INVESTIGATION OF SUSPICIOUS DEATHS IN THE CONTEXT OF SYNTHETIC DRUG CONSUMPTION

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Abstract:
The increasing use of synthetic drugs represents one of the most significant challenges faced by modern forensic investigation. Unlike traditional narcotics, new psychoactive substances (NPS) are characterized by rapid chemical evolution, diverse toxicological profiles and limited availability of analytical standards, which often complicate the process of detection and interpretation in post-mortem examinations. This study explores the forensic and medico-legal aspects of investigating suspicious deaths associated with synthetic drug use, emphasizing the need for close cooperation between the forensic investigator, toxicologist and pathologist. The article emphasizes the importance of multidisciplinary collaboration in establishing both the cause and mechanism of death, as well as the social and criminal implications of synthetic drug consumption. It also discusses the growing need for national and international databases dedicated to emerging psychoactive substances, which would facilitate the identification of unknown compounds and support comparative toxicological research.
Keywords: *forensic science, synthetic drugs, new psychoactive substances (NPS), suspicious death.*

INTRODUCTION

The phenomenon of synthetic drug consumption has become one of the most pressing issues confronting forensic science and criminal justice systems in the twenty-first century. The proliferation of so-called *new psychoactive substances* (NPS), designed to mimic the effects of traditional drugs such as cocaine, amphetamines, or cannabis, has created an evolving challenge for law enforcement, forensic toxicology and public health alike. These substances, often sold under misleading labels such as “legal highs,” “bath salts,” or “herbal blends”, are characterized by rapid chemical innovation, unpredictable effects and limited detectability through standard analytical procedures. As a result, the investigation of deaths linked to synthetic drug consumption requires a far more complex and adaptive approach than in cases involving classical narcotics.

In forensic investigation, deaths related to synthetic drugs often fall under the category of *suspicious deaths*, as their external manifestations rarely offer clear evidence of overdose or poisoning. Victims may be found in non-violent circumstances, without

visible trauma or signs of struggle, yet the toxicological cause may remain concealed within the body's biochemical reactions. In such cases, the combined expertise of the forensic investigator, the pathologist and the toxicologist becomes indispensable. Each contributes to reconstructing the circumstances of death: the criminalist secures and documents the environment, the pathologist examines the physiological evidence and the toxicologist identifies the substances responsible for the fatal outcome.

Unlike traditional drugs, synthetic compounds frequently differ in their chemical structure from the controlled substances listed under international conventions. Small molecular modifications allow manufacturers to evade legal restrictions while maintaining psychoactive potential. This chemical variability creates immense difficulties for forensic laboratories, which must continuously update their reference databases and detection methods [1]. Moreover, the high potency of these substances, sometimes active in microgram quantities, means that even minimal exposure can cause severe physiological reactions, including cardiac arrest, respiratory failure and cerebral edema.

At the crime scene, the signs of synthetic drug involvement may be subtle or ambiguous. Investigators often find minimal physical evidence, small packets of powder, vaping devices, capsules, or unmarked tablets. The absence of injection marks or visible lesions can obscure the suspicion of drug use. Therefore, the criminalist must carefully document all potential indicators, including paraphernalia, packaging, or residues, while maintaining strict procedures for the chain of sample collection, preservation and handling required for later chemical analysis. Collaboration with the pathologist is crucial at this stage, as the position of the body, color of the skin and state of the pupils can provide preliminary hints of toxicological influence.

During autopsy, the forensic pathologist typically encounters non-specific findings. The organs may show congestion, pulmonary edema, or myocardial hypertrophy, none of which alone confirm intoxication. Internal examination may reveal cerebral swelling, petechial hemorrhages, or fatty liver changes, but these are merely indirect markers [1]. Only through detailed toxicological analysis can the presence of synthetic compounds be confirmed and their concentrations correlated with lethal outcomes. In this context, forensic toxicology has become a cornerstone of modern death investigation, with analytical methods such as gas chromatography–mass spectrometry (GC-MS), liquid

chromatography–tandem mass spectrometry (LC-MS/MS) and high-resolution time-of-flight spectrometry playing a decisive role.

The challenges extend beyond technical limitations. Many synthetic drugs are metabolized rapidly, disappearing from the bloodstream within hours or even minutes, leaving behind only trace metabolites. This transient detectability demands not only rapid sample collection but also specialized preservation techniques.

