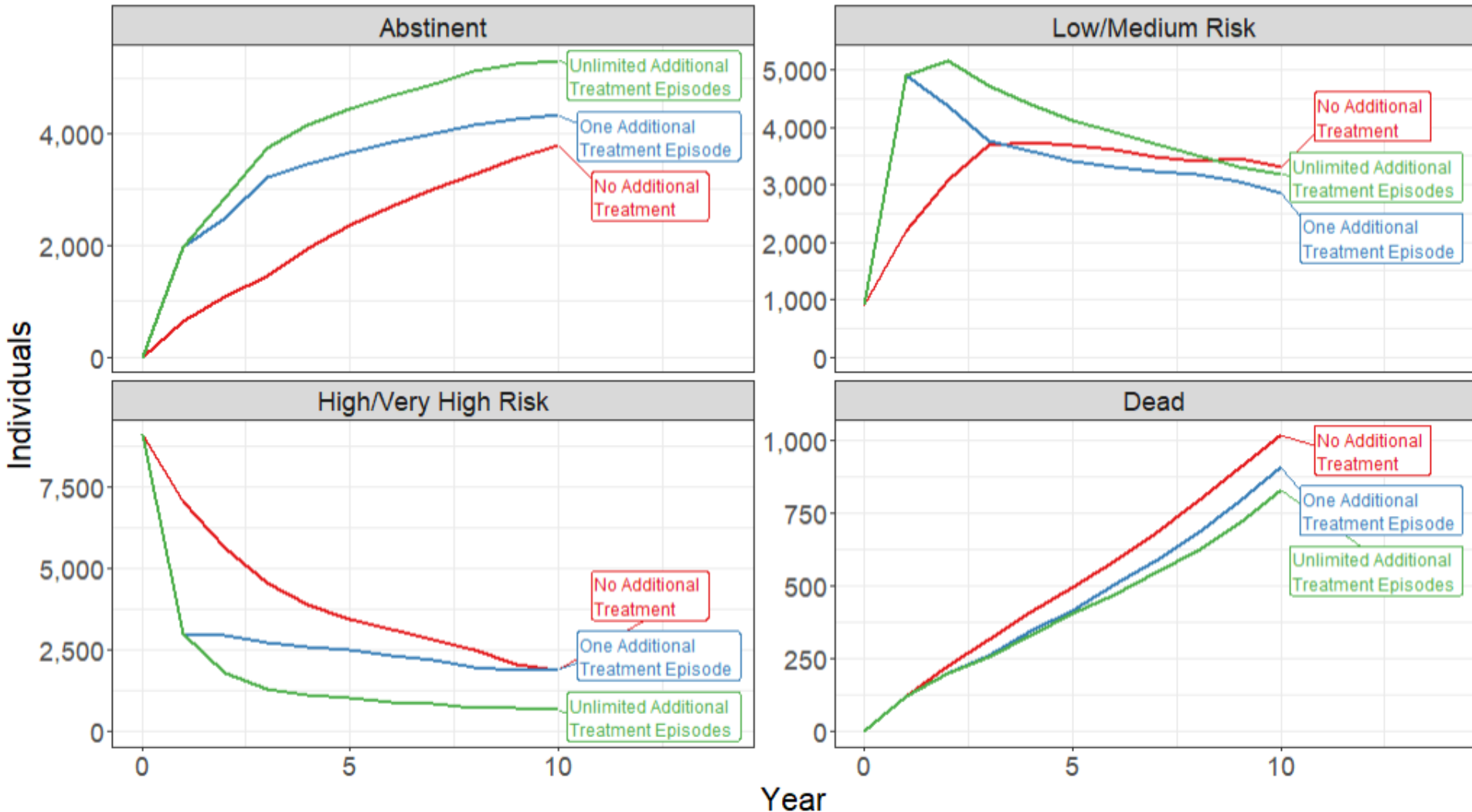
Societal perspective: includes healthcare perspective, as well as criminal justice costs, and cost-offset due to productivity

Parameter uncertainty: one-way sensitivity analysis and probabilistic sensitivity analysis



Results

Drinking Trajectories Over 10 Years for Select Scenarios



Aim 1

Assess the impact of a **long-term horizon** on the estimates of the cost-effectiveness of alcohol treatment

