

Supplement S2

Supplementary Figures

Structural Barriers, Stochastic Avoidance, and Outbreak Risk
in HIV Prevention for People Who Inject Drugs

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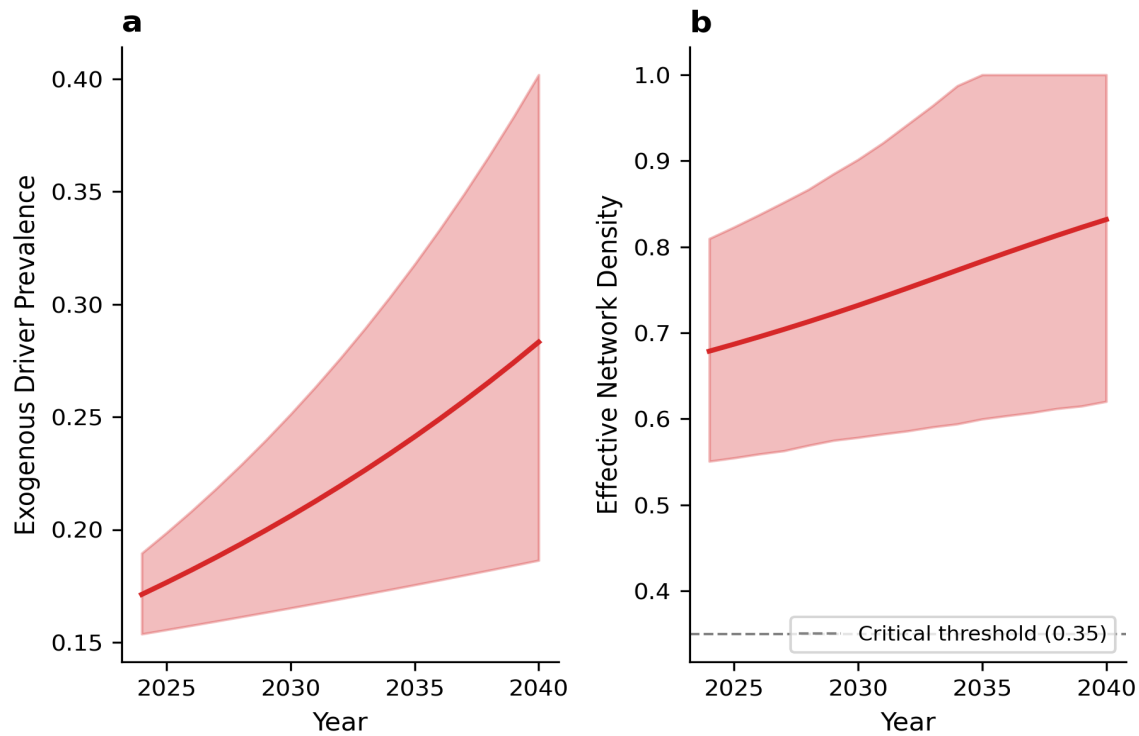
Figure S1. Regional Exogenous Driver Trajectories

Figure S1. Regional exogenous contextual driver trajectories and network density projections. **(a)** Exogenous driver prevalence trajectories from 2024-2040 showing mean estimates with 90% confidence intervals. Prevalence is projected to increase from approximately 17% to over 28% nationally by 2040. **(b)** Effective network density evolution showing approach toward critical outbreak threshold (dashed line at 0.35). Network density increases are driven by rising driver prevalence combined with housing instability and limited harm reduction coverage.