Furthermore, because reference standards for many emerging substances are unavailable or insufficiently validated, laboratories must often rely on advanced data interpretation and pattern recognition rather than direct compound identification. These limitations highlight the necessity of continuous collaboration between forensic institutions, national monitoring centers and international agencies such as the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) or the United Nations Office on Drugs and Crime (UNODC).

From a forensic perspective, deaths associated with synthetic drugs are not merely toxicological phenomena but also social and legal events. They reflect broader trends in illicit markets, patterns of online distribution and the increasing overlap between digital anonymity and chemical innovation. For investigators, this means that each case represents not only an isolated event but also a potential indicator of emerging public health threats. Establishing the source, distribution chain and user network can provide critical intelligence for preventing future fatalities.

Therefore, the investigation of suspicious deaths linked to synthetic drug consumption demands an integrated, multidisciplinary approach, one that unites the precision of chemical analysis with the observational accuracy of forensic pathology and the methodological discipline of criminalistics. The success of such investigations depends on continuous adaptation to new substances, inter-institutional cooperation and the ethical and scientific integrity of experts who interpret complex toxicological data within the judicial framework.

FORENSIC AND TOXICOLOGICAL ASPECTS OF SYNTHETIC DRUG-RELATED DEATHS

The investigation of deaths associated with synthetic drug use requires an in-depth understanding of both the pharmacological properties of these substances and the forensic mechanisms by which they manifest their effects. Unlike classical drugs of abuse such as heroin, cocaine, or cannabis, whose toxicodynamics and physiological responses are well-documented, synthetic drugs are characterized by extreme chemical variability, rapid onset and unpredictable potency. Each generation of new psychoactive substances (NPS) introduces modified compounds designed to bypass legal restrictions, often resulting in mixtures whose effects on the human body remain poorly understood. This chemical and biological uncertainty is what makes forensic interpretation particularly complex in cases of synthetic drug-related deaths.

From a forensic perspective, synthetic drugs can be classified into several major categories based on their dominant psychoactive effects: synthetic cannabinoids, synthetic cathinones, phenethylamines, tryptamines and various designer opioids. Synthetic cannabinoids, often sprayed on herbal material and sold as “Spice” or “K2,” act on the same brain receptors as THC but with significantly higher potency, sometimes several hundred times stronger. Their use has been associated with acute psychosis, seizures, respiratory failure and sudden cardiac arrest. Synthetic cathinones, known colloquially as “bath salts,” are stimulant compounds related to amphetamines.

They induce euphoria, paranoia and aggression, but also lead to hyperthermia, metabolic acidosis and cardiovascular collapse. Phenethylamines and tryptamines, hallucinogenic substances similar to LSD or mescaline, can produce sensory distortion and severe autonomic instability. Designer opioids, particularly fentanyl analogues, pose the greatest immediate risk due to their microgram-level lethality and high potential for respiratory depression.

Each of these substance classes leaves specific, although often subtle, forensic and toxicological indicators. At the scene, investigators may observe minimal or non-specific signs, *id est* [2] disarrayed environments, presence of smoking devices, foil packets, or vaping cartridges. In many cases, synthetic drug users are found in ordinary circumstances, without clear external trauma or visible evidence of overdose [3]. Because

of this, the collaboration between the forensic investigator and the forensic pathologist is crucial. The investigator secures all possible paraphernalia and traces, powders, capsules, pipes, syringes, or residues, ensuring proper labeling and preservation for laboratory analysis. Meanwhile, the pathologist examines the body for non-specific but suggestive findings such as cyanosis, froth at the mouth, pulmonary congestion, or dilated pupils, which can point toward toxic intoxication.

Autopsy findings in synthetic drug deaths are frequently non-diagnostic. In most cases, the pathologist identifies generalized visceral congestion, cerebral and pulmonary edema, petechial hemorrhages and occasionally fatty degeneration of the liver. The heart may exhibit arrhythmogenic lesions or structural abnormalities such as left ventricular hypertrophy or interstitial fibrosis, especially in cases of chronic use. Histological examination may reveal neuronal swelling and astrocyte activation in the brain, indicating hypoxic injury. Yet these findings alone cannot establish a definitive cause of death; they must be interpreted in conjunction with toxicological data.