Comparing:

No additional treatment episodes

One additional treatment episode (at beginning of simulation)

Three time horizons:

1 year after treatment

5 years after treatment

Lifetime



Aim 1: Impact of Time Horizon

Measure	One-Year Time Frame			Lifetime Time Frame		
	No Additional Treatment	One Additional Treatment Episode	% Diff	No Additional Treatment	One Additional Treatment Episode	% Diff
Treatment Cost	\$0	\$1,293	n/a	\$0	\$1,293	n/a
Count of Alcohol Attributable Hospitalizations	0.07	0.05	-28%	2.43	2.37	-2%
Count of Non-Attributable Hospitalizations	0.04	0.04	0%	2.99	3.04	2%
Count of Total Hospitalizations	0.11	0.09	-18%	5.42	5.41	0%
Hospitalization Cost	\$1,401	\$1,019	-27%	\$32,198	\$30,920	-4%
Productivity	\$40,140	\$44,575	11%	\$593,624	\$608,327	2%
Crimes Committed	0.11	0.06	-45%	1.01	0.87	-14%
Crime Cost	\$2,683	\$1,518	-43%	\$17,986	\$14,953	-17%
Life Years	0.98	0.98	0%	29.86	30.21	1%
QALYs	0.70	0.72	3%	13.18	13.36	1%

Notes: QALYs—Quality-adjusted life years. Mean values shown in columns 2-3 and 5-6. % Diff columns represent the difference between the one additional treatment scenario and the no additional treatment scenario. Dollar values in 2020 dollars; costs and QALYs discounted at 3% annually.

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Aim 1: ICERs, Health Care Perspective

Scenario	QALYs	Incremental QALYs	Cost	Incremental Cost	ICER
One-Year Time Frame					
No Treatment	0.699	—	\$1,401	—	—
1 Treatment Episode	0.715	0.016	\$2,311	\$910	\$55,590
Five-Year Time Frame					
No Treatment	3.245	—	\$5,926	—	—
1 Treatment Episode	3.295	0.050	\$6,063	\$137	\$2,746
Lifetime Time Frame					
No Treatment	13.177	—	\$32,198	—	—
1 Treatment Episode	13.357	0.180	\$32,212	\$14	\$78

Notes: Treatment episode is one additional treatment episode; no treatment is no additional treatment episode. QALYs—Quality-adjusted life years. Dollar values in 2020 US dollars, costs and QALYs discounted at 3% annually.

Aim 1: ICERs, Societal Perspective

Scenario	QALYs	Incremental QALYs	Cost	Incremental Cost	ICER
One-Year Time Frame					
1 Treatment Episode	0.715	—	-\$40,746	—	—
No Treatment	0.699	-0.016	-\$36,055	\$4,691	Dominated
Five-Year Time Frame					
1 Treatment Episode	3.295	—	-\$191,414	—	—
No Treatment	3.245	-0.050	-\$177,628	\$13,786	Dominated
Lifetime Time Frame					
1 Treatment Episode	13.357	—	-\$561,162	—	—
No Treatment	13.177	-0.180	-\$543,440	\$17,722	Dominated

Notes: Treatment episode is one additional treatment episode; no treatment is no additional treatment episode. QALYs—Quality-adjusted life years. Dollar values in 2020 US dollars, costs and QALYs discounted at 3% annually. Strategies that are dominated are excluded from the ICERs. Strategies are strictly dominated when they have a higher cost and lower effectiveness than another strategy.

Aim 2

Assess the impact of **multiple treatment episodes** on estimates of the cost-effectiveness of alcohol treatment

Time horizon: Lifetime

Comparing five scenarios:

