Application of Systems Science in Opioid Misuse

Mohammad Jalali (‘MJ’), PhD
Assistant Professor, Harvard Medical School
Senior Lecturer, MIT Sloan School of Management

All pictures of articles are hyperlinked to their full text.

Credit: All credits go to lab members, students, and colleagues.
Disclaimer: This presentation does not represent the views of any institutions. Opinions expressed are my own.
Conflict of interest: None
Systems Science

• An **interdisciplinary** field that studies complex systems and their behavior.

• It seeks to understand **the behavior** of these systems by examining their components, interactions, and feedback mechanisms.

• It helps identify potential **leverage points** for effective interventions and policies.
In This Talk

- Systems perspective
- Modeling for understanding
- Modeling for prediction
- Data gaps and analytics
- Stakeholder engagement

Systems science in opioids misuse
Systems science in opioids misuse

Holistic view of various interconnected components
The opioid crisis is a complex and multifaceted problem

- involves multiple factors and stakeholders
- requires a systems perspective to understand and address it

A systems perspective recognizes the interconnectedness and interdependence of these factors and stakeholders, and their impact on each other and the larger system.
Systems perspective

Modeling for understanding

- Key dynamics
- The status quo
- Counterfactuals

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Simulation Modeling

Through a collaboration with FDA, we developed SOURCE, a population-based simulation model.

The model addresses strategic “what if” questions and goals.
Essential to capture the flows of individuals across various states
But going beyond the flows:
Including feedback loops, better representing the real world
SOURCE replicates 15 longitudinal datasets at once; six shown here
Complex estimations: Was the unprecedented **rise** in opioid overdose deaths (OODs) in 2020 **only** because of **COVID-19**?

**SOURCE:** 43% of the excess OODs due to continued increases in **fentanyl**.
Overdose death hazard; competing influences of fentanyl & naloxone

Overdose death hazard among people who use illicit opioids has shifted noticeably due to two competing influences:

**Fentanyl**: Starting around 2013, highly potent synthetic opioids like fentanyl have been increasingly present in the illicit drug supply.

**Naloxone**: Over roughly the same period, there have been numerous efforts to increase access to the lifesaving overdose reversal drug naloxone.
Counterfactuals

What if there were no naloxone?

What if there were no illicitly manufactured fentanyl?
About 59,000 lives would have been saved in the absence of illicitly manufactured fentanyl

About 20,000 lives saved due to layperson naloxone
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- Modeling for understanding
- Modeling for prediction
  - Projection of future trends
  - Intervention analysis and comparison
  - Cost-effectiveness analysis
Projecting various outcomes over the next decade

Over the next decade, total deaths range from 543,000 to 842,000
Strategy analysis

Strategies Simulated in SOURCE
(Changed by 20% in desired direction)

Goal and Intervention Strategy

A) Opioid Misuse and OUD Prevention

Interventions targeting people at risk for misuse
(1) ↓ Diverted Rx Init
(2) ↓ Heroin Init
(3) ↓ Own Rx Init

Interventions targeting systems, including health care
(4) ↓ People with Rx
(5) ↓ Developing OUD

B) Buprenorphine Treatment Capacity

Interventions to increase buprenorphine prescribing
(6) ↑ Bup Providers
(7) ↑ Bup Prov Capacity

C) Recovery Supports

Interventions to support sustained improvements in functioning
(8) ↓ Return to OUD
(9) ↑ Peer Recovery

D) Overdose Harm Reduction

Interventions to reduce risk of overdose
(10) ↓ Fent OD Risk

Interventions to reduce death from overdose
(11) ↑ Naloxone (Nx) Kits
Misuse and OUD Prevention

Interventions targeting people at risk for misuse

(1) ↓ Diverted Rx Init

(2) ↓ Heroin Init

↓ Own Rx Init

Interventions targeting systems, including health care

(4) ↓ People with Rx

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people with OUD

opioid overdose deaths
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Overdose Harm Reduction

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Interventions to reduce death from overdose

(11) ↑ Nx Kits

people with OUD

opioid overdose deaths
Change in prevalence of OUD

- Bup Prov Capacity
- Own Rx Init
- Heroin Init
- Diverted Rx Init
- Developing OUD
- People with Rx
- Return to OUD
- Peer Recovery

Change in opioid overdose deaths

- Bup Prov Capacity
- Own Rx Init
- Diverted Rx Init
- Developing OUD
- People with Rx
- Heroin Init
- Nx Kits
- Return to OUD
- Peer Recovery
Diving deeper...

From discussing ongoing policy questions

Removing The X-Waiver Is One Small Step Toward Increasing Treatment Of Opioid Use Disorder, But Great Leaps Are Needed

To informing implementation of policy solutions

If policymakers only target 2 policies to reduce OODs, they should be to increase capacity and duration, enacted quickly and aggressively.
Stay tuned for SOURCE-based cost-effectiveness analysis of buprenorphine interventions...

forthcoming in *JAMA Health Forum*
Systems science in opioids misuse

- Identifying incomplete data on the components of the system
- Empowering data science and machine learning methods
Data Gaps

A systems perspective can highlight areas where data is lacking or incomplete.

Examples:

- Underreporting of opioid-related overdoses
- Lack of standardized data collection
- Insufficient data on the social and economic determinants of the crisis
- Lack of longitudinal data on many factors
Data Analytics

- Data science and machine learning have been increasingly used in the opioid crisis to help identify patterns and trends in data and predict outcomes of interest (e.g., overdoses).

- By using a systems thinking approach, data science methods can better account for multiple factors influencing opioid misuse.
Systems science in opioids misuse

- Systems perspective
- Modeling for understanding
- Modeling for prediction
- Data gaps and analytics
- Stakeholder engagement

Bringing people with different perspectives to the table
Stakeholder Engagement

• Providing a **common language** and **framework** for stakeholders to understand the complex issues

• Facilitating a **shared understanding** of the complex and interconnected factors that contribute to the opioid crisis,

• Facilitating **collaborative** problem-solving and decision-making processes, taking into account the perspectives and interests of all stakeholders

• Engage communities in building and using the models
Not Only for Opioids...

- Our work does not limit to opioids; alcohol, stimulants, polysubstance

- **Systems science can similarly help with psychedelics**
  - Provide a framework for understanding the complex interactions between the biological, psychological, social, and environmental factors that influence the effects of psychedelic substances
  - Develop effective interventions and policies for
    - safe and responsible use of psychedelics
    - prevention of potential harms
  - Analyze potential unintended consequences
All articles shown today are publicly available:

mj-lab.mgh.harvard.edu

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