Toxicological analysis plays a decisive role in confirming the involvement of synthetic substances. However, this process is fraught with challenges. Many NPS are not included in routine toxicology panels and require advanced analytical methods such as gas chromatography–mass spectrometry (GC-MS), liquid chromatography–tandem mass spectrometry (LC-MS/MS) and high-resolution time-of-flight mass spectrometry (HRMS). These techniques allow for the detection of both parent compounds and their metabolites, even when present in minute concentrations. Sample selection is equally critical: blood, urine, vitreous humor, hair and tissue specimens (especially liver and brain) can yield valuable toxicological evidence. Because many synthetic drugs metabolize rapidly, the timing of sample collection and storage conditions significantly influence detection success [4].

Another complicating factor is the emergence of hybrid or multi-component mixtures. Street preparations often contain multiple psychoactive ingredients combined in unpredictable ratios. The toxicological interpretation becomes even more difficult when interactions between compounds lead to synergistic or antagonistic effects. For example, combining synthetic cannabinoids with alcohol or benzodiazepines can potentiate respiratory depression, while mixing cathinones with MDMA or amphetamines can

exacerbate hyperthermia and cardiac stress. These complex interactions require not only analytical precision but also a deep understanding of pharmacological mechanisms.

In addition to identifying the substance, toxicologists must establish the toxicokinetic parameters, absorption, distribution, metabolism and excretion, to determine whether detected concentrations are consistent with a fatal event. Reference data for many new compounds are lacking, which forces experts to rely on comparative analysis with chemically related substances or data from previous case reports. International toxicology networks, such as the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) or the National Institute on Drug Abuse (NIDA), play a crucial role in updating forensic laboratories with information on emerging drugs, metabolites and threshold values.

From a medico-legal standpoint, the forensic pathologist must integrate the toxicological findings with morphological observations and investigative data. Determining the cause of death, whether it was due to direct toxicity, a combination of substances, or secondary complications such as cardiac arrhythmia or aspiration, requires careful correlation between medical and investigative evidence. In many cases, the mechanism of death is multifactorial, involving both central nervous system depression and systemic organ dysfunction.

The forensic investigator's contribution extends beyond evidence collection. They provide essential contextual information about the circumstances surrounding the death, *id est* [5] the victim's behavior prior to collapse, witness statements, environmental conditions and digital evidence such as text messages or social media activity related to drug use. This contextual data allows the pathologist and toxicologist to interpret laboratory results more accurately and to differentiate between accidental overdose, suicidal intent and potential criminal involvement (for example, distribution of adulterated substances).

Finally, the interpretation of synthetic drug-related deaths demands transparency and caution in expert reporting. Given the rapid evolution of these substances and the uncertainty surrounding their toxic thresholds, experts must avoid overinterpretation and clearly state the limitations of their findings. The forensic report should specify the analytical methods used, the substances detected, their concentrations and the likely

pharmacological effects in correlation with the observed pathological findings. Only through such detailed, multidisciplinary synthesis can forensic experts provide conclusions that withstand scientific and judicial scrutiny.

The forensic and toxicological investigation of deaths related to synthetic drug use is a complex process that requires advanced technical expertise, continuous adaptation and interdisciplinary cooperation. Each case demands not only analytical precision but also interpretative depth, bridging the gap between chemistry, medicine and law. Through the combined efforts of criminalists, pathologists and toxicologists, forensic science continues to evolve to meet the challenges posed by synthetic substances, ensuring that even the most elusive poisons leave behind traces that can speak for the silent victims they claim.

METHODOLOGY AND INTERDISCIPLINARY COLLABORATION IN THE INVESTIGATION OF SYNTHETIC DRUG-RELATED DEATHS

The investigation of deaths associated with synthetic drug use requires an approach that transcends traditional disciplinary boundaries. Such cases are inherently complex, as they often involve substances that are chemically unstable, rapidly metabolized and legally undefined at the time of death. Therefore, a coordinated methodological framework, uniting the expertise of the forensic investigator, forensic pathologist and toxicologist, is essential to ensure both scientific accuracy and judicial validity. Each specialist contributes a unique but interdependent perspective and only through their integration can the circumstances of death be reconstructed with precision.

The investigative process begins at the crime scene, where the forensic investigator assumes a leading role in the initial documentation and preservation of evidence. The first task is to secure the area, establish control zones to prevent contamination and maintain a detailed log of all personnel entering the scene [6]. Synthetic drug-related deaths often occur in domestic environments, vehicles, or public spaces and their presentation can vary from apparently natural deaths to sudden collapses following recreational use. The investigator must therefore approach each scene without presupposition, recognizing that the absence of visible trauma does not exclude intoxication.

