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Opium and Opioid Toxicity: AI-Enhanced Insights into Pharmacology, Clinical Manifestations, and Emergency Management

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Abstract: *Artificial intelligence can be used to personalise the counselling plan for individuals with drug addiction, identified through our screening process. Thus, anyone who scores above the average reported in research studies is considered to have issues related to opioid abuse. Additionally, artificial intelligence can provide verified and highly relevant information essential for clarifying the situation of those who respond to the questionnaire. When certain key indicators or markers appear in their answers, it can help young people more easily accept the idea that they are dealing with a form of substance dependence. This represents a significant advantage for individuals with substance use disorders, who often do not accept criticism or being labeled by a doctor or psychologist. However, they may be more open to accepting a perspective offered by a computer-based system. Such a system is perceived as neutral, non-judgmental, and highly objective. In this context, the individual feels that their responses are being evaluated fairly, which encourages greater honesty and increases the likelihood of accepting the AI-generated conclusions as well-founded and difficult to dispute.*

Keywords: *artificial intelligence; toxicology; opioids; drug addiction.*

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1. Introduction

1.1. General Information on Poisoning

Poisoning occurs when a toxic substance enters the body, causing biological and clinical changes that can be either reversible or irreversible. These changes can affect metabolism, cellular structure, and organ function (Vale, 2011). In cases of acute poisoning, the situation can become a medical emergency, sometimes with fatal consequences if not treated in time (Bronstein et al., 2011). A toxic substance is any chemical, biological, or mineral compound that, once inside the body, causes pathophysiological imbalances, affecting an individual's health (Klaassen, 2013).

Several factors influence the toxicity level of a substance, as presented in the table below:

Table 1. Factors Influencing the Toxicity Level of a Substance
(Adapted from Casarett & Doull's Toxicology (Klaassen, 2013))

Toxicological Factor	**Explanation of Mechanism**
Physicochemical Properties	The chemical and physical characteristics of the substance influence its toxicity level.
Toxic Dose	The ingested or absorbed amount determines its effects on the body.
Toxic Concentration	Higher concentrations may worsen poisoning symptoms.
Route of Entry	The way the substance enters the body (oral, inhalation, dermal, etc.) affects its impact.
Absorption Rate	The speed at which the toxin is absorbed affects poisoning severity.
Patient Characteristics	Factors such as age, sex, and body weight influence the body's response.
Tolerance and Dependence	The body may develop tolerance, altering the poisoning effects.
Dietary Habits	Diet can affect the absorption and metabolism of toxic substances.
Health Status	Pre-existing conditions can amplify poisoning risks.

It is important to note that the toxicity of a substance is not absolute. The human body does not distinguish between "natural" and "synthetic" substances. A natural compound is not always harmless, and a synthetic compound is not necessarily dangerous (Gosselin et al., 1984).

1.2. General Information and Treatment of Poisoning

Poisoning refers to the harmful effects that occur when a toxic substance enters the body. It can influence biological functions, causing metabolic imbalances that, in some cases, can be life-threatening (World Health Organisation, 2004). The severity of poisoning depends on several factors, including the type of toxin, the amount absorbed, and the affected person's health status.

A substance can be toxic regardless of its origin—natural (plants, metals, fungi) or synthetic (drugs, pesticides, solvents). Thus, "natural" does not always mean safe, just as "synthetic" is not automatically harmful (Gosselin et al., 1984).

Table 2. Factors Influencing the Toxicity of a Substance

Factor	**Description**
Chemical and Physical Composition	Solubility, volatility, and stability influence toxicity.
Dose	The ingested or absorbed quantity determines the severity of effects.
Absorption Rate	The way the substance enters the body affects the speed of toxic reactions.
Age, Sex, and Body Weight	Different organisms metabolise toxins differently.
Health Status	Pre-existing conditions may exacerbate toxic effects.
Lifestyle Habits	Alcohol consumption, smoking, or substance use can influence the body's reaction.
Diet	Certain foods can facilitate or hinder toxin absorption.

