Modeling Overdose and Naloxone: (Cost)-Effectiveness

Phillip Coffin, MD MIA
San Francisco Department of Public Health
University of California San Francisco

phillip.coffin@ucsf.edu

Background

- Lay naloxone distribution is associated with reduced opioid overdose mortality *(Walley et al., BMJ 2013)*
- No models of heroin user's life except for time period around buprenorphine treatment; no models of overdose at all
- And …
  - The #1 risk factor for overdose is a prior overdose
  - And heroin users are expensive

Methods

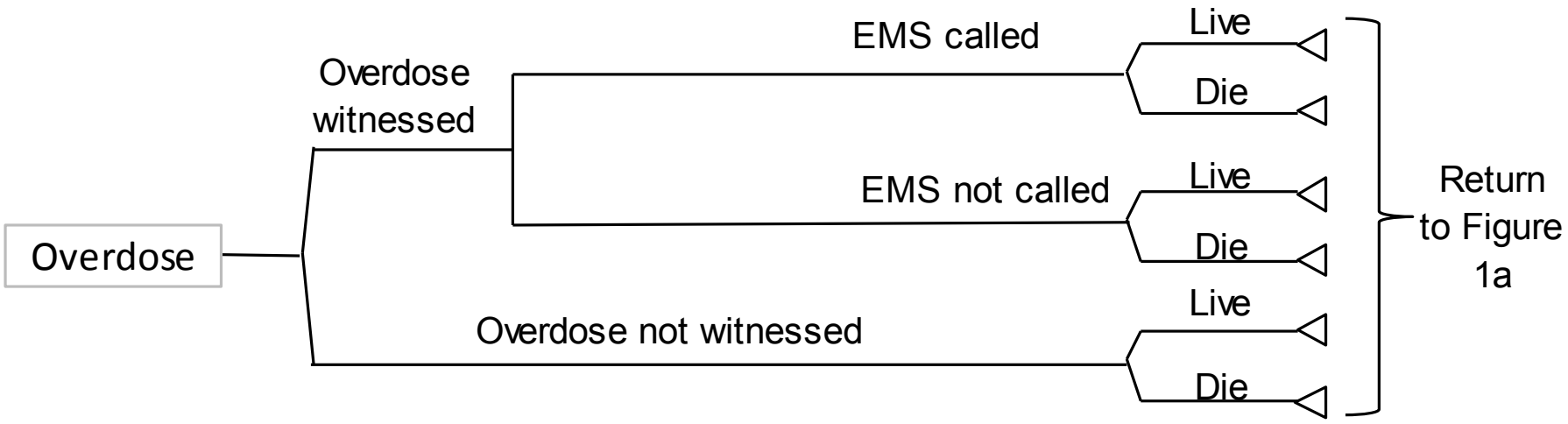
- Markov model + embedded decision analytic tree, Microsoft Excel 2010
- Annual transitions beginning at median age of initiating heroin use in U.S.
- Standard background mortality, 3% annual discounting
- Societal perspective, incremental cost per quality-adjusted life year, deterministic and probabilistic
- Iterative process, calibrated to epidemiologic data

