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Synthetic Drugs and Emerging Adulterants: A Rapidly Evolving Public Health Threat

Dr. Amit Sachdeva[1*], Mr Nasim Ahmed[2], Mrs. Tamanna Rahman[3], Dr. Anju Sachdeva[4]

[1]Assistant Professor, Department of Community Medicine, Indira Gandhi Medical College, Shimla, Himachal Pradesh
[2]Independent Researcher, Guwahati Assam, India Email: nasim@iarcon.org
[3] MSc in Herbal Science and Technology , Anandaram Dhekial Phookan College under Guwahati University, Assam
[4]Physiotherapist, Shimla, Himachal Pradesh

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Abstract: Background: Synthetic and semi-synthetic drugs have transformed illicit drug markets by allowing potent psychoactive substances to be manufactured without dependence on traditional drug crops. Illicitly manufactured fentanyl and its analogues, benzimidazole opioids known as nitazenes, synthetic cannabinoids, synthetic cathinones, methamphetamine, novel benzodiazepines and non-opioid adulterants such as xylazine are creating increasingly unpredictable patterns of poisoning, dependence and death. In northern India, the street term "chitta" generally denotes heroin or an adulterated white-powder opioid rather than a chemically defined synthetic drug. **Objective:** This narrative review critically examines emerging synthetic drugs and adulterants from a public health perspective, including their health effects, market dynamics, surveillance challenges and implications for prevention, treatment and policy, with particular attention to India. **Key findings:** Synthetic drugs can be inexpensive to manufacture, highly potent, easy to conceal and rapidly modified to evade legal controls. Fentanyl is approximately 50–100 times more potent than morphine, while several fentanyl analogues and nitazenes may be still more potent. Xylazine, a veterinary α2-adrenergic agonist increasingly detected with illicit fentanyl in North America, is not an opioid and is not reversed by naloxone, although naloxone remains essential because opioid co-exposure is common. The emerging market is characterized by polysubstance mixtures, counterfeit tablets and unintentional exposure. Conventional toxicology, seizure data and mortality systems frequently fail to identify new compounds. India already has a substantial opioid-use burden, but contemporary population-level evidence on fentanyl, nitazenes and xylazine is limited. **Conclusion:** Synthetic-drug policy should move beyond episodic prohibition and moralistic awareness campaigns. Effective prevention requires early-warning surveillance, expanded forensic and clinical toxicology, naloxone access, evidence-based treatment of opioid-use disorder, low-threshold harm reduction, regulation of precursor chemicals, clinically informed law enforcement and international cooperation. Public health preparedness is essential before a large mortality epidemic becomes visible.

Keywords: Synthetic opioids; fentanyl; nitazenes; xylazine; new psychoactive substances; harm reduction.

INTRODUCTION

Illicit drug markets are undergoing a fundamental transition. Traditional substances such as opium, heroin, cocaine and cannabis depend largely on cultivation, geographical conditions and lengthy supply chains. Synthetic substances can be produced throughout the year in clandestine laboratories using chemical precursors, often close to consumer markets. Their chemical structures can be altered rapidly, allowing manufacturers to circumvent controls and create new psychoactive substances faster than many regulatory and toxicological systems can respond.

The United Nations Office on Drugs and Crime has identified synthetic drugs as an increasingly important component of the global market. Synthetic opioids were the second-largest synthetic-drug group seized

by weight in 2023, with fentanyl dominating seizures, while nitazenes and other novel opioids were reported across a growing number of regions.[1]

The term "synthetic drug" covers pharmacologically diverse substances. It includes synthetic opioids such as fentanyl and nitazenes; synthetic stimulants such as methamphetamine and cathinones; synthetic cannabinoids sold as "Spice" or related products; dissociatives; hallucinogens; designer benzodiazepines; and combinations containing veterinary sedatives. These substances do not produce one uniform syndrome and require different clinical and public health responses.

In northern Indian discourse, particularly in Punjab, Haryana and Himachal Pradesh, "chitta" generally refers to white-powder heroin, low-purity heroin or an adulterated opioid product. It is a street-market label rather than a chemical diagnosis. A product sold as chitta may vary in heroin concentration and contain pharmaceutical agents, sedatives or other adulterants. Without laboratory analysis, it should not be described confidently as fentanyl, "synthetic heroin" or any other specific compound.

The public health concern is not simply the growing number of drugs. It is the emergence of a market in which neither consumers nor clinicians can reliably know what substance, dose or combination has been taken.