1.3. Natural Substances (Opiates)

Opiates are endogenous alkaloids derived from the opium poppy (Papaver somniferum). These include morphine, codeine, thebaine, papaverine, and noscapine. They bind to μ-opioid receptors in the central nervous system, modulating pain perception and mood (Katzung, 2018).

Opium is the dried latex obtained from poppy capsules and has historically been used for its analgesic and antidiarrhoeal properties. Its addiction potential is well-documented and comparable to morphine, though dependence may progress more slowly (Booth, 1996).

Harvesting involves incising immature poppy pods to collect latex, which is dried and processed. Approximately 20,000 capsules yield 1 kg of raw opium (United Nations Office on Drugs and Crime [UNODC], 2023). The substance undergoes further processing into "pharmacologically prepared opium," known as chandu in Southeast Asia.

Opioids are alkaloid substances or drugs derived from certain species of poppy (Papaver somniferum). They are primarily used for their analgesic effect, reducing or eliminating pain sensitivity. Morphine is considered the main representative of this class of drugs (Rang et al., 2016).

Based on their interaction with opioid receptors, opioids are classified into several categories: pure agonists (e.g., morphine, methadone), weak agonists (e.g., codeine, tramadol), partial agonists (e.g., nalbuphine, buprenorphine), and pure antagonists (e.g., naloxone) (Katzung, 2018).

Heroin, also known as diacetylmorphine, is a semi-synthetic derivative of morphine, obtained through acetylation. Although opium has historically been referred to as the "plant of happiness" for its effects, its recreational use dates back to 3400 BC (Booth, 1996). However, heroin was first synthesised in 1874 by chemist C. R. Alder Wright.

Pure heroin is extremely rare on the illegal market. The final product often contains weaker alkaloids along with various added substances such as acetaminophen, caffeine, or sugar, which give it a distinct appearance (United Nations Office on Drugs and Crime [UNODC], 2023).

The receptors involved in nociceptive analgesia are mainly the mu (μ) receptors, responsible for central analgesic effects, and the kappa (κ) receptors, which contribute to spinal analgesia (Rang et al., 2016).

Heroin crosses the blood-brain barrier rapidly—within 20 seconds when injected—producing a euphoric "rush" (National Institute on Drug Abuse [NIDA], 2020). Diacetylmorphine has a pharmacokinetic half-life of about 3 minutes, explaining its short duration of action but intense effect. The duration of heroin's effects ranges from 3 to 5 hours, after which withdrawal symptoms such as nausea, vomiting, and tremors may appear.

Heroin is considered one of the most potent substances with a high potential for both physical and psychological dependence. It remains responsible for the majority of accidental overdose deaths worldwide (United Nations Office on Drugs and Crime [UNODC], 2023).

Opiates are naturally occurring alkaloids derived from the opium poppy (Papaver somniferum). These include morphine, codeine, thebaine, papaverine, and noscapine. They bind to opioid receptors in the central nervous system, modulating pain perception and mood (Katzung, 2018). Harvesting involves incising immature poppy pods to collect latex, which is dried and processed. Approximately 20,000 capsules yield 1 kg of raw opium (United Nations Office on Drugs and Crime [UNODC], 2023). The substance undergoes further processing into "prepared opium," known as chandu in Southeast Asia.

1.4. Acute Opioid Intoxication

Acute opioid use leads to a set of predictable clinical signs—referred to as the opioid -induced toxidrome—including central nervous system (CNS) depression, respiratory depression, and miosis (Boyer, 2012).

The severity of symptoms varies but often involves the central nervous system, respiratory system, and cardiovascular system. In advanced cases, complications such as pulmonary oedema or respiratory arrest can occur rapidly.

Common complications of opioid intoxication include acute respiratory failure, hypoventilation, and hypoxia, especially in intravenous drug users. Infections such as cellulitis, abscesses, osteomyelitis, and endocarditis are frequent due to unsafe injection practices (Darke, Duflou, & Torok, 2007).