Coffin & Sullivan, Ann Int Med 2013

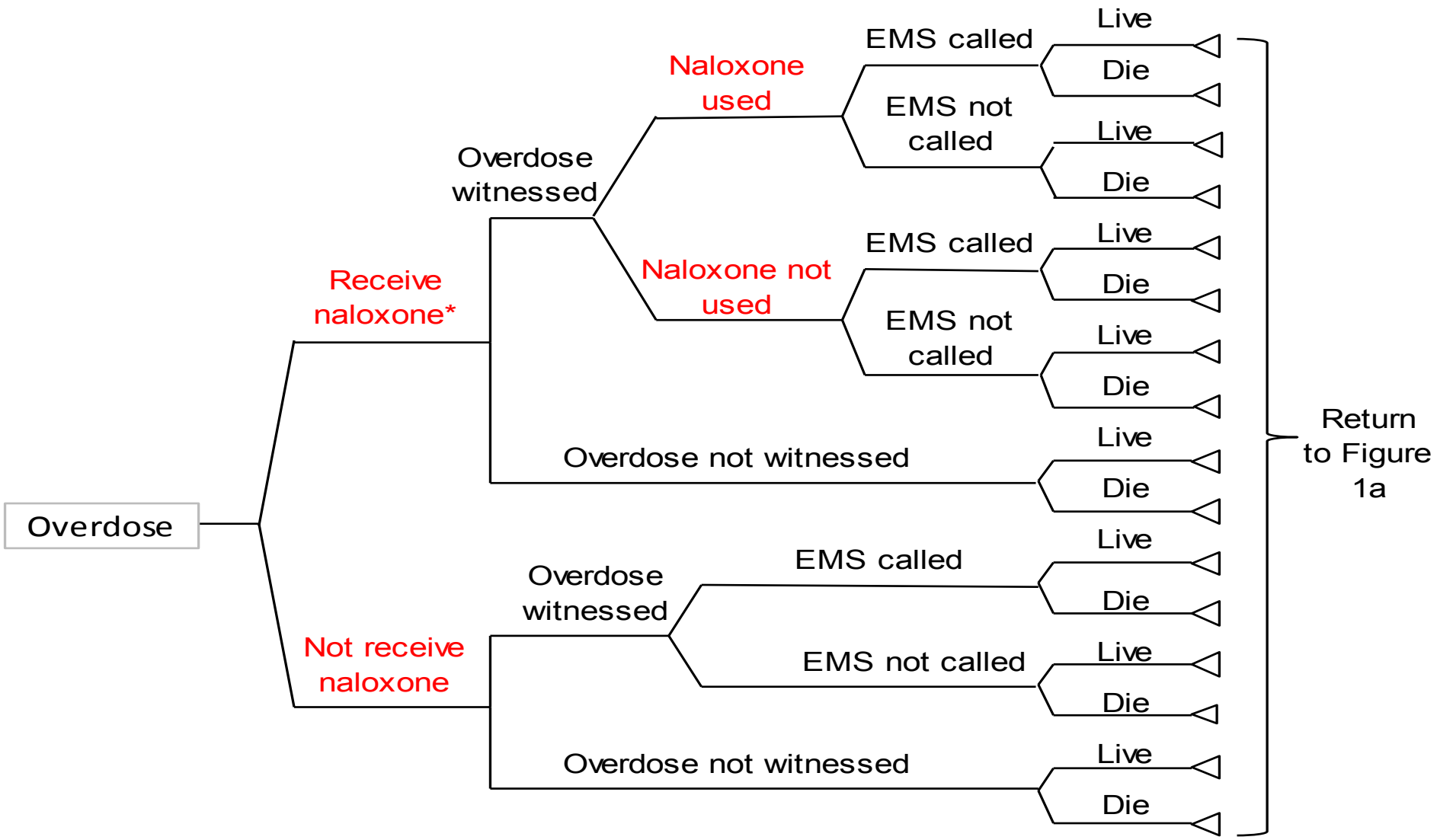
A Textbook Heroin Overdose

- How often are overdoses witnessed?
- How often are emergency services called?
- What is the mortality from heroin overdose, with and without medical help?
- How widespread is naloxone distribution?
- How likely is a recipient to have their naloxone at an overdose?
- How likely is a person with naloxone at an overdose to use it?
- What is the likelihood of death if naloxone is administered by a lay person?