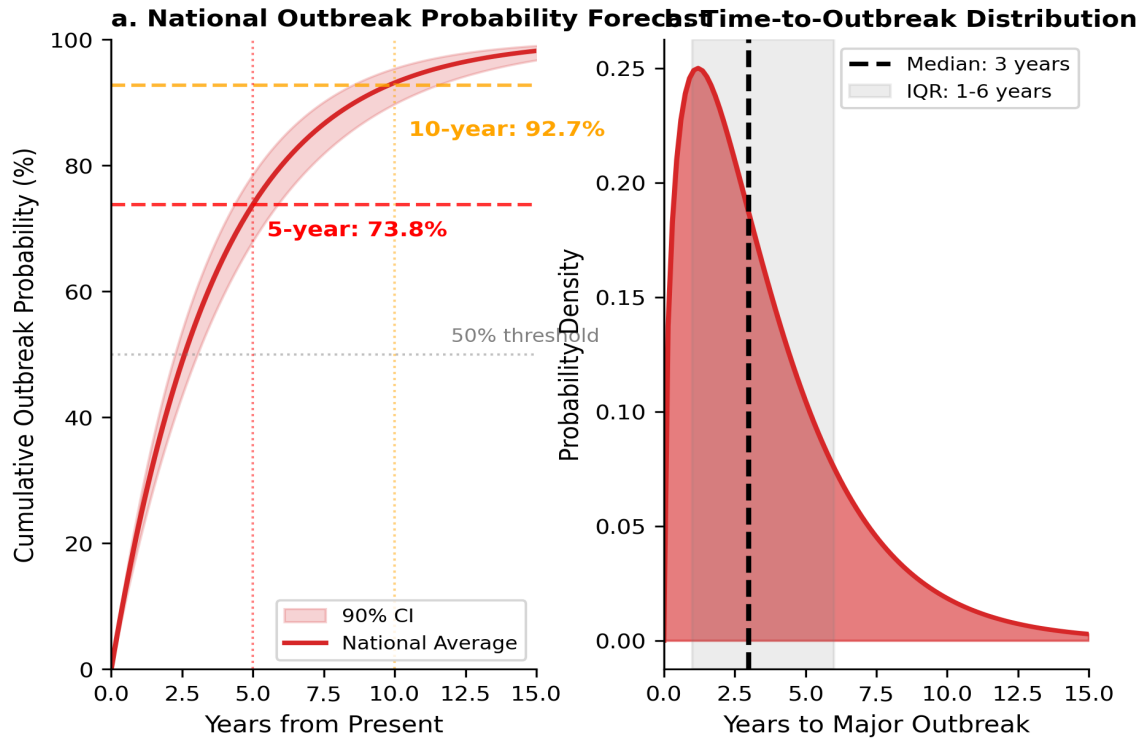
Figure S2. National Outbreak Probability Forecast

Figure S2. National outbreak probability forecast under current policy conditions. **(a)** Cumulative outbreak probability over time showing 73.8% probability within 5 years and 92.7% within 10 years. The 50% threshold is crossed by approximately year 2 (2026). Shaded region represents 90% confidence interval from probabilistic sensitivity analysis. **(b)** Time-to-outbreak distribution with median of 3.0 years (dashed line). Interquartile range spans 1-6 years, indicating high probability of outbreak in the near term. Distribution is right-skewed, reflecting the accelerating nature of outbreak risk as network density approaches critical threshold.