Opioid withdrawal syndrome occurs after abrupt discontinuation and is marked by autonomic symptoms like sweating, diarrhoea, muscle aches, and anxiety (Kosten & George, 2002).

Artificial intelligence (AI) systems are increasingly making their way into the field of drug discovery. As a result, an increasing number of drugs and vaccines have been developed with the help of artificial intelligence. However, questions remain regarding the efficacy of these molecules in clinical trials. To explore this aspect, we conducted an initial analysis of the clinical pipelines of AI-based biotechnology companies.

Artificial intelligence (AI) and machine learning (ML), in particular, are transforming the pharmaceutical industry, offering innovative solutions to critical challenges such as toxicology and opioid addiction. As the opioid epidemic continues to impact millions of people globally, AI can play a key role in identifying risks, preventing addiction, and developing safer alternatives.

The toxicological profile of a drug and its potential to cause addiction are essential factors in the development process. Traditionally, these aspects are assessed through laborious and costly methods, but AI can significantly accelerate and improve this process. By analysing massive datasets, AI can help researchers detect hidden patterns that lead to addiction and optimise drug formulations to minimise risks.

2. Methodology

In this research, the authors employed comprehensive data collection methods including analysis of preliminary information, identification of target groups, the development and application of questionnaires, interview guides, and focus group discussions, tailored for various stakeholders—injectable drug users, police officers, prison staff, media representatives, medical personnel, hospitality workers, youth, and educators. These mixed-method approaches are commonly used in public health studies to assess the scope and impact of drug-related behaviours (UNAIDS, 2000; World Health Organisation, 2001).

To track the evolution of drug use trends, a second rapid assessment was carried out in 2002, coordinated by the National Commission for the Fight Against AIDS, the ROMTENS Foundation, and UNICEF. The goal was to identify effective harm-reduction strategies and prevent future health and socioeconomic consequences of injectable drug use (UNICEF, 2002).

An essential component of this study was the use of the capture-recapture method—a statistical tool used to estimate hidden populations such as people who inject drugs (PWID). This method has proven to be a reliable and cost-effective way to measure hard-to-reach population sizes in epidemiological studies (Hook & Regal, 1995; EMCDDA, 2007).

Table 3. Preferred Substances

Substance	**Number of Responses**	**Percentage**
Alcohol	3	12%
I don't use drugs	2	8%
No	3	12%
Nothing	3	12%
Opiates	2	8%
Xanax	2	8%
I don't consume anything	1	4%
(Other individual answers)	1 each	4% each

The results confirmed that heroin was the most commonly used substance among Romanian injectors and that these individuals were at significant risk of engaging in high-risk behaviours, including needle sharing and unsafe sex, which increase the risk of HIV, Hepatitis B, and C transmission (UNAIDS, 2000; EMCDDA, 2007).

