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Machine Learning Models for Predicting Future Substance Abuse Risk

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Abstract

Machine learning (ML) holds promises in predicting potential substance abuse risk, enabling early interventions to prevent addictive behaviors. Most studies focus on prognosis of individuals already affected by substance use disorders (SUDs), however, a few investigations explore the prediction of future SUD risk. These studies use diverse data, including socio-economic status, psychological features, genetic information and social media activity, achieving accuracy rates more than 96% in some cases. However, heterogeneity in methodology and lack of standardized frameworks limit their applicability. This review highlights the need for consistent approaches to fully know the potential of ML in preventing substance abuse.

Keywords: Support Vector Machines; Machine Learning Algorithms; Medical Services; Prediction Algorithms; Synchronization; Prognostics and Health Management; Regression Tree Analysis; Machine Learning; Naive-Bayes; Decision Trees; Random Forest; KNN; SVM; Logistic Regression; SGD; Disease Prediction

Abbreviations

ML: Machine Learning; Suds: Substance Use Disorders; GWAS: Genome-Wide Association Studies.

Introduction

The use of machine learning (ML) techniques in medicine has gained considerable attention recently, especially predictive models for complex, multifaceted health issues [1]. One of the most pressing concerns is substance abuse, a major public health challenge that affects millions of people globally [2]. The potential to predict future substance abuse risk could be transformative, allowing earlier interventions and more personalized treatment plans. Machine learning has the ability to analyze massive datasets and show hidden patterns, holding great promise in this domain.

Most studies on the use of machine learning in predictibg substance use disorders (SUDs) have focused on prognosis, predicting outcomes for individuals already struggling with addiction [3], including predictions of hospital admission, relapse, overdose, and treatment effectiveness [4-6]. While these applications are valuable for managing the situations of those currently affected by SUDs, there is an important but less explored era: predicting the risk of future addiction. The ability to identify individuals at risk before addiction develops could allow for proactive interventions, potentially preventing the progress to advanced substance use disorders [7]. Given that addiction is often chronic and relapsing, early detection is critical, as interventions in this stage can considerably reduce long-term impacts of the disorder [8].

Nevertheless, studies on predicting future addiction risk differ widely in methodology. These differences arise partly from the diverse risk factors and variables considered to be predictive. Some studies focus on socio-economic data -such as income level, education, and family history of addiction- to assess risk [9]. Others incorporate psychological and behavioral assessments, such as mental health condition and early substance abuse patterns [10,11]. Few models have achieved accuracy rates as high as 96.72 [9] using these factors. On the more sophisticated end, studies using genomic data of large-scale genome-wide association studies (GWAS) combined with EEG readings, have revealed highly accurate predictions. One study, which used data from large-scale genome projects and EEG data and family history reports, reported an accuracy rate of 87.55 in one of their models [12].

Further studies have taken a new approach by analyzing non-traditional data sources, such as social media activity. For example, research analyzing large datasets from platforms like Instagram has shown capacity in predicting future substance use behaviors [13]. These studies are often groundbreaking in their application of behavioral signals from online platforms, which might mirror real-life substance abuse patterns. However, these studies also highlight the significant variability in methodologies. Each study uses different variables, different machine learning algorithms, which makes it challenging to compare results across studies.

The lack of homogenous variables and algorithms across these different studies is a major limitation. Studies have not yet tested the same set of variables or algorithms in real-world settings to provide robust, reproducible data that can assess the predictive power of these models for future SUDs. This variability emphasizes the need for future research that can establish the most effective risk factors and algorithms into integrated frameworks. With such consistency we might be able to evaluate whether machine learning models can actually be effective instruments for detecting high-risk individuals and preventing SUDs before they occur. While studies on machine learning models for predicting the risk of future substance abuse are still in their early stages, the potential benefits are immense.

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