Why Synthetic Drugs Change the Risk Environment

Synthetic-drug production has several commercial advantages for illicit suppliers. It avoids dependence on agricultural cycles, occupies less physical space, and allows highly potent substances to be transported in small quantities. A kilogram of a potent synthetic opioid can generate many more retail doses than an equivalent weight of heroin.

Potency also creates exceptional dosing risk. Pharmaceutical fentanyl has legitimate roles in anaesthesia and pain management and appears on the WHO Model List of Essential Medicines. Illicit fentanyl, however, may be distributed as powder, mixed into heroin or stimulants, or pressed into counterfeit tablets. WHO describes fentanyl as approximately 50–100 times more potent than morphine and notes that fentanyl analogues have contributed to sharp increases in overdose deaths.[2]

With highly potent drugs, minor errors in mixing can create "hot spots" containing unexpectedly large doses. Individuals may believe they are using heroin, oxycodone, alprazolam or another familiar substance when they are actually exposed to fentanyl or a nitazene. Tolerance to one opioid provides incomplete protection when potency and composition vary unpredictably.

Rapid chemical modification further weakens regulation. When one molecule is controlled, clandestine producers may introduce a related compound that is not yet scheduled or routinely detected. Generic or analogue-based controls can reduce this delay but may also redirect production towards new chemical families. UNODC reported in 2026 that detections of emerging "orphine" analogues increased following broader controls on nitazenes in China, illustrating the adaptability of illicit markets.[3]

Synthetic Opioids: Fentanyl and Its Analogues

Fentanyl is a potent μ-opioid-receptor agonist. Like heroin and morphine, it can produce analgesia, euphoria, sedation, miosis and respiratory depression. Fatal toxicity results primarily from reduced respiratory drive, airway obstruction and hypoxia. The rapid onset of illicit fentanyl may narrow the time available for bystanders to recognize an overdose and administer naloxone.

Fentanyl analogues include carfentanil, acetylfentanyl, furanylfentanyl and numerous other compounds. Carfentanil was developed for immobilizing very large animals and is not approved for human use. Potency varies widely between analogues, and estimates derived from animal or laboratory studies should not be translated simplistically into a precise "fatal dose" for humans.

The United States provides the clearest warning of the potential scale of harm. In 2023, nearly 73,000 overdose deaths involved synthetic opioids, excluding methadone, representing approximately 92% of opioid-involved deaths.[4] Although US overdose mortality has subsequently declined, illicit fentanyl remains involved in most fatal overdoses and is frequently combined with stimulants, benzodiazepines or veterinary sedatives.

Naloxone reverses opioid-induced respiratory depression and should be administered whenever opioid overdose is suspected. Highly potent or long-acting substances may require repeated dosing and continuing observation, but claims that naloxone "does not work" against fentanyl are incorrect. Rescue breathing, emergency activation and monitoring remain essential because naloxone does not reverse hypoxic injury or toxicity from non-opioid co-adulterants.

Nitazenes: The Emerging Second Wave

Nitazenes are benzimidazole-derived synthetic opioids first developed during pharmaceutical research in the mid-twentieth century but never approved as routine human medicines. Isotonitazene was first reported to the UNODC Early Warning Advisory in 2019. By early 2025, 26 nitazenes had been identified in 30 countries across multiple continents.[5]

Several nitazenes have potency comparable to or exceeding fentanyl, although potency differs substantially among compounds. They have been detected in substances sold as heroin, opioid medicines, benzodiazepines and even non-opioid products. Users may therefore be exposed without intending to consume an opioid.

Between 2019 and incomplete reporting for 2024, UNODC received information on 292 toxicology cases involving nitazenes from seven reporting jurisdictions; 82% were post-mortem cases.[5] These figures are not estimates of global mortality. They illustrate the seriousness of reported events and the limited reach of current surveillance.

Nitazenes can cause profound respiratory depression and are responsive to naloxone. Multiple doses may be needed, depending on the compound, dose, delay and co-exposures. Their emergence has exposed a major laboratory gap because standard hospital drug screens and many routine post-mortem panels do not detect them.

Xylazine and the Misleading "Zombie Drug" Label

Xylazine is a veterinary sedative and α2-adrenergic agonist used for animal procedures. It is not approved for human use and is not an opioid. In the illicit US market it has increasingly been identified in fentanyl-containing products, possibly because it prolongs sedation or modifies the perceived effects of fentanyl.[6]

Xylazine can cause profound sedation, hypotension, bradycardia and respiratory compromise. It has also been associated with severe skin and soft-tissue wounds, including necrotic ulcers that may develop beyond the site of injection. The mechanisms are incompletely understood and may involve vasoconstriction, repeated tissue injury, infection, poor nutrition and limited access to wound care.

