

GuardianRx: An AI-Driven Predictive Tool for Monitoring Emerging Psychoactive Drug Trends

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Abstract— Drug abuse, particularly involving Novel Psychoactive Substances (NPDs) and necrotizing "flesh-eating" drugs like xylazine and krokodil, presents a growing global health crisis. This paper presents GuardianRx, a community-driven AI tool designed to predict and combat these trends. By integrating retrospective clinical data from OSF Healthcare with digital epidemiology from Google Trends and Generative AI-simulated social discourse, we established a predictive model. Our analysis of 43,419 hospital admissions and ten years of search data reveals a significant positive correlation ($r=0.26$ to 0.54) between digital search activity and subsequent hospitalizations. These findings validate the potential of GuardianRx to serve as a real-time, cost-effective early warning system for public health officials.

Keywords: Digital epidemiology; predictive modeling; artificial intelligence; public health; flesh eating drugs

I. INTRODUCTION

Drug abuse represents a significant global health crisis, recently exacerbated by the rise of "flesh-eating" Novel Psychoactive Substances (NPDs) such as xylazine and krokodil. In 2022, the Drug Enforcement Administration (DEA) observed a sharp increase in the trafficking of fentanyl mixed with xylazine across 48 states. This trend resulted in a quadrupling of xylazine-associated deaths, leading the White House to designate the mixture as an "emerging threat". To address the limitations of traditional monitoring, GuardianRx was developed as a community-driven Artificial Intelligence (AI) tool that integrates clinical records from OSF HealthCare, digital epidemiology from Google Trends, and Generative AI (GenAI) simulations.

The remainder of this paper is organized as follows. Section II details the methodology, including data collection and simulation processes. Section III presents the results regarding demographic patterns and the correlation between digital searches and admissions. Section IV concludes the paper with Conclusion and Future Work

II. METHODOLOGY

The development of the GuardianRx framework utilized a multi-modal approach that integrated retrospective clinical analysis, digital footprint tracking, and simulated social discourse

A. Data Sources and Collection

A multi-modal data collection strategy was employed, spanning a ten-year period from January 2015 to December 2024. Clinical data was retrospectively collected from the OSF HealthCare System. De-identified records for 43,419 substance use admissions were retrieved, representing a

cohort of 27,694 adult patients. The inclusion criteria for this dataset encompassed non-pregnant patients aged 18 and above who were admitted for issues related to fentanyl, krokodil, or xylazine. Digital epidemiology was gathered using Google Trends, specifically analyzing "interest over time" and Designated Market Area (DMA) scores for eight key search terms associated with "flesh-eating" drugs. This data was extracted in 10-year, yearly, and three-month snapshots to capture varied temporal patterns. Additionally, supplementary socioeconomic and substance-related information was integrated from the State Unintentional Drug Overdose Reporting System (SUDORS), the Centers for Disease Control and Prevention (CDC), and relevant peer-reviewed manuscripts.

B. Generative AI Simulation

To analyze public discourse while avoiding the privacy complexities of social media during the early stages of model creation, Generative AI (GenAI) platforms were utilized. Simulations were conducted using ChatGPT, Meta AI, Grok AI, and CoPilot. Over 2,000 conversations regarding potential substance use were simulated, incorporating keywords, phrases, and scenarios tailored to both rural and urban community contexts. In total, 7,169 lines of simulated online chat were analyzed to identify common slang terms and prevailing sentiments regarding drug acquisition and coping mechanisms.

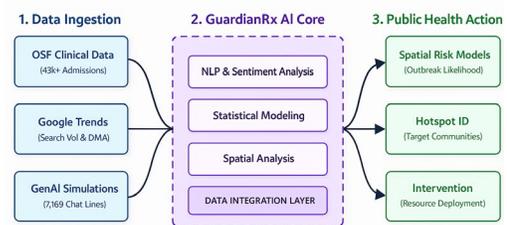


Figure 1. GuardianRx Framework. Data Ingestion: Combines clinical records (OSF Epic), Google Trends, and 7,169 lines of GenAI social discourse. Analysis: AI identifies community slang, sentiment, and geographic hotspots. Prediction: Generates spatial risk models to forecast "flesh-eating" drug trends and support resource allocation.

C. Predictive Modeling

The objective of the modeling phase was to develop precise AI and spatial models for accurate trend forecasting. By merging retrospective patient data with GenAI simulations and web-based search data, drug use patterns were simulated for specific socioeconomic regions. This integrated data serves as the foundation for training future models to predict the likelihood of drug abuse-related infections within target communities. (Figure 1).