Overdose Decision Tree: No Naloxone



Overdose Decision Tree With Naloxone

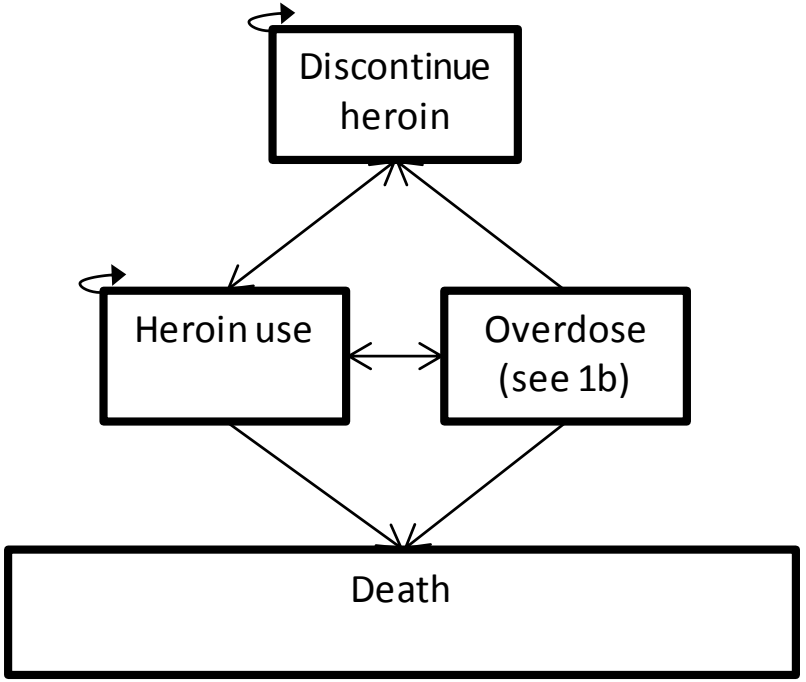


The Life of a Heroin User

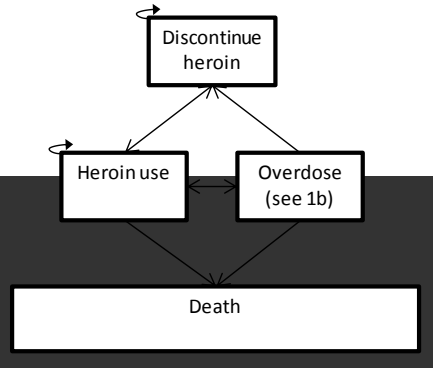
- At what age does a person start using heroin?
- How often do they stop using?
- How often do they relapse to use?
- For how long do most heroin users continue using?
- How often do they die for non-overdose reasons?
- How often do they overdose?
- What affects the frequency of heroin overdose?

Markov Model:

Iterative Development

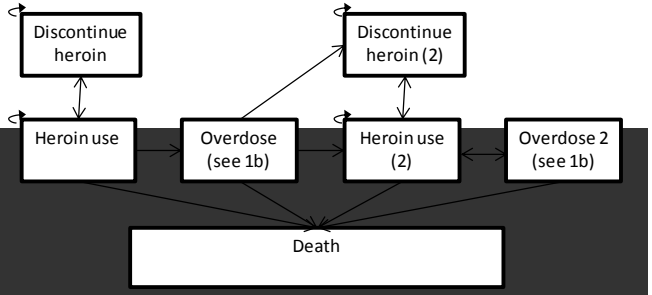


Model Calibration



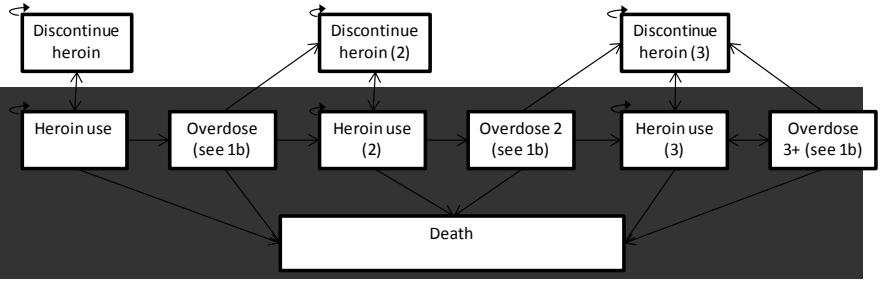
Parameter	Literature Estimate	1-Stage Model
Annual OD / 100 active users	10-25	15*
Proportion ever having overdose	33-70	78
Proportion OD resulting in death	3-19	1.1
% survive without assistance	90	90*
% survive with EMS or naloxone	96-100	98*
Annual OD mortality / 100 active users	1.0	0.2
Annual all-cause mortality / 100 active users	1.5-2.5	3.8
Among those aged <30 years	0.91	0.9
Median age OD death	31-40	29
% distributed naloxone used to reverse OD	9-40	4
Median duration of heroin use	10-15y	7y