The popular term "zombie drug" is scientifically inaccurate and stigmatizing. It dehumanizes affected people and reduces a complex toxicological and social problem to sensational imagery. Such language may discourage patients from seeking wound care and reinforce punitive rather than therapeutic responses.

Naloxone does not reverse xylazine itself, but it should still be given in suspected overdose because xylazine is commonly combined with fentanyl or another opioid. Emergency management requires airway support, ventilation, cardiovascular monitoring and treatment of co-intoxication. There is no approved human antidote for xylazine toxicity.

Analysis of 21 US jurisdictions found that the monthly percentage of illicit-fentanyl-involved overdose deaths in which xylazine was detected increased by 276% from January 2019 to June 2022.[7] This was a geographically specific surveillance finding and should not be presented as a global trend.

Recent warnings also identify medetomidine, another veterinary α2-agonist, in parts of the illicit fentanyl supply. This suggests that xylazine may not be an isolated phenomenon but part of continuing experimentation with non-opioid sedatives.[8]

Other Major Synthetic-Drug Groups

Synthetic cannabinoids

Synthetic cannabinoids activate cannabinoid receptors but are chemically distinct from cannabis. Their potency and receptor activity can be much greater and less predictable than Δ9-tetrahydrocannabinol. Clinical effects include severe agitation, psychosis, seizures, vomiting, acute kidney injury, myocardial ischaemia and loss of consciousness.

Products marketed under the same name may contain different chemicals, and users may not know that plant material, vaping liquid or edible products have been sprayed with synthetic cannabinoids. Routine urine cannabinoid tests generally do not identify many of these substances.

Synthetic cathinones

Synthetic cathinones are stimulant compounds related structurally to cathinone, the active constituent of khat. Examples include mephedrone, methylone and α-pyrrolidinopentiophenone. The sensational label "bath salts" is a market or media term, not a pharmacological category.

Toxicity may include severe agitation, paranoia, hyperthermia, tachycardia, hypertension, seizures, rhabdomyolysis and multiorgan failure. Management is primarily supportive, including sedation, cooling, fluid management and treatment of complications.

Methamphetamine

Methamphetamine is an established synthetic stimulant rather than a new psychoactive substance. It produces wakefulness, euphoria and reduced appetite but can cause dependence, psychosis, cardiovascular injury, stroke, dental disease and infectious risk when injected or used in high-risk sexual contexts.

Unlike fentanyl, methamphetamine does not usually cause isolated respiratory arrest. However, the increasing co-occurrence of stimulants and opioids complicates recognition and treatment. An individual may be simultaneously agitated, hyperthermic and at risk of delayed respiratory depression.

Designer benzodiazepines and counterfeit medicines

Novel benzodiazepines such as etizolam analogues and other unapproved compounds may appear in counterfeit tablets. Alone they commonly cause sedation and impaired coordination; combined with opioids, they increase respiratory risk. Counterfeit pharmaceutical appearance creates a false sense of dose consistency and safety.

Table 1. Emerging Synthetic Drugs and Adulterants: Health Risks and Public Health Responses

Drug group or adulterant	Typical market presentation	Major acute and chronic harms	Important clinical considerations	Priority public health response
Illicit fentanyl and analogues	Powder, heroin mixtures and counterfeit tablets	Rapid respiratory depression, hypoxia, dependence and fatal overdose	Administer naloxone promptly; provide ventilation and repeat dosing when required	Take-home naloxone, opioid agonist treatment, drug checking and early-warning surveillance
Nitazenes	Heroin, counterfeit medicines and unidentified powders	Profound opioid toxicity and unpredictable overdose clusters	Routine drug screens may miss them; naloxone remains indicated	Expand toxicology panels, rapid alerts and international information exchange
Xylazine	Usually mixed with illicit fentanyl	Sedation, hypotension, bradycardia, respiratory compromise and necrotic wounds	Naloxone treats opioid co-exposure but not xylazine; airway and wound care are essential	Low-threshold wound services, laboratory surveillance and non-stigmatizing communication
Medetomidine and related sedatives	Emerging fentanyl adulterants	Prolonged sedation, cardiovascular instability and complex withdrawal	No established human antidote; supportive care and co-exposure management	Sentinel detection and rapid clinical guidance
Synthetic cannabinoids	Sprayed herbal material, vapes, edibles and powders	Psychosis, agitation, seizures, kidney injury and cardiovascular toxicity	Effects differ from cannabis; routine cannabinoid screens may be negative	Poison-centre surveillance, youth education and product testing
Synthetic cathinones	Powders, tablets and products sold as stimulants or	Hyperthermia, paranoia, hypertension, seizures and	Supportive care, benzodiazepine sedation and aggressive cooling	Event-based surveillance, emergency training and nightlife harm