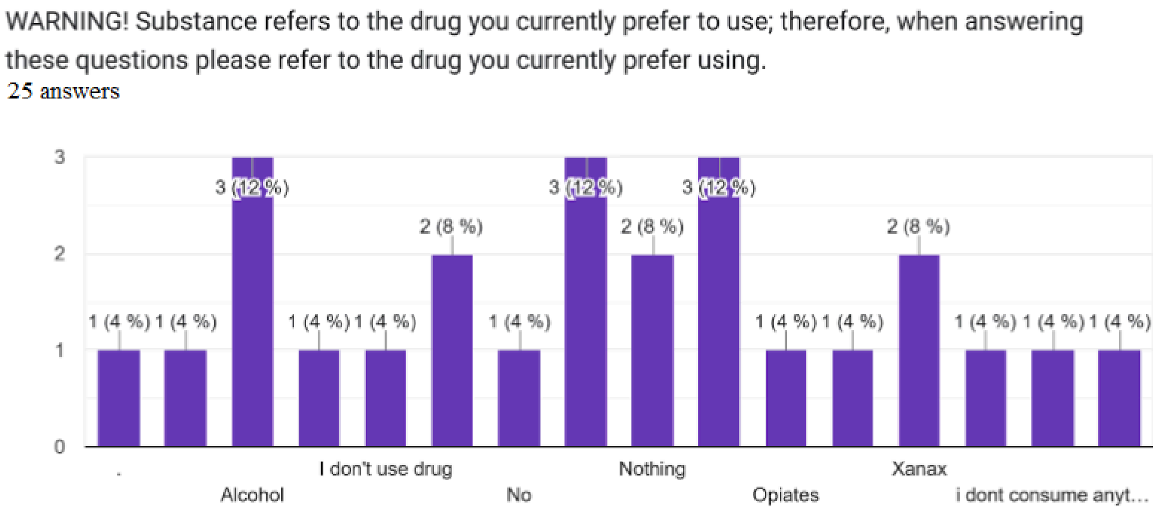

Chart 1. The graph presents data from 25 respondents regarding their preferred substance use, as collected through a Google Form survey

The question instructed participants to consider the drug they currently prefer when responding. The chart includes a variety of responses, some of which indicate active substance use, while others suggest abstinence or confusion in interpreting the question.

Among the most frequently reported substances were alcohol, “no,” and “nothing,” each accounting for 12% of the total responses. These categories, while numerically equivalent, vary in interpretability. The category “alcohol” clearly indicates the substance used, whereas “no” and “nothing” are ambiguous. These latter responses may reflect denial, misunderstanding of the question, or a genuine lack of substance use. Such ambiguity complicates the interpretation and highlights a limitation in the design or phrasing of the survey item.

Opiates and Xanax were each identified by 8% of respondents, signalling the presence of users of specific, high-risk substances within the sample. These responses are particularly relevant for substance abuse research, as both categories are associated with a high potential for dependence and adverse health outcomes. Additionally, 8% of participants indicated that they do not use drugs, while 4% explicitly stated they do not consume anything, reinforcing a notable subgroup of non-users or abstinent individuals.

The remaining responses, each comprising 4% of the total, include isolated mentions that may reflect atypical preferences or individual interpretations not captured by the main categories. These results suggest a heterogeneous group with varying levels of substance use, and the presence of overlapping or unclear responses such as “no,” “nothing,” and “I don’t use drugs” emphasises the need for clearer survey design in future research.

In conclusion, the data indicate a distribution of both active substance users and abstainers, but it also reveals a degree of inconsistency and ambiguity in participant interpretation. This highlights the importance of precise language and categorical clarity in survey instruments used for research on substance preference and addiction profiles.

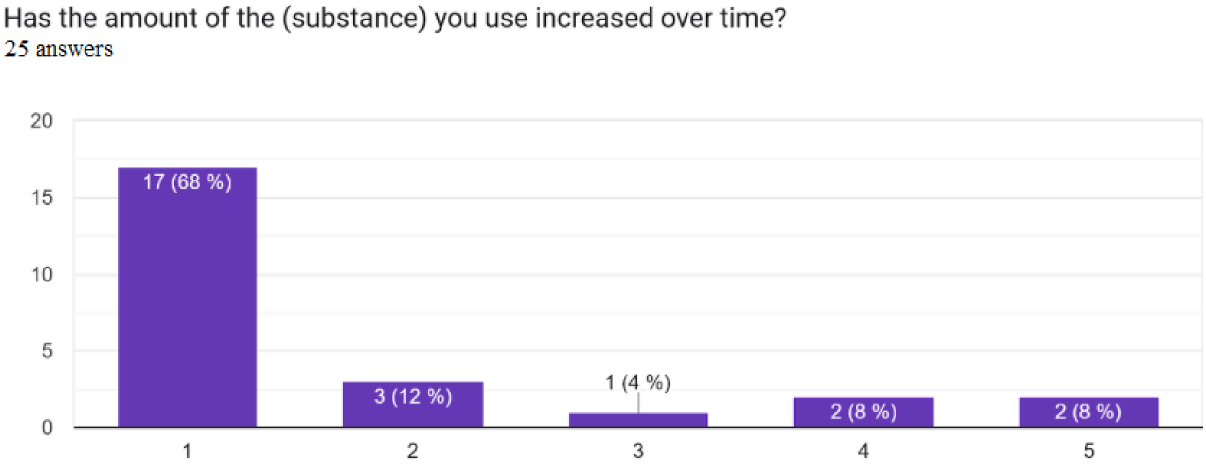

Chart 2. The graph presents data from 25 respondents regarding their preferred substance use increased over time