Model Calibration



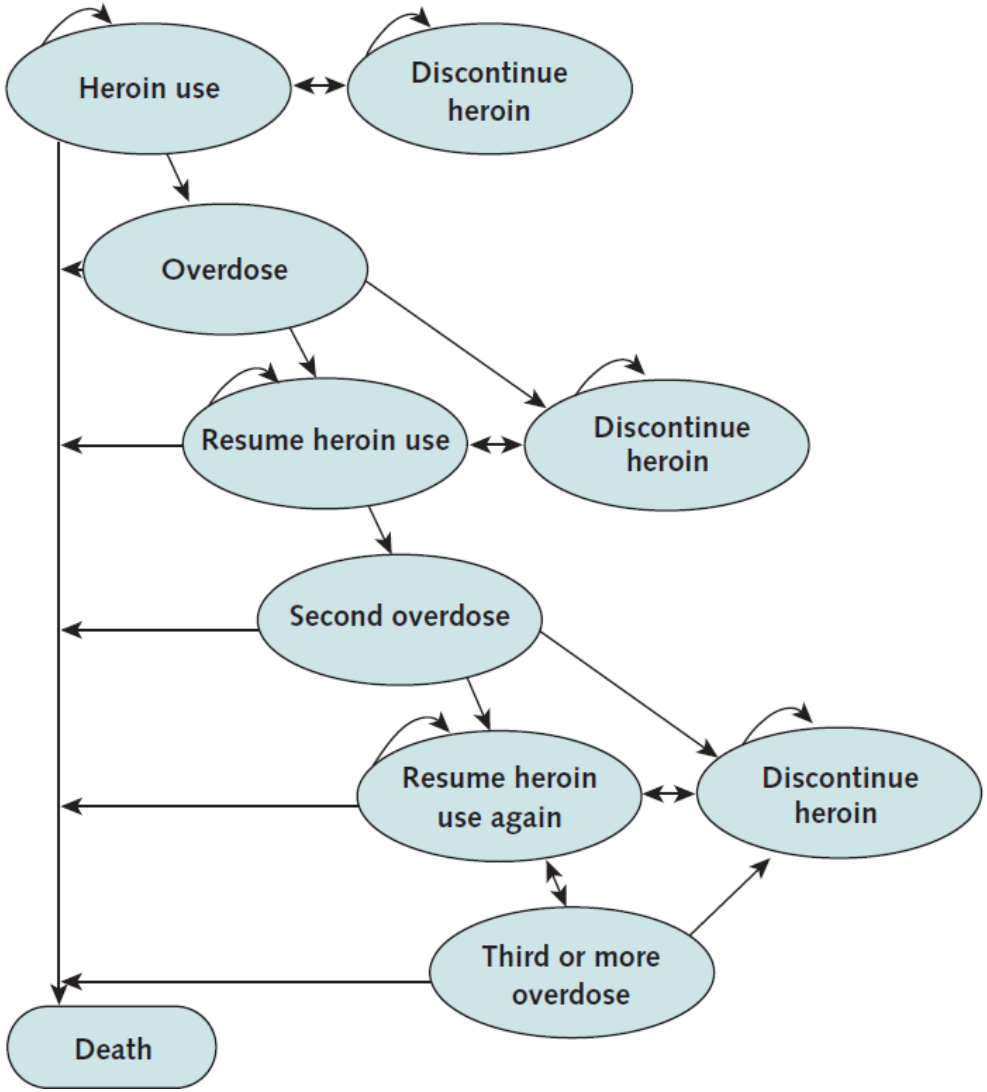
Parameter	Literature Estimate	2-Stage Model
Annual OD / 100 active users	10-25	19
Proportion ever having overdose	33-70	78
Proportion OD resulting in death	3-19	1.5
% survive without assistance	90	90*
$ survive with EMS or naloxone	96-100	98*
Annual OD mortality / 100 active users	1.0	0.4
Annual all-cause mortality / 100 active users	1.5-2.5	4.0
Among those aged <30 years	0.91	1.4
Median age OD death	31-40	32
% distributed naloxone used to reverse OD	9-40	13.6
Median duration of heroin use	10-15y	12y