No additional treatment episodes

One additional treatment episode

Up to two additional treatment episodes

Up to four additional treatment episodes

Unlimited additional treatment episodes



Aim 2: Impact of Multiple Treatment Episodes

Measure	No Additional Treatment	One Additional Treatment Episode		Up to Four Additional Treatment Episodes		Unlimited Additional Treatment Episodes	
	Mean	Mean	% Diff	Mean	% Diff	Mean	% Diff
Treatment Cost	\$0	\$1,293	n/a	\$2,970	n/a	\$3,385	n/a
Total Treatment Episodes	0.00	1.00	n/a	2.66	n/a	3.25	n/a
Count of Alcohol Attributable Hospitalizations	2.43	2.37	-2%	2.28	-6%	2.26	-7%
Count of Non-Attributable Hospitalizations	2.99	3.04	2%	3.11	4%	3.14	5%
Count of Total Hospitalizations	5.42	5.41	0%	5.38	-1%	5.40	0%
Hospitalization Cost	\$32,198	\$30,920	-4%	\$29,230	-9%	\$29,037	-10%
Productivity	\$593,624	\$608,327	2%	\$622,242	5%	\$623,994	5%
Crimes Committed	1.01	0.87	-14%	0.69	-32%	0.65	-36%
Crime Cost	\$17,986	\$14,953	-17%	\$11,628	-35%	\$11,183	-38%
Life Years	29.86	30.21	1%	30.67	3%	30.81	3%
QALYs	13.18	13.36	1%	13.56	3%	13.61	3%

Notes: QALYs—Quality-adjusted life years. % Diff column represents the difference between the treatment scenario represented in that column and the no additional treatment scenario. Dollar values in 2020 dollars, costs and QALYs discounted at 3% annually.

Aim 2: Impact of Multiple Treatment Episodes

Measure	No Additional Treatment	One Additional Treatment Episode		Up to Four Additional Treatment Episodes		Unlimited Additional Treatment Episodes	
	Mean	Mean	% Diff	Mean	% Diff	Mean	% Diff
Treatment Cost	\$0	\$1,293	n/a	\$2,970	n/a	\$3,385	n/a
Total Treatment Episodes	0.00	1.00	n/a	2.66	n/a	3.25	n/a
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Total Treatment Episodes	0.00	1.00	n/a	2.66	n/a	3.25	n/a
Count of Alcohol Attributable Hospitalizations	2.43	2.37	-2%	2.28	-6%	2.26	-7%
Count of Non-Attributable Hospitalizations	2.99	3.04	2%	3.11	4%	3.14	5%
Count of Total Hospitalizations	5.42	5.41	0%	5.38	-1%	5.40	0%
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Life Years	29.86	30.21	1%	30.67	3%	30.81	3%
QALYs	13.18	13.36	1%	13.56	3%	13.61	3%

Notes: QALYs—Quality-adjusted life years. % Diff column represents the difference between the treatment scenario represented in that column and the no additional treatment scenario. Dollar values in 2020 dollars, costs and QALYs discounted at 3% annually.

Aim 2: ICERs, Health Care Perspective

Scenario	QALYs	Incremental QALYs	Cost	Incremental Cost	ICER
Up to 2 Additional Treatment Episodes	13.455	—	\$32,145	—	—
No Additional Treatment	13.177	-0.277	\$32,198	\$52	Dominated
Up to 4 Additional Treatment Episodes	13.565	0.110	\$32,200	\$55	\$499
1 Additional Treatment Episode	13.357	-0.208	\$32,212	\$12	Dominated
Unlimited Additional Treatment Episodes	13.609	0.044	\$32,422	\$222	\$5,049

Notes: Treatment episode is in addition to base case of past treatment experience. QALYs—Quality-adjusted life years. Dollar values in 2020 US dollars, costs and QALYs discounted at 3% annually. Strategies that are dominated are excluded from the ICERs. Strategies are strictly dominated when they have a higher cost and lower effectiveness than another strategy.

Aim 2: ICERs, Societal Perspective

Scenario	QALYs	Incremental QALYs	Cost	Incremental Cost	ICER
Unlimited Additional Treatment Episodes	13.609	—	-\$580,389	—	—
Up to 4 Additional Treatment Episodes	13.565	-0.044	-\$578,414	\$1,974	Dominated
Up to 2 Additional Treatment Episodes	13.455	-0.110	-\$570,625	\$7,789	Dominated
1 Additional Treatment Episode	13.357	-0.098	-\$561,162	\$9,463	Dominated
No Additional Treatment	13.177	-0.180	-\$543,440	\$17,722	Dominated

Notes: Treatment episode is in addition to base case of past treatment experience. QALYs—Quality-adjusted life years. Dollar values in 2020 US dollars, costs and QALYs discounted at 3% annually. Strategies that are dominated are excluded from the ICERs. Strategies are strictly dominated when they have a higher cost and lower effectiveness than another strategy.