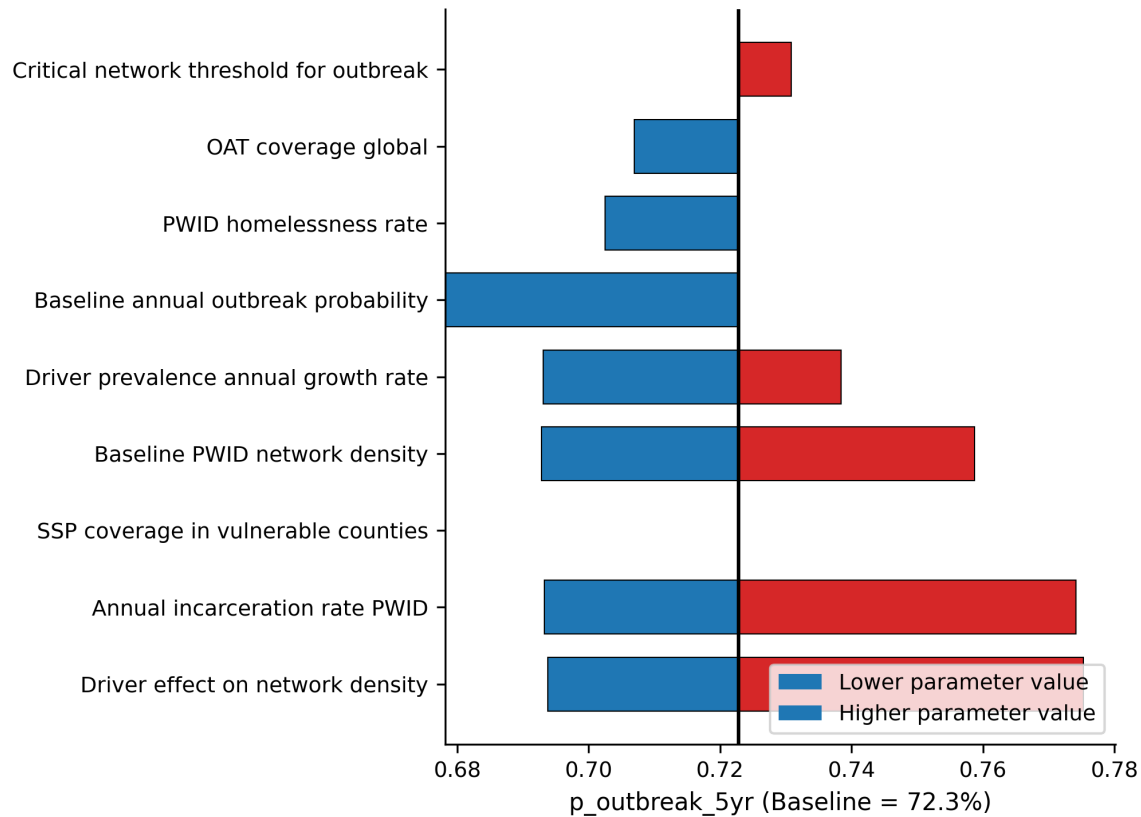
Figure S3. Tornado Diagram: Parameter Sensitivity Analysis

Figure S3. Tornado diagram showing one-way sensitivity analysis results for 5-year outbreak probability. Parameters are ranked by outcome range when varied from lower to upper bound. The vertical line indicates baseline outbreak probability. Blue bars indicate outcome when parameter is at lower bound; red bars indicate outcome at upper bound. Top influential parameters include: (1) Driver effect on network density (8.2 percentage point range), (2) Annual incarceration rate for PWID (8.1 pp), (3) SSP coverage in vulnerable counties (7.1 pp), (4) Baseline PWID network density (6.6 pp), and (5) Driver prevalence annual growth rate (4.5 pp). Results demonstrate that modifiable policy parameters (incarceration, SSP coverage) have comparable influence to contextual factors.