The crime scene examination involves a systematic visual and instrumental assessment of the environment. The investigator photographs the scene comprehensively, wide shots to capture spatial relationships and close-ups for critical details such as paraphernalia, containers, or residue traces [7]. Items commonly associated with synthetic drugs include smoking devices, vape cartridges, powders, pills, capsules, foil packets and improvised laboratory materials. The discovery of digital evidence such as mobile phones, laptops, or printed materials can also reveal communications, purchase records, or instructions for drug synthesis [8]. These must be secured under appropriate cyber forensic protocols.

The forensic pathologist's participation at the scene is indispensable. Their medical expertise allows for the immediate evaluation of external indicators such as body position, lividity, rigor mortis, skin coloration and the presence of froth or vomit. In certain cases, the pattern of livor mortis or the distribution of post-mortem changes can suggest whether the death was instantaneous or delayed, information vital for subsequent toxicological interpretation [9]. Coordination between the investigator and the pathologist at this stage ensures that both the body and surrounding traces are examined as a coherent system rather than as isolated components.

Following the on-site examination, the body is transported to the forensic institute under controlled conditions. During autopsy, the forensic pathologist performs a meticulous external and internal examination, documenting all visible lesions, organ changes and physiological indicators that might suggest intoxication. The lungs, brain, liver and heart receive particular attention, as they frequently exhibit characteristic congestion, edema and cellular degeneration associated with drug toxicity [10]. Simultaneously, the pathologist collects biological samples-blood, urine, vitreous humor, bile, liver tissue and hair, for subsequent toxicological testing. The correct labeling, storage and preservation of these samples are critical because many synthetic substances degrade rapidly at room temperature or under exposure to light and air.

The toxicologist's contribution begins with the analytical evaluation of the collected materials. Given the chemical diversity of synthetic drugs, screening and confirmation require advanced technologies. The process typically includes preliminary screening using immunoassay kits or enzyme-linked techniques to detect the presence of known

drug classes, followed by targeted analysis through gas chromatography, mass spectrometry (GC-MS) or liquid chromatography, tandem mass spectrometry (LC-MS/MS) to identify specific compounds. When necessary, non-targeted analysis using high-resolution mass spectrometry (HRMS) or time-of-flight spectrometry (TOF-MS) is employed to detect unknown or novel substances based on fragmentation patterns and molecular weights [11].

Throughout this analytical process, close communication between the toxicologist and the pathologist is essential. For instance, the detection of synthetic cannabinoids in the liver and blood must be correlated with the absence of trauma or asphyxial signs to establish a toxic mechanism of death. Similarly, if stimulant-type compounds such as synthetic cathinones are identified, the presence of hyperthermia, cardiac lesions, or rhabdomyolysis in autopsy findings supports a pathophysiological link [12]. This reciprocal interpretation ensures that laboratory data are contextualized within biological and environmental evidence.

The forensic investigator continues to play an active role even after the laboratory analyses are completed. They collect supplementary contextual information such as statements from witnesses, surveillance footage, social media activity and transaction data that can reveal the timeline of substance use, potential suppliers, or co-users [13]. Such information not only strengthens the forensic narrative but also helps authorities identify criminal networks responsible for the distribution of lethal synthetic drugs.

The integration of all these findings culminates in a comprehensive forensic report, jointly produced or reviewed by the involved experts. This report must detail the environmental findings and trace evidence collected at the scene, the autopsy observations and histopathological results, the toxicological results specifying analytical methods and detection limits and the expert interpretation linking the medical and investigative conclusions. The report should be written in clear, objective and scientifically verifiable language, avoiding speculative statements [14]. Its conclusions must establish, with as much certainty as the evidence allows, whether the death resulted from acute intoxication, combined substance effects, or secondary complications such as cardiac arrest or aspiration.

Interdisciplinary collaboration also extends to institutional cooperation [15]. Many countries have established networks linking forensic institutes, toxicology laboratories and law enforcement agencies to share data on emerging substances and analytical results. Participation in these networks, such as the European Early Warning System coordinated by the EMCDDA, allows forensic professionals to identify new compounds promptly and adapt their methodologies accordingly. The continuous exchange of information reduces analytical gaps and improves the overall reliability of toxicological findings

Educational and procedural standardization is another pillar of successful collaboration [16]. Joint training sessions, simulation-based exercises and interdepartmental workshops foster mutual understanding between investigators, pathologists and toxicologists [17]. Standard operating procedures should clearly define responsibilities at each stage of the investigation, from scene processing to reporting, ensuring consistency and accountability.