Discussion

Main Takeaways (I)

- Longer time horizon captures long-term impacts of alcohol treatment; even with just one treatment episode, QALYs increase, costs decrease, and treatment is more cost-effective (lower ICERs).
 - **Health Care Perspective:** ICER reduces from about \$55,000 to about \$80 from one-year to lifetime horizon.
 - **Societal Perspective:** treatment dominates for all time frames.
- Value of alcohol treatment is even higher when accounting for broader impacts of alcohol consumption on crime and productivity.
- However, impact of alcohol treatment decreases with time for only one episode.

Main Takeaways (II)

- As many treatment episodes as necessary is highly cost-effective (ICER < \$5,000/ QALY for health care perspective).
- Multiple treatment episodes can lead to long lasting improvements in drinking patterns; this is in line with the chronic recurrent course of AUD.
- Under unlimited treatment access, on average, individuals need between 3 and 4 treatment episodes over the lifetime to sustain abstinent, low or medium risk drinking levels.
- **Limitations:**
 - Assuming those who need treatment are high- or very high-risk drinkers and that all receive treatment.
 - Treatment impact assumed to be the same for multiple episodes.
 - Not accounting for fixed costs and treatment capacity constraints.

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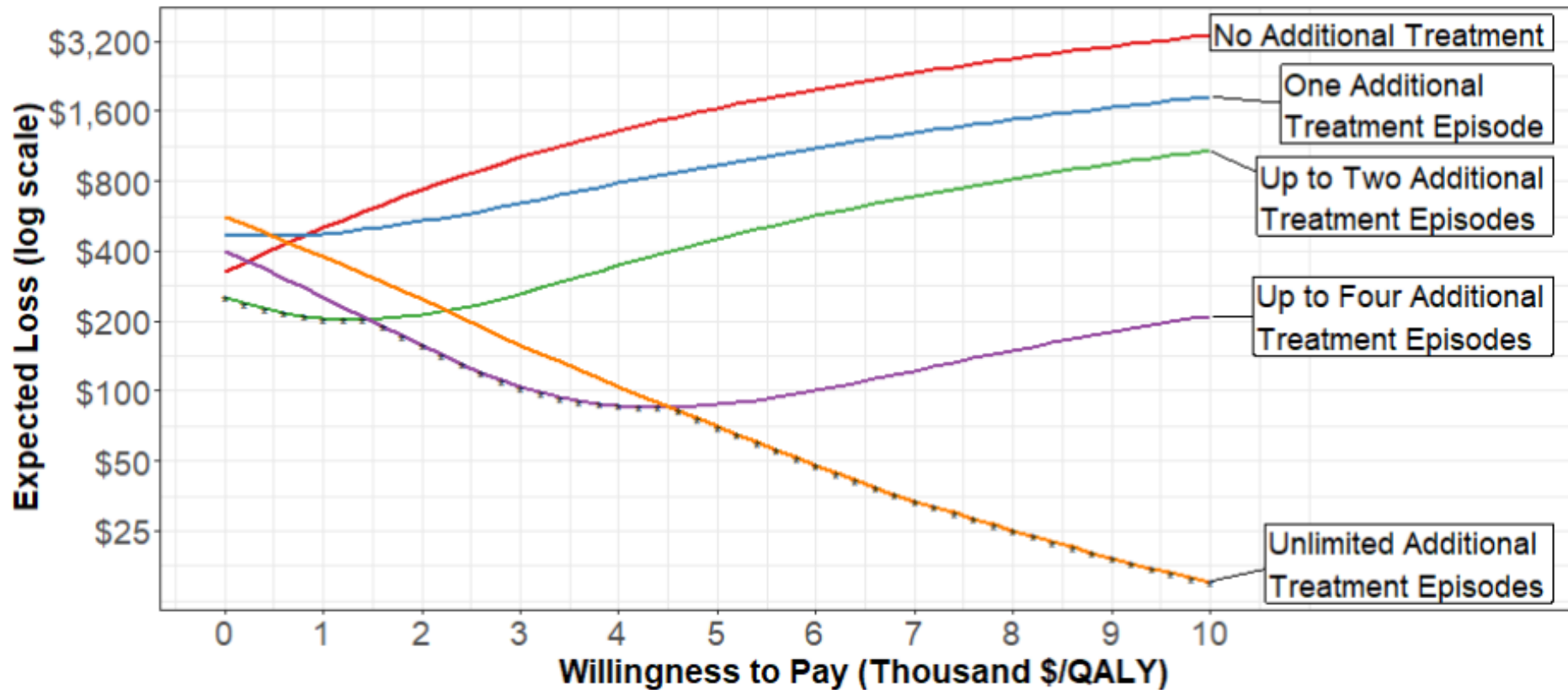
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POCKET SLIDES