Model Calibration



Parameter	Literature Estimate	3-Stage Model
Annual OD / 100 active users	10-25	21
Proportion ever having overdose	33-70	52
Proportion OD resulting in death	3-19	6
% survive without assistance	90	90*
$ survive with EMS or naloxone	96-100	98*
Annual OD mortality / 100 active users	1.0	1.3
Annual all-cause mortality / 100 active users	1.5-2.5	3.6
Among those aged <30 years	0.91	1.4
Median age OD death	31-40	38
% distributed naloxone used to reverse OD	9-40	13.6
Median duration of heroin use	10-15y	11y

Markov Model



Model Calibration - Final

Parameter	Literature Estimate	Final Model
Annual OD / 100 active users	10-25	12
Proportion ever having overdose	33-70	50
Proportion OD resulting in death	3-19	4
% survive without assistance	90	90.0
$ survive with EMS or naloxone	96-100	97.8
Annual OD mortality / 100 active users	1.0	1.0
Annual all-cause mortality / 100 active users	1.5-2.5	1.97
Among those aged <30 years	0.91	0.98
Median age OD death	31-40	38
% distributed naloxone used to reverse OD	9-40	13.6
Median duration of heroin use	10-15y	15y

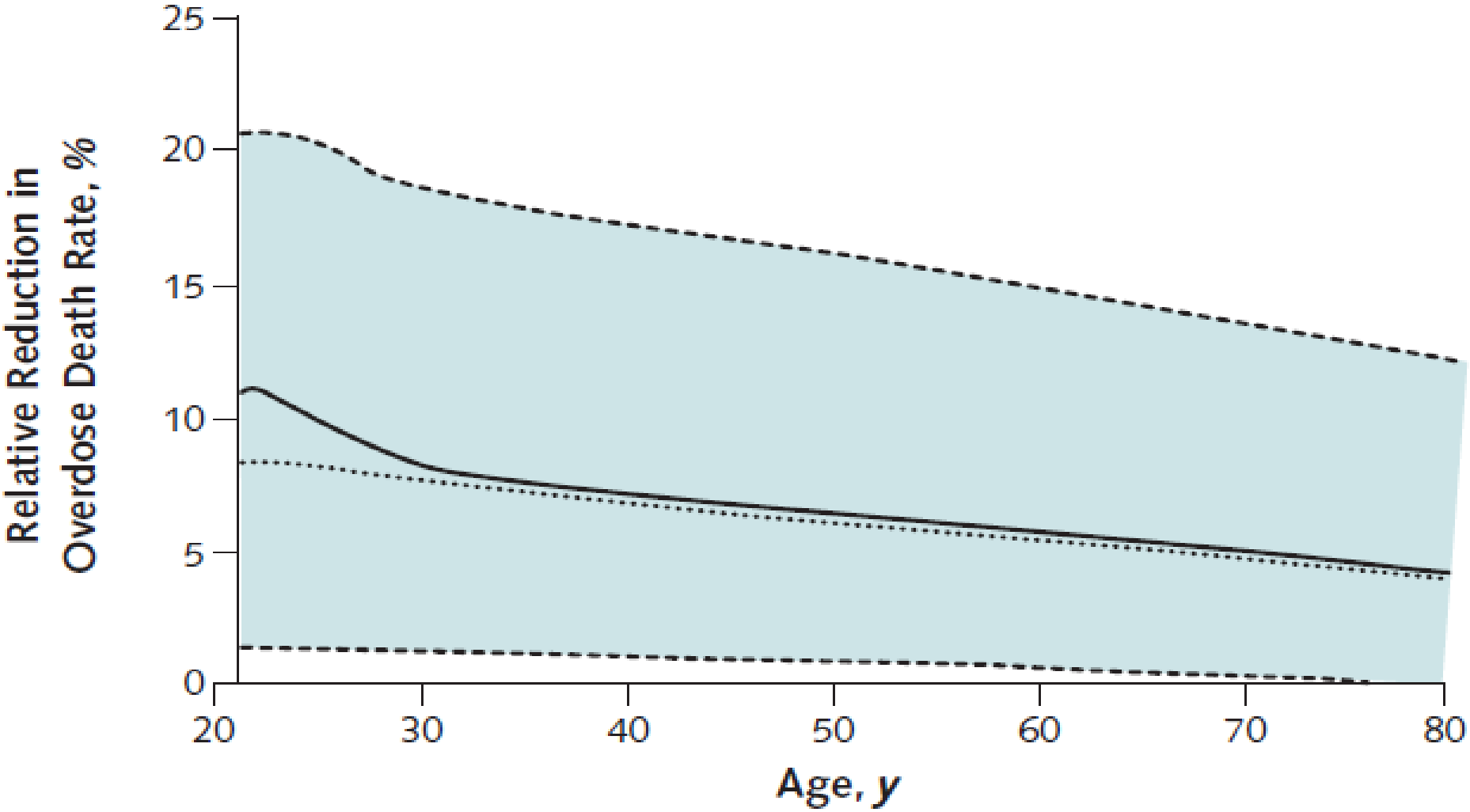
Model Calibration – Post Publication

Parameter	Subsequent Data from UK	Final Model
Fatality at witnessed overdose	6.0	6.5

Individual Outcomes, Baseline Deterministic Model

	No Naloxone	Naloxone
Life-years	44.625	44.955
Among those who discontinue heroin use	27.782	27.974
Discounted QALYs	19.121	19.229
Discounted costs, USD	$2140	$2217
Incremental cost / QALY gained, USD	-	$421
Kits needed to prevent 1 death	-	164