Finally, ethical and legal considerations underpin the entire investigative process [18]. Handling of biological samples, privacy of toxicological data and impartial interpretation of results must adhere to the principles of scientific integrity and respect for human dignity. Transparency in communication and documentation guarantees that expert conclusions withstand both judicial scrutiny and public trust [19].

The methodology for investigating synthetic drug-related deaths exemplifies the need for seamless interdisciplinary cooperation. It unites field investigation, medical examination and chemical analysis into a single, coherent process that transforms scattered traces into scientifically grounded truth [20]. The collaboration between the forensic investigator, pathologist and toxicologist ensures not only the identification of the cause and mechanism of death but also contributes to a broader understanding of the evolving phenomenon of synthetic drug abuse, reinforcing the intersection of science, justice and public health.

CONCLUSIONS

The investigation of deaths associated with synthetic drug use represents one of the most complex and dynamic areas of contemporary forensic science. These cases

challenge traditional methodologies due to the chemical diversity, rapid metabolism and legal ambiguity of new psychoactive substances. Determining the cause and mechanism of death in such situations requires not only technical precision but also genuine interdisciplinary collaboration between the forensic investigator, the forensic pathologist and the toxicologist [21]. Each contributes essential expertise that, when combined, transforms uncertain or incomplete data into coherent and scientifically substantiated conclusions.

Synthetic drug-related deaths are particularly difficult to interpret because they often lack specific external or internal signs [22]. The forensic investigator must therefore rely on subtle environmental indicators, residues, paraphernalia, or behavioral evidence, to suggest the possibility of intoxication. The forensic pathologist must interpret non-specific anatomical findings, such as pulmonary or cerebral edema and correlate them with toxicological results. Meanwhile, the toxicologist must overcome analytical challenges posed by rapidly evolving substances that may not yet have established detection standards. This interdependence illustrates the necessity for communication and cooperation between all experts involved.

Beyond technical considerations, the interdisciplinary nature of such investigations underscores the broader role of forensic science as a bridge between medicine, chemistry and law. Each death attributed to synthetic drug use is not an isolated event but a symptom of a wider social and criminal phenomenon. Therefore, the forensic process extends beyond determining the immediate cause of death, it contributes to identifying distribution networks, patterns of abuse and the emergence of new psychoactive compounds that may endanger public health

In this context, collaboration is not merely procedural but strategic. The integration of medical, toxicological and investigative data ensures that every hypothesis is tested from multiple perspectives. A crime scene clue becomes meaningful only when correlated with biochemical evidence and a toxicological result gains legal value only when interpreted in light of the body’s pathological findings. The synthesis of these viewpoints allows for a multidimensional reconstruction of events, one that combines scientific accuracy with legal clarity.

Equally important is the need for continuous education and adaptation. The rapid evolution of synthetic drugs demands that forensic professionals remain up to date with new analytical techniques and emerging substances [23]. Inter-institutional networks, such as the European Early Warning System, must be strengthened to facilitate information exchange and establish standardized reporting protocols. Such cooperation not only enhances efficiency but also fosters uniformity in the interpretation of forensic results across jurisdictions.

Ethical responsibility forms the foundation of this collaboration. The handling of biological samples, the disclosure of toxicological findings and the preparation of forensic reports must all respect both scientific objectivity and human dignity. Experts have a dual obligation, to serve justice through truth and to protect the privacy and integrity of the individuals they investigate [24].

Ultimately, the investigation of deaths caused by synthetic drugs exemplifies the modern forensic paradigm, a science that is both empirical and interdisciplinary, analytical and humane. The integration of field investigation, autopsy examination and toxicological analysis transforms fragmented traces into a scientifically coherent narrative capable of withstanding judicial scrutiny [25]. Through the collective effort of investigators, pathologists and toxicologists, each silent victim of synthetic drug intoxication regains a voice in the search for truth. This process not only fulfills the requirements of criminal justice but also contributes to the prevention of future tragedies, strengthening the essential bond between science, society and the law.

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