Substance Use and Use Disorder in HIV Acquisition: Insights from Advanced Machine Learning

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Fanghui Shi[1,2], Huiyi Xia[1,2], Xiaoming Li[1,2], Xueying Yang[1,2],
[1]South Carolina SmartState Center for Healthcare Quality, University of South Carolina Arnold School of Public Health, Columbia, SC, USA
[2]Department of Health Promotion, Education and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA

BACKGROUND

- Substance use, particularly substance use disorder (SUD), is a well-documented risk factor for HIV acquisition
- Little is known about how **dynamic substance use/disorder patterns**, such as SUD relapse and poly-substance use over time, influence HIV acquisition.
- By integrating self-reported survey data and multiple domains of EHRs in All of Us (AoU), this study aimed to use Bayesian network models in machine learning to assess substance use and SUD pattern-related risk factors for HIV acquisition.

METHODS

- Data source: **AoU controlled tier data, version 8**, which included individuals enrolled in AoU from May 6, 2018, to October 1, 2023.
- **Comprehensive phenotyping algorithms** based on multi-sourced data (e.g., electronic health records and survey data) were developed to identify substance use/disorder patterns in AoU.
- **Multivariable Logistic regression analysis** was conducted to identify potential risk factors.
- The **Bayesian Network (BN) model** examined associations between HIV status and substance use/disorder-related risk factors, with model parameters estimated using maximum likelihood and model performance evaluated through 15-fold cross-validation.

RESULTS

- Among **633,547** AoU participants, we identified 61,457 (9.7%) nicotine dependence, 27,737 (4.4%) alcohol use disorder, and 24,599 (3.9%) illicit drug use disorder, with opioid use disorder (1.2%) and cocaine use disorder (0.9%) being the two most common ones.
- The BN model revealed that **cocaine use, men who have sex with men (MSM), and income level** were directly associated with HIV status, while other substance-related factors were indirectly associated through cocaine use or income level.

Integrating substance use screening and treatment into HIV prevention efforts is essential, especially for men who have sex with men and individuals with low socioeconomic status.

RESULTS

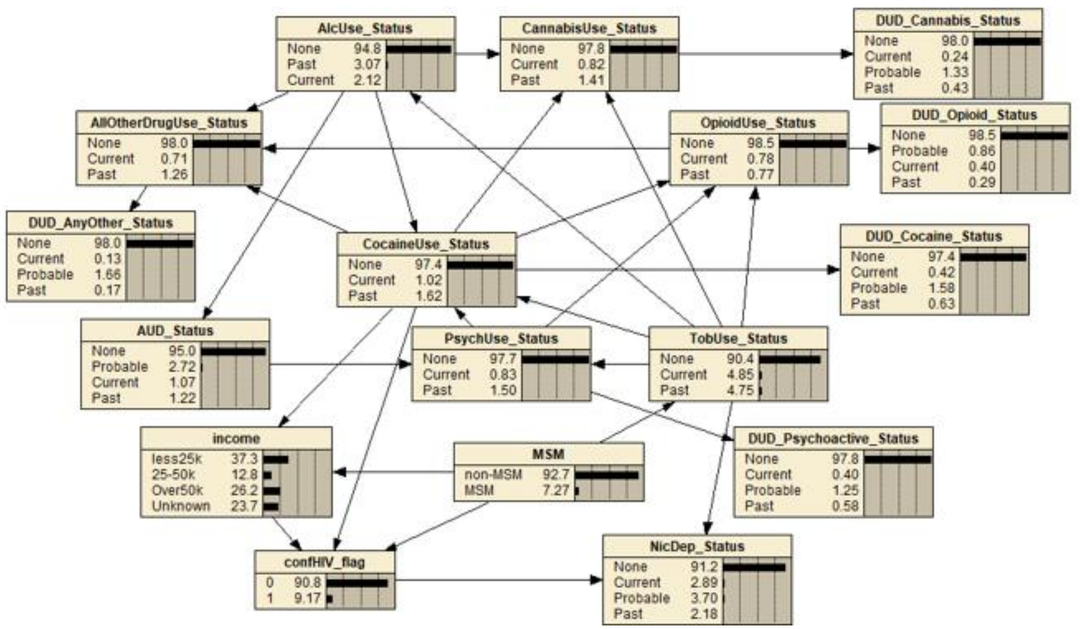


Figure 1. Predictive inference of HIV acquisition by Bayesian network

RESULTS

- Participants who were current/relapse cocaine users, MSM, and with an annual income below $25,000 exhibited an **80% probability** of HIV infection.
- Poly-substance use involving cocaine consistently demonstrated the highest risk for HIV than other combinations **(33.44% to 33.53%).**
- Strong synergistic effects were observed for other combinations, such as opioids with cannabis, which conferred a **10.69%** higher risk than cannabis alone and **9.01%** higher than opioids alone.

CONCLUSIONS

- The BN models formulated in this study allowed for **personalized risk assessment** and the development of tailored prevention and treatment strategies informed by both historical and real-world data and accounting for the interrelationships among different risk factors.
- This study reinforced the significant role of **cocaine and opioid use** in HIV acquisition, both independently and within poly-substance use patterns.
- **Synergistic effects** between cocaine use and other substances further amplify risk compared to single-substance use.
- These findings highlight the critical need for targeted, **multi-substance prevention and intervention strategies** that account for the complex interplay of substance use behaviors, socioeconomic factors, and risky sex behaviors.

ADDITIONAL KEY INFORMATION

Fanghui Shi: FSHI@email.sc.edu

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UNIVERSITY OF South Carolina