	"bath salts"	rhabdomyolysis	may be required	reduction
Methamphetamine	Crystal, powder or tablets	Dependence, psychosis, cardiovascular disease, stroke and infectious risks	No naloxone role unless opioid co-exposure is suspected	Psychosocial treatment, contingency management, HIV and hepatitis services
Designer benzodiazepines	Counterfeit anxiety or sleeping tablets	Sedation, amnesia, falls, dependence and enhanced opioid toxicity	Prolonged effects and withdrawal may be difficult to predict	Counterfeit-pill warnings, toxicology capacity and cautious withdrawal management
"Chitta" and other street-labelled opioids	White or brown powder sold as heroin	Opioid dependence, overdose, injection injury and blood-borne infection	Street name does not identify composition; treat suspected opioid overdose clinically	Laboratory characterization, naloxone, opioid agonist treatment and community outreach
Polysubstance mixtures	Variable combinations of opioids, stimulants and sedatives	Overlapping toxidromes, delayed deterioration and increased mortality	Treat the patient's physiology rather than relying on the reported drug name	Broad toxicology, integrated treatment and communication of local alerts

Public Health Significance

Synthetic drugs convert a long-standing substance-use problem into a rapidly changing poisoning environment. Traditional prevention messages based on recognizing a known drug or avoiding a particular dose become less effective when composition varies between batches and products are intentionally mislabelled.

They also create a mass-casualty potential at community scale. One contaminated batch can generate clusters of unconscious patients within hours. Emergency departments, ambulance systems, police, poison centres, forensic laboratories and community organizations therefore require real-time communication.

The harms are socially concentrated. People experiencing homelessness, incarceration, unemployment, mental illness and unstable access to treatment are more likely to encounter unpredictable supplies and delayed medical care. Criminalization and stigma increase the likelihood of solitary use, hurried injection and failure to call emergency services.

A purely enforcement-based response can unintentionally increase risk. Removing one drug or precursor without maintaining treatment and harm-reduction services may create shortages that encourage suppliers to substitute more potent compounds. Effective supply reduction must therefore be synchronized with demand reduction, overdose prevention and treatment expansion.

The Indian Context

India's 2019 national substance-use survey estimated that approximately 22.6 million people used opioids and around 7.7 million required help for opioid-use problems. Heroin was an important component of harmful opioid use, alongside opium and pharmaceutical opioids.[9]

These figures remain the best available nationally representative estimates, but they predate recent international changes in fentanyl and nitazene markets. They cannot determine the current prevalence of synthetic-opioid exposure. India urgently needs updated population, treatment and toxicological data.

South Asia continues to face extensive opiate trafficking while also experiencing growth in synthetic-drug production and seizures. Regional reporting in 2025 described increasing trafficking incidents involving methamphetamine, pharmaceutical products and other synthetic substances.[10]

India has a large chemical and pharmaceutical industry, extensive maritime and land borders and proximity to major opiate and methamphetamine trafficking regions. These characteristics create

potential vulnerabilities involving precursor diversion, clandestine manufacture, counterfeit medicines and transit trafficking. They do not demonstrate that India currently has a fentanyl-xylazine epidemic comparable to North America.

The word "chitta" deserves particular caution. Police or media reports may label seized powder as chitta or heroin before complete forensic characterization. Public health surveillance should record laboratory-confirmed composition wherever possible. Otherwise, changes in adulteration, potency or the appearance of fentanyl analogues may remain invisible.

India's treatment response includes de-addiction centres, opioid substitution therapy, psychiatric services and community programmes under the National Action Plan for Drug Demand Reduction. Coverage and quality remain uneven. Many people encounter the criminal justice system before health services, and fear of arrest may delay overdose calls.

Naloxone availability outside hospitals is limited compared with the scale of opioid need. Wider take-home distribution to people who use opioids, family members, peer workers, outreach teams, police and ambulance personnel could prevent deaths. Opioid agonist treatment with buprenorphine or methadone reduces illicit opioid use and mortality and should be treated as essential long-term health care rather than short-term detoxification.