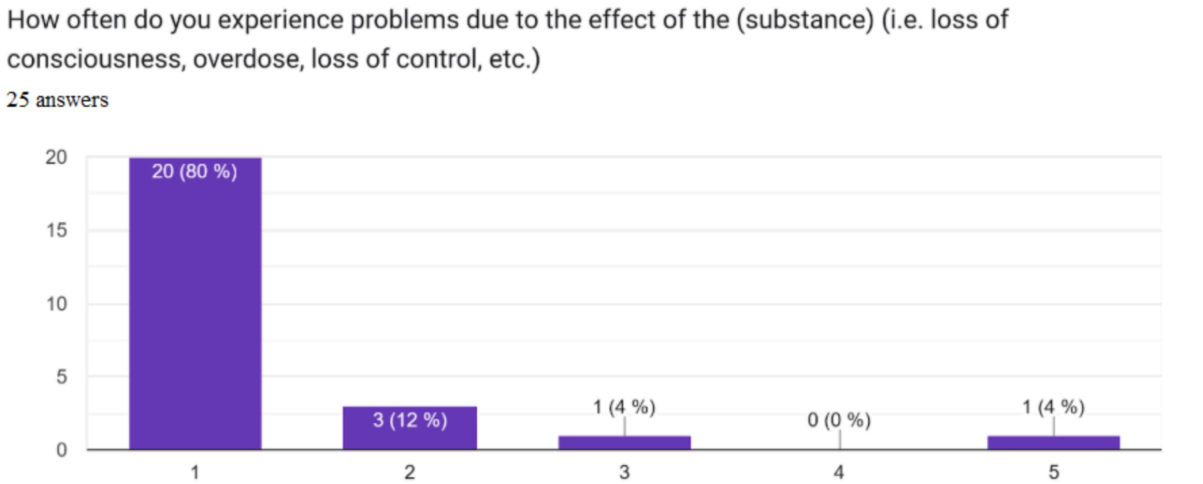

Chart 3. The graph presents data from 25 respondents regarding the problems experienced due to the effect of the substance

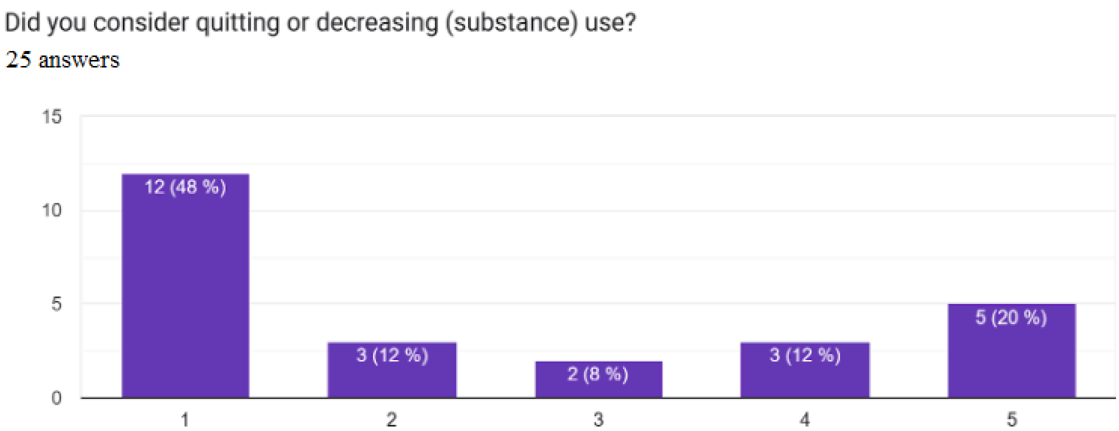

Chart 4. The graph presents data from 25 respondents regarding the quitting substance used