III. RESULTS

A. Demographic Analysis

The evaluation of clinical data from Illinois identified distinct demographic patterns among substance use admissions. A significant majority of the 27,694 patients were aged 25 or older (90.1%), with a mean age of 46.8 ± 16.9 years. Residential analysis indicated that 88.5% of admissions originated from urban areas, while 11.5% were from rural locations. Social factors revealed that 55.8% of the cohort was single and 69.2% identified as non-Hispanic white. These demographic distributions are illustrated in Figure 2.

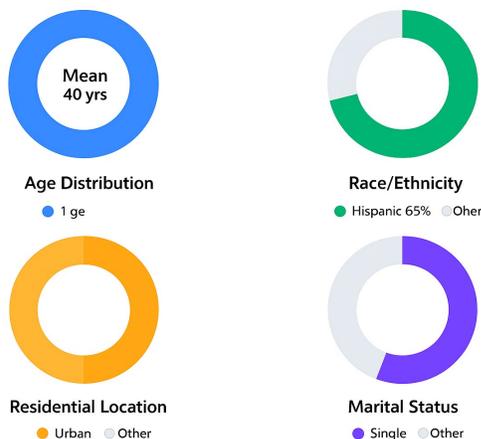


Figure 2. Demographic distribution of substance use admissions in Illinois (2015–2024). (A) Age distribution of the 27,694 patients, with a mean age of 46.8 ± 16.9 years, showing that majority (90.1%) are aged 25 or older. (B) Racial composition of the cohort, predominantly Non-Hispanic White (69.2%). (C) Residential distribution highlights a significant prevalence of admissions from urban areas (88.5%) compared to rural locations. (D) Marital status, with 55.8% of the population identified as single.

B. Digital Footprints and Sentiment

Analysis of 7,169 simulated GenAI chat lines identified prevalent slang terms and distinct sentiments—both positive and negative—related to drug acquisition and coping strategies. Google Trends data successfully identified regional geographic hotspots for searches related to krokodil, fentanyl, and xylazine. The highest level of search activity was consistently observed in the Chicago area.

C. Correlation between Search Activity and Admissions

A significant positive correlation was established between peak digital search volume and subsequent hospital admissions, with correlation coefficients ranging from $r = 0.26$ to $r = 0.54$ ($P < 0.05$). Autoregressive models confirmed a strong association between these variables. Cross-correlation lag analysis demonstrated that the strongest association between search queries and clinical presentation occurs with a lag of approximately nine months, or three quarters. This predictive lag was consistent across all analyzed regions and Designated Market Areas (DMAs).

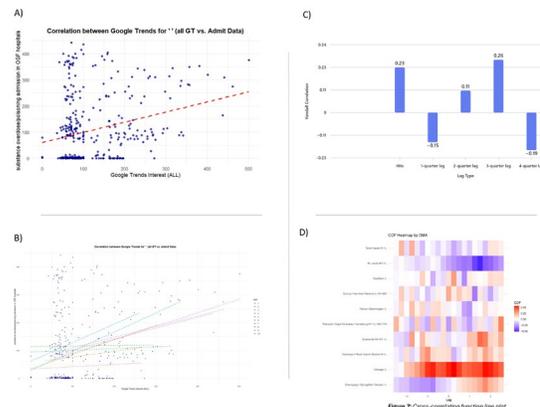


Figure 3. Search volume vs. substance use admissions. (A–B) Significant positive correlation ($r=0.54$) between search queries and hospital admissions (quarterly and yearly). (C–D) Cross-correlation shows a peak 9-month lag (3 quarters) between searches and subsequent admissions across all regions and DMAs.

IV. CONCLUSION AND FUTURE WORK

The potential of GuardianRx as an AI-powered predictive tool for monitoring emerging psychoactive drug trends was demonstrated throughout this study. By integrating a decade of digital search data with over 43,000 hospital admissions, a significant positive correlation ($r=0.26$ to 0.54) between online information seeking and clinical substance use presentations was established. These findings validate the capability of the framework to serve as a real-time, cost-effective early warning system for public health officials. The integration of digital footprints with real-world healthcare data offers a powerful, proactive approach to public health intervention and resource management. Future work will focus on the continued validation of this model using large-scale, retrospectively collected real-world admission datasets. Model algorithms and performance metrics will be iteratively refined until the tool captures the dynamics of drug abuse-related infections in target areas with an accuracy of $\geq 95\%$. Upon full validation, the deployment of GuardianRx is intended to enable public health officials and government agencies to identify geographic hotspots and implement targeted intervention strategies to mitigate substance abuse risks globally.

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