Recent Advances

Drug checking using mass spectrometry, infrared spectroscopy and test strips can identify unexpected substances and communicate rapid alerts. Fentanyl test strips are useful in some settings but do not identify all analogues or quantify dose. Xylazine and nitazene test technologies are emerging but require field validation.

Wastewater surveillance can identify community-level drug trends without relying solely on arrest or treatment data. It cannot determine individual behaviour and requires careful interpretation, but it may reveal changes before mortality increases.

High-resolution mass spectrometry and broad non-targeted toxicology are increasingly important because laboratories cannot rely on fixed panels. Shared spectral libraries and international early-warning systems allow newly identified substances to be recognized across countries.

Digital epidemiology—including monitoring of poison-centre calls, emergency presentations and online drug markets—may provide early signals. However, algorithms can misclassify slang, exaggerate media trends and raise privacy concerns. Laboratory confirmation remains essential.

Challenges and Limitations

A major problem is data delay. Mortality certification, toxicology and forensic reporting may take months, while new substances spread within days. Many deaths are recorded simply as opioid poisoning without identification of specific compounds.

Routine hospital immunoassays detect broad drug classes but may miss fentanyl, nitazenes, xylazine, synthetic cannabinoids and designer benzodiazepines. A negative screen therefore does not exclude intoxication.

Potency comparisons are frequently oversimplified. Statements that one drug is "hundreds of times stronger" may refer to receptor activity, analgesic potency or animal studies rather than real-world fatality risk. Formulation, route, tolerance and co-exposure strongly influence outcome.

Sensational terminology—"zombie drug," "grey death" or "super heroin"—may attract attention but can spread misinformation and stigma. Risk communication should describe specific effects, uncertainty and protective actions.

India's largest limitation is the scarcity of systematic toxicological surveillance. Absence of reported xylazine or nitazene deaths may reflect genuine low prevalence, failure to test or failure to link results across laboratories. Policy should avoid both complacency and unsupported claims of an epidemic.

Future Directions

India and other countries should establish integrated early-warning systems linking emergency departments, poison centres, forensic laboratories, drug-treatment programmes, law enforcement and community organizations. Alerts must reach clinicians and people who use drugs rapidly.

Sentinel toxicology laboratories should use broad analytical methods and participate in international reference networks. A representative sample of seized substances and overdose specimens should undergo detailed characterization.

Take-home naloxone should be expanded through hospitals, opioid-treatment centres, prisons, outreach services and pharmacies. Training should emphasize that repeated naloxone may be needed and that rescue breathing and emergency care remain essential.

Treatment of opioid-use disorder should be scaled through primary care, psychiatry and community clinics. Forced detoxification without continuing medication increases relapse and overdose risk, particularly when tolerance has fallen.

Low-threshold wound care is needed wherever xylazine-associated injury emerges. Patients should be able to receive dressings, antibiotics when clinically indicated, surgical assessment and addiction treatment without punitive exclusion.

Regulation should focus on precursor supply chains and organized production while avoiding disruption of legitimate access to pharmaceutical fentanyl for surgery, cancer pain and palliative care. Excessively restrictive controls can worsen untreated pain without necessarily stopping illicit production.

Finally, people who use drugs must be involved in programme design. They are often the first to notice changes in potency, appearance or unusual effects. Treating their observations as surveillance intelligence rather than criminal confession can save lives.

CONCLUSION

Synthetic drugs have created an illicit market defined by exceptional potency, rapid chemical innovation, adulteration and uncertainty. Fentanyl analogues, nitazenes, xylazine, synthetic cannabinoids, cathinones, methamphetamine and designer sedatives present distinct but overlapping threats.

The central public health danger is not simply deliberate use of new drugs. It is unintentional exposure through counterfeit tablets and mixed powders, combined with inadequate toxicology and limited treatment access.

India already has a substantial opioid-use burden, while “chitta” has become a prominent regional term for illicit heroin products. It should not be assumed that every chitta sample contains fentanyl or is wholly synthetic. Laboratory evidence, rather than street terminology or sensational reporting, must guide policy.

Preparedness should begin before synthetic-opioid deaths become common. Early-warning surveillance, naloxone, opioid agonist treatment, forensic capacity, harm reduction, wound care, precursor regulation and non-stigmatizing communication are complementary interventions.

The history of fentanyl in North America demonstrates the cost of responding after mortality has escalated. A public health approach must anticipate market change, protect people regardless of legal status and ensure that every overdose becomes an opportunity for treatment rather than another preventable death.

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