The graph in the image represents responses to the question "Did you consider quitting or decreasing (substance) use?" from a sample of 25 participants. The responses are presented on a Likert-type scale, presumably ranging from 1 (Not at all) to 5 (Very much), which is a standard format for measuring attitudes or intentions.

According to the data, the majority of participants (48%, n = 12) selected option 1, indicating that they did not consider quitting or reducing their substance use. This suggests a high level of ambivalence or resistance towards change among nearly half of the sample. Only 20% of respondents (n = 5) selected option 5, the strongest endorsement of intent to quit or reduce use, highlighting that only a small fraction are firmly considering behavioural change.

Responses at intermediate levels (2, 3, and 4) were less frequent and fairly evenly distributed: 12% each for options 2 and 4 (n = 3), and 8% for option 3 (n = 2). This distribution shows a minority expressing moderate consideration of change, but not a strong intention.

These findings have significant implications for intervention strategies. The fact that nearly half of the respondents are not contemplating reduction or cessation of use suggests that many are in the precontemplation stage of change, according to the Transtheoretical Model (Stages of Change). This stage is typically characterised by denial, lack of awareness of the problem, or minimisation of risks associated with substance use. Tailored interventions focusing on raising awareness, motivational interviewing, and harm reduction strategies may be more appropriate for individuals at this stage rather than more intensive treatment approaches aimed at those ready to quit.

Overall, the data reveal a predominant resistance to behaviour change in this sample, with only a small subset showing readiness or motivation to reduce or stop using substances. This underlines the importance of early-stage engagement and psychoeducation in addiction-related interventions.

The Addiction Profile Index (API) is a multidimensional self-report questionnaire designed to assess substance use behaviour and its psychological, behavioural, and social consequences. It provides a comprehensive profile of addiction-related symptoms and risk factors through a structured set of questions rated on Likert-type scales.

The API typically includes items across several domains such as substance use frequency, loss of control, craving, psychosocial impact, and readiness for change. Each item contributes to a subscale score, and together they allow for a total score that reflects the individual's risk or severity of addiction.

In the present dataset, responses to API items are measured on a five-point Likert scale, with higher scores indicating more frequent or intense experiences related to substance use. Descriptive statistics for these items suggest that most respondents reported relatively low levels of problematic use, with certain items—such as those related to difficulty resisting substances or the desire to quit—scoring higher, potentially indicating emerging risk behaviours.

The API can also be analysed for internal consistency using Cronbach's Alpha, which assesses the reliability of the scale. In SPSS, this is performed by selecting Analyse > Scale > Reliability Analysis, and entering all relevant questionnaire items. A Cronbach's Alpha value above 0.70 is typically considered acceptable, indicating that the items measure a common underlying construct.

Moreover, the API allows for subscale analysis to examine which dimensions are more prominent in the sample. This can guide interventions by identifying areas such as emotional dependence, impulsivity, or social dysfunction that may need targeted support.

The API serves as a robust psychometric tool for identifying addiction risk profiles and understanding the multi-faceted nature of substance use behaviour within a population.

The dataset includes participant responses on a variety of substance use behaviours, measured on a Likert scale ranging from 1 to 5. Descriptive statistics were computed for all relevant variables. Most of the items fall within the expected range, with means typically close to the lower end of the scale, indicating generally low self-reported substance use and related problems across the sample. As shown in Table 4, the mean scores and standard deviations for each substance and behavioural indicator are presented.