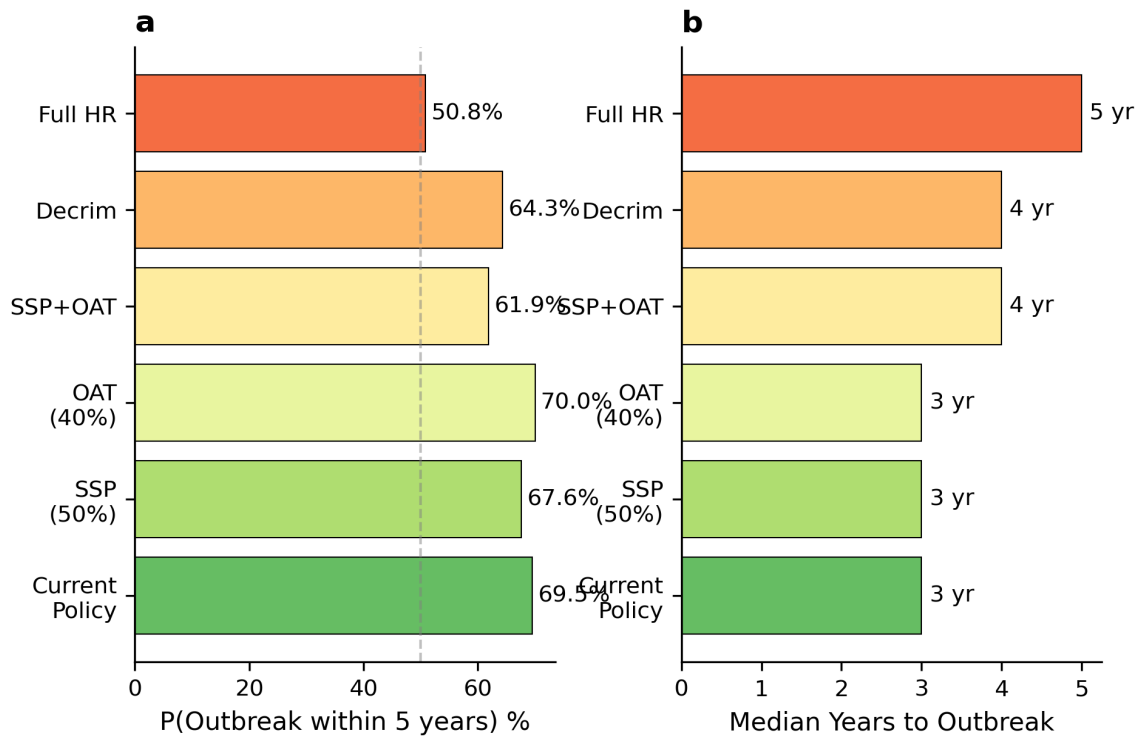
Figure S4. Policy Scenario Comparison: Outbreak Probabilities

Figure S4. Policy scenario comparison for stochastic avoidance outcomes. **(a)** Five-year outbreak probability across policy scenarios. Current policy: 69.5%; SSP expansion to 50%: 67.6%; OAT expansion to 40%: 70.0%; Combined SSP+OAT: 61.9%; Decriminalization effect: 64.3%; Full harm reduction: 50.8%. Even the most comprehensive harm reduction scenario maintains >50% outbreak probability. **(b)** Median years to outbreak by scenario. Current policy and single interventions maintain median of 3 years; combined interventions extend to 4 years; full harm reduction achieves 5 years. Results indicate that while comprehensive harm reduction can delay outbreak, current approaches cannot prevent it indefinitely.

Summary of Key Values

All figures were generated from authoritative simulation outputs dated January 10, 2026.

Stochastic Avoidance Results (National)

- P(outbreak within 5 years): **73.8%**
- P(outbreak within 10 years): **92.7%**
- Median years to outbreak: **3.0 years**
- PSA 90% CI for 5-year probability: 63.5% - 82.0%

Regional Outbreak Probabilities (5-year)

- Pacific Northwest: **86.3%** (median 2 years)
- Appalachia: **78.4%** (median 2 years)
- Northeast Urban: **78.3%** (median 2 years)
- National Average: **72.5%** (median 3 years)

Policy Scenario Comparison

- Current Policy: 69.5% (median 3 yr)
- SSP Expansion (50%): 67.6% (median 3 yr)
- OAT Expansion (40%): 70.0% (median 3 yr)
- Combined SSP+OAT: 61.9% (median 4 yr)
- Decriminalization: 64.3% (median 4 yr)
- Full Harm Reduction: **50.8%** (median 5 yr)

Top Sensitivity Parameters

1. Driver effect on network density: 8.2 pp range
2. Annual incarceration rate PWID: 8.1 pp range
3. SSP coverage in vulnerable counties: 7.1 pp range
4. Baseline PWID network density: 6.6 pp range
5. Driver prevalence annual growth rate: 4.5 pp range