Evaluating Results under Parameter Uncertainty



Productivity

- Two regression models were used to estimate:
 - (a) average hourly earnings by groups defined by demographic characteristics and educational attainment, and
 - (b) average hours worked by demographic group and drinking level.
- Earnings were adjusted to account for benefit costs so that the measure of productivity represented total compensation. Adjusted earnings were then assigned to the different drinking levels using educational attainment as a proxy.
- 2018 Current Population Survey March Supplement: hourly earnings and sociodemographic characteristics
- 2019 National Survey on Drug Use and Health: hours worked in the past week and drinking behavior on a nationally representative sample
- Bureau of Labor Statistics report on Employer Costs for Employee Compensation: employee benefit costs
- NESARC III: distribution of educational attainment by drinking risk state

Crime

- Crime included violent (rape, robbery, assault, murder, and child abuse) and property (larceny, burglary, and motor vehicle theft) crimes.
- The probability of committing a crime by age, sex, and drinking level was estimated by applying the age and sex distribution of the probability of “having serious trouble with the police or the law” in the past 12 months from NESARC-III to the annual probability of committing a crime by people with AUD and those with previous AUD (not current) who were drinking at a low-risk level from Neumann et al. (2016).
- The age and sex-specific probabilities of committing a crime for people with AUD and those with low-risk drinking were assigned by applying the low risk drinking estimate to the abstinent, low, and medium risk levels and the AUD estimate to the high and very high-risk drinking levels.
- Instances of crime were multiplied by a unit cost of \$15,354 (1999 dollars) derived from the literature (Miller et al., 2006).

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Utilities

- Utilities are a building block of QALYs, and QALYs are a measure of health benefit recommended to be used in cost-effectiveness analyses (CEAs).
- QALYs are years of life adjusted by the quality of those years, with quality measured by health state utilities anchored at 0 for dead and 1 for perfect health.
- Health utility scores by age, sex, and drinking risk level for people with lifetime AUD were taken from recently published estimates (Barbosa et al., 2019).
- To avoid reliance on small cell sizes, utilities for ages 70 to 79 were used for all individuals aged 70 or older.
- A crosswalk between the 28 alcohol-attributable conditions included in the model and health conditions in NESARC-III was developed, and average health utility scores were computed for people with a given condition by age and sex as in Barbosa et al. (2022).

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Morbidity risks and costs

Risk of hospitalization and hospitalization costs were estimated for 28 alcohol-attributable conditions and for all other conditions using:

- 2014 Healthcare Cost and Utilization Project National Inpatient Sample and National Readmissions Database
- 2014 Medical Expenditure Panel Survey
- Relative risks from the peer-reviewed literature

Based on the nature of the alcohol-related condition, each condition was assumed to be acute (i.e., lasting 1 year or less), long-term (lasting an average of 5 years), or chronic (lasting for the remainder of one's lifetime) in the model.

Simulation Process

10,000 individuals

At each time step, each individual may:

- **Hospitalized** for one or more alcohol-related conditions, or for any other cause
- **Recover** from alcohol-related conditions
- **Costs** due to hospitalizations and crime committed; **productivity**; and quality-adjusted life years (**QALYs**)
- **Die** of alcohol-related causes or any other cause
- If still alive, **transition** between drinking states