Table 4: Descriptive Statistics for Substance Use Behaviours and Related Indicators in the Sample

Substance	Mean Score (M)	Standard Deviation (SD)
Alcohol	2.32	1.14
Cannabis	1.56	1.16
Heroin	1.20	N/A
Crack	1.20	N/A
Cocaine	1.20	N/A
Volatile Substances	1.20	N/A
Difficulty Resisting Use	2.12	1.59
Importance of Quitting	2.44	N/A

**N/A=Not Available*

The mean score for alcohol use was 2.32 (SD = 1.14), suggesting occasional use among participants. Cannabis had a lower mean of 1.56 (SD = 1.16), and substances such as heroin, crack, cocaine, and volatile substances all had mean values close to 1.2, reflecting very infrequent or minimal reported use. These low mean scores, paired with standard deviations under 1 in most cases, indicate little variability in responses and a low prevalence of use across these substances.

Behavioural and psychological indicators of substance use problems exhibited slightly higher variability. For instance, the item assessing difficulty resisting substance use when it was available had the highest average score at 2.12 (SD = 1.59), which may indicate a subgroup experiencing significant control-related issues. Similarly, items regarding the importance of quitting or reducing use had relatively high means (2.44 and 2.52), suggesting that while substance use is generally low, some participants perceive it as problematic and express a desire to change.

Overall, the data indicate a sample with predominantly low engagement in substance use, but with a minority showing patterns that may reflect risk or emerging problems. These insights can guide further analyses, such as correlation or regression, to explore which factors are most associated with higher perceived risk or difficulty controlling use.

3. Discussion

Artificial Intelligence in Counselling for Individuals with Substance Addiction

Artificial Intelligence (AI) can be effectively used to personalise the counselling plans for individuals suffering from drug addiction, identified through a screening process conducted by our team. Any individual who scores above the average reported in research studies is considered to be at high risk for opioid abuse.

Another major benefit of AI is its ability to provide verified and relevant information, which can help clarify the situation for the person being evaluated. When specific indicators or key markers appear in young people's answers, it may help them more easily accept the reality of a possible substance addiction.

This represents a critical advantage, especially for individuals who tend to reject criticism or labels from doctors or psychologists. Instead, they may be more receptive to conclusions presented by an AI system, which is perceived as neutral, objective, and non-judgemental. The user inputs their answers, and the system delivers fast and clear feedback tailored to the person's level of education. AI can adapt the interpretation of results in a way that makes them easily comprehensible and acceptable from the start.

Intervention Stages: Screening and Awareness. The individual completes a self-administered questionnaire, and the AI analyses the responses to provide personalised feedback. The message is adapted to the user's educational level and delivered in accessible language.

Accepting Counselling – The next step involves proposing a periodic counselling plan (e.g., one session per week or more frequently, depending on the case), with continuous encouragement and recognition of even the smallest progress. Unlike human interactions, AI does not criticise, judge, or respond emotionally when an individual admits to continued substance use. The responses generated convey respect and empathy, maintaining a consistently pleasant and optimistic tone. Moreover, AI can repeat the same message as many times as necessary until the person understands and accepts it.

A crucial advantage is the system's constant availability. Unlike therapists or psychologists who have limited working hours, AI is accessible 24/7. For example, a young person returning home late at night can receive real-time support, without being dependent on a professional's schedule.

Access is entirely unconditional – anyone, regardless of language, cognitive ability, education level, social status, gender, or race, can benefit from this platform. The AI-based counselling programme is public, clearly structured, and easy to follow, especially for users familiar with tablets, smartphones, or other devices. This greatly increases the potential number of users.

If, for instance, 1,000 individuals access the programme at the same time, each will receive a personalised response tailored to their individual profile. Native language translation is supported, and messages are scaled to match each user's level of understanding.

The term drug use per se refers strictly to the consumption of illicit substances, independent of possession, trafficking, or production offences. This legal distinction varies across jurisdictions within the European Union. For instance, in Spain, Italy, and Portugal, law enforcement differentiates between use and possession for trafficking, often applying alternative or administrative sanctions for the former (EMCDDA, 2022).