Impact of naloxone availability on OD deaths among active heroin users

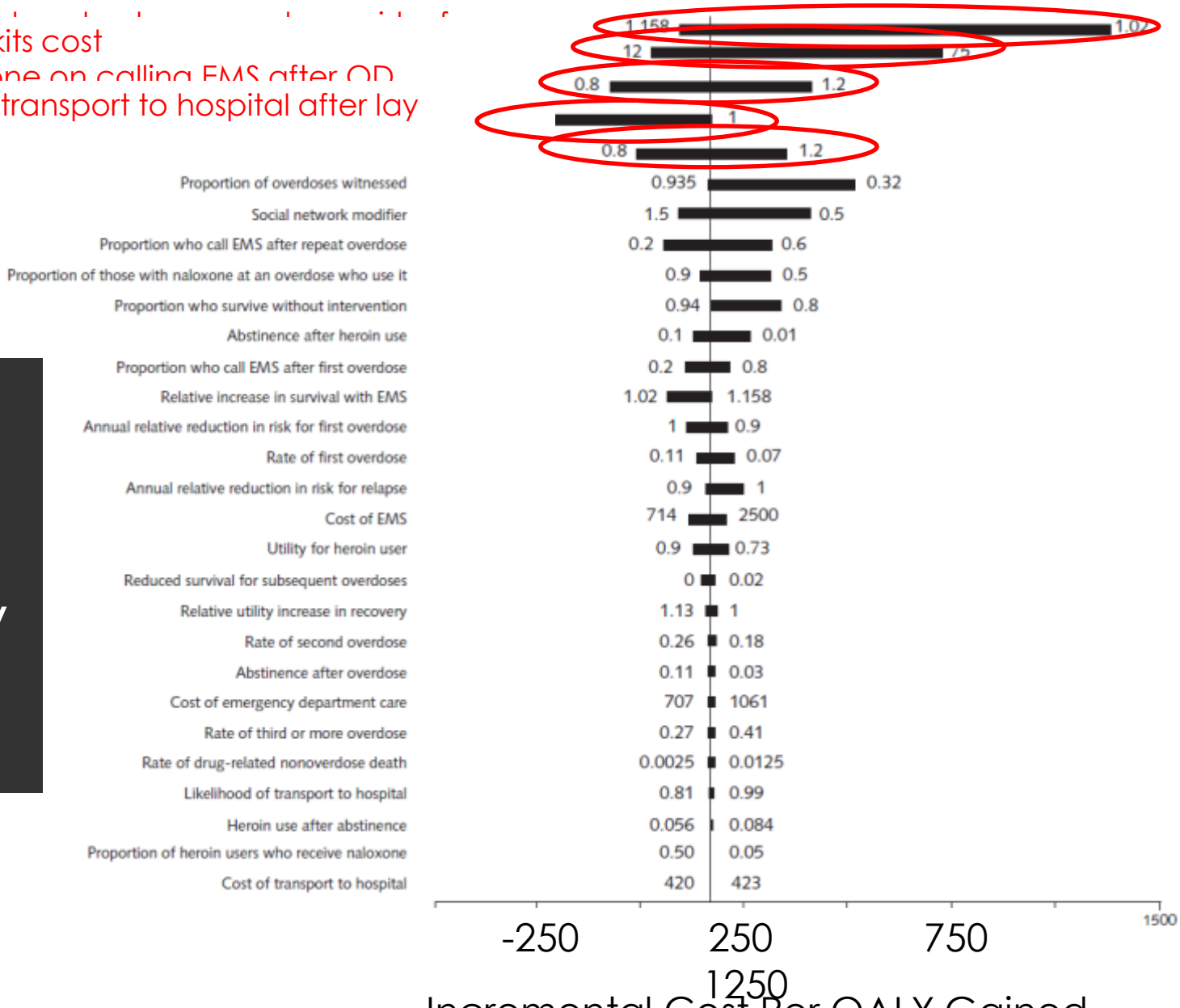


How much naloxone kits cost

Effect of giving naloxone on calling EMS after OD

Likelihood of needing transport to hospital after lay naloxone

One-Way Sensitivity Analyses



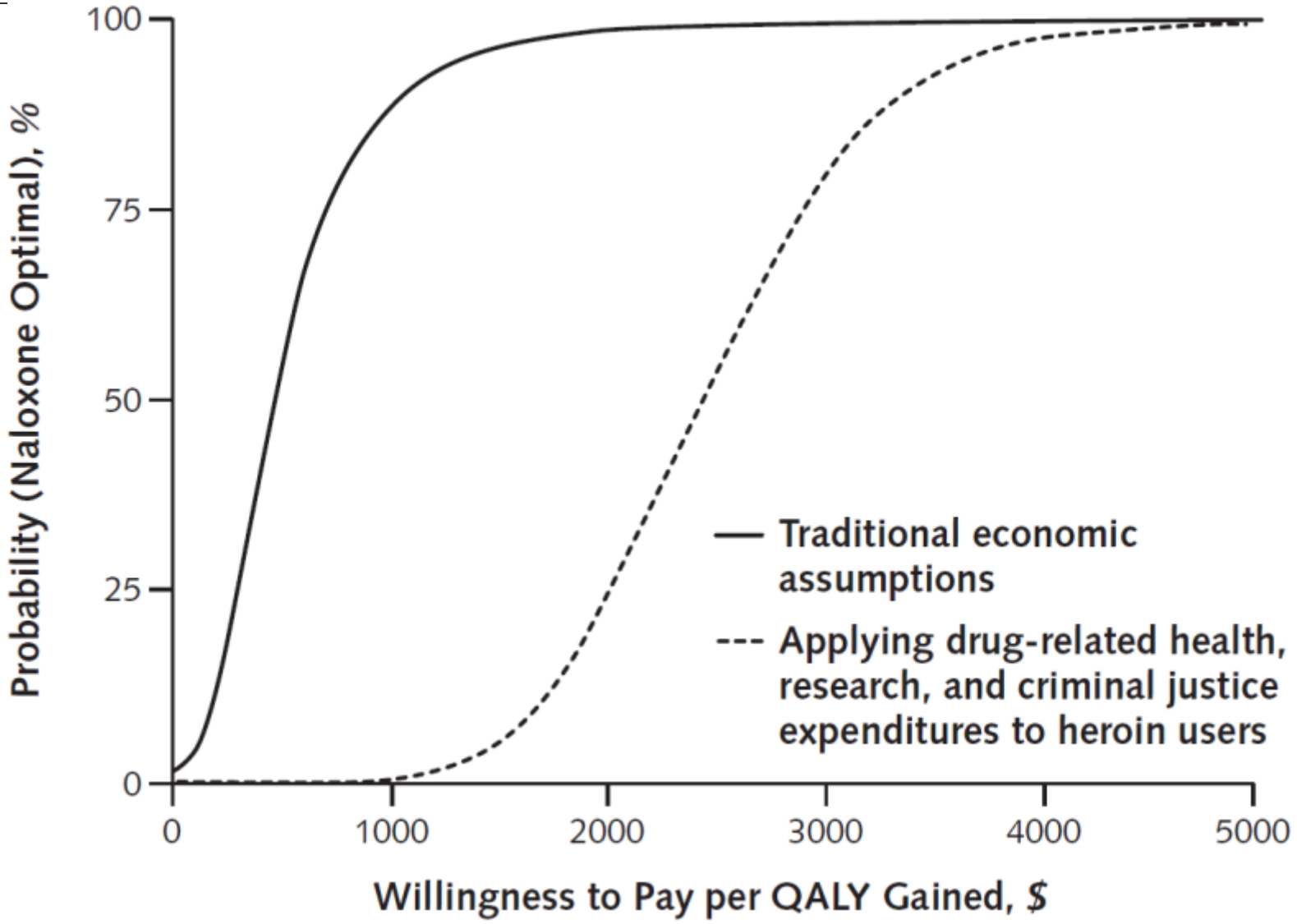
Scenario Analyses

	% OD Death averted		NNT	ICER $
	5y	Lifetime		
Base case (d)	10.6	6.5	164	421
Base case (p)	8.5	6.1	227	438
Deterministic sensitivity analyses				
OD rarely witnessed; naloxone expensive, rarely used, barely helps	0.4	0.3	2781	14,000
Upper limit probability naloxone used	65.5	42.1	95	321
Naloxone receipt lowers OD risk	32.0	31.2	36	Dominant

Population Outcomes / 200,000 Heroin users

Deterministic Scenario	No Naloxone	Naloxone
Base case		
Lifetime OD	918,509	930,759
Lifetime OD Deaths	27,406	25,613
Naloxone kits delivered	-	294,484

Willingness to pay



Limitations

- Limited data on costs of medical care and naloxone effectiveness
- Does not address prescription opioid overdose
- Limited knowledge of ancillary effects of naloxone

Conclusions

- Naloxone distribution to heroin users for lay overdose reversal very likely to be cost-effective under any reasonable circumstances
- May be dominant if results in less EMS use or if delivery results in a reduction in overdose risk behaviors

Acknowledgments

- Sean D Sullivan, University of Washington
- The drug users who make this intervention possible
- Paper published as:
  - Coffin PO, Sullivan SD. Cost-effectiveness of naloxone distribution to heroin users for lay overdose reversal. Annals of Internal Medicine. 2013 Jan 1;158(1):1-9. PMID 23277895