Virtual Opioid User: Simulating the Effects of Counterfeit Pill Prevalence with a Control Theory Model

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What is control theory?

- Control of *dynamical systems*
 - Evolution of a thing over time
- Signal generates action to bring a variable to its set point
- \circ Variable
 - Water temperature
 - Opioid concentration
- \circ Set point
 - Target temperature
 - Opioid use threshold
- \circ Action
 - Turn on heating element
 - Take opioids



Why a control theory model of opioid use?



State-based model

- Discrete states
- Immediate transitions
- $_{\circ}\,$ Person can occupy only one state
- Underlying mechanisms not modeled
- Better suited to domains like infectious disease modeling

Why a control theory model of opioid use?



Continuous model

- Gradual transitions
- No explicit states
 - Any number of attributes could be inferred from use patterns
 - E.g., recreational vs. "problematic" use
- $_{\circ}~$ Underlying mechanisms modeled



Example 1: Low starting dose does not lead to dose increase



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Example 2: High starting dose leads to dose increase



Application: Counterfeit pills

- Microsimulation with thousands of VOU agents
- Add counterfeit pill prevalence parameter
 - · More likely to include fentanyl
 - Higher dose than expected
 - · Possibility of "bad batch"
- Model effect of counterfeit pill prevalence on overdose rate

Variable	Coef.	Std.Err.	t	P> t
const	-5.842286	0.375841	-15.544565	6.898769e-54
dose_variability	1.040000	0.240046	4.332508	1.487929e-05
fentanyl_prob	2.060000	0.480091	4.290849	1.795882e-05
counterfeit_prob	1.633883	0.369301	4.424256	9.775141e-06
starting_dose	0.005335	0.001374	3.881876	1.042889e-04
dose_increase	0.052244	0.008148	6.411796	1.500018e-10
behavioral_variability	1.373068	0.168235	8.161624	3.684188e-16
availability	2.282449	0.444478	5.135119	2.870256e-07
internal_risk	3.257163	0.086002	37.872992	2.626166e-294
external_risk	3.830941	0.092469	41.429573	0.000000e+00
counterfeit_prob_dose_variability	1.672161	0.825782	2.024942	4.289865e-02
counterfeit_prob_fentanyl_prob	1.538462	1.651565	0.931517	3.516074e-01

Thank you

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