In Portugal, the landmark Law No. 30/2000 decriminalised the personal use and possession of small quantities of drugs (below 10 daily doses) and established Commissions for the Dissuasion of Drug Addiction, which apply administrative measures rather than criminal penalties (Hughes & Stevens, 2010). The policy aimed to reduce the stigma surrounding drug use and increase access to treatment and social support, with promising public health outcomes such as reductions in HIV transmission among PWID.

In Italy, although the "daily dose" criterion was abolished in 1993, authorities continue to differentiate between user-level and trafficking-level possession, often using discretion during enforcement (EMCDDA, 2022). Administrative sanctions, such as licence suspension or mandatory counselling, may still apply.

The Netherlands maintains a pragmatic classification system for drugs. "Soft" drugs like cannabis are tolerated for personal use (under 30g), while "hard" drugs such as heroin and cocaine remain strictly prohibited (van het Loo, van Beusekom, & Kahanet, 2002). Similar harm-reduction approaches are adopted in Austria, Luxembourg, and Ireland, with variations in penalty severity and conditional suspensions for cannabis use or therapeutic exceptions.

These varied approaches reflect an evolving legislative landscape in the EU that leans increasingly towards decriminalisation or public health-oriented policies. They also emphasise the prevention of drug use, treatment, and harm reduction, rather than purely punitive measures (EMCDDA, 2022).

For Romania, addressing drug use effectively requires evidence-based strategies aligned with the National Anti-Drug Strategy 2005–2012, which was developed during the EU accession period and recognised drug use as a growing health and social concern (Romanian National Anti-Drug Agency, 2005). Key factors identified include increased drug trafficking, a rise in injectable heroin use, and the spread of infectious diseases such as HIV and Hepatitis C.

Without comprehensive analysis and early intervention, drug use could escalate into a significant social and healthcare burden. The use of scientific evidence and international best practices is essential for shaping coherent and effective national policies.

4. Conclusions and Limitations

Pilot Phase and Program Expansion

In the initial phase, we focused on the Romanian population and conducted a pilot study. The responses generated by AI are highly flexible, and if a user wishes to contact a therapist, they can do so via email or phone.

Since 1998, Romania has initiated national research to better understand the extent and dynamics of drug use. One of the earliest and most relevant studies was the "Rapid Assessment of the Situation of Injectable Drug Users in Romania," conducted with the support of UNICEF, UNAIDS, and CIDA. It followed the World Health Organisation (WHO) methodology for rapid assessments, commonly used in countries with emerging drug use trends and limited surveillance infrastructure (World Health Organisation, 2000; UNICEF, 2002).

The study targeted key urban centres, Bucharest, Constanta, Iasi, and Timisoara, selected for their demographic significance and proximity to drug trafficking routes. These cities were identified as high-risk zones for injectable heroin use, often associated with unsafe practices like needle sharing, leading to increased rates of HIV, Hepatitis B, and C infections (UNAIDS, 2000; EMCDDA, 2007).

The evidence highlighted a steady rise in drug consumption in Romania since the 1990s, mirroring trends observed in neighbouring Eastern European countries. However, the scale of the phenomenon remained relatively small.

The study emphasised that early intervention, evidence-based policies, and cross-sector collaboration (healthcare, law enforcement, education) are essential to prevent drug use from evolving into a major social and public health crisis (Romanian Anti-Drug Agency, 2005).

These findings contributed to the development of Romania's National Anti-Drug Strategy (2005–2012), a policy aimed at harmonising national responses with European Union standards as part of the EU accession process (EMCDDA, 2022).

We note that, for this stage, we are preparing a strategy aimed at selecting a large number of young people and adolescents who will benefit from a combined intervention method — the use of Artificial Intelligence (AI) alongside close monitoring by experienced specialists.

In practice, we will provide a dual form of counselling: one generated by AI and personalised for each individual, and another involving human oversight to ensure the quality of the interaction. Based on the specialists' observations, adjustments, or improvements to the intervention can be made, as needed.

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