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The Fentanyl Crisis

Abstract

The Fentanyl Crisis refers to the growing public health emergency caused by the widespread misuse and overdose deaths linked to fentanyl, a synthetic opioid. Initially developed for medical purposes, fentanyl is now a leading cause of opioid-related deaths, particularly in North America. Its potency — 50 to 100 times stronger than morphine—makes it extremely dangerous, especially when illicitly mixed with other drugs like heroin, cocaine, or counterfeit prescription pills.

The crisis has worsened due to its illegal production and distribution, mainly by organized crime groups. The increasing availability of fentanyl has compounded the ongoing opioid epidemic. In 2021, fentanyl was involved in a significant portion of the 70,000 opioid overdose deaths in the United States. This crisis has severe societal impacts, disproportionately affecting marginalized communities, people of color, and those living in poverty.

Efforts to combat the fentanyl crisis include public health campaigns, improved addiction treatment access, naloxone distribution, and harm reduction strategies like supervised injection sites. Governments are also focused on law enforcement actions to intercept fentanyl shipments. Despite these efforts, resolving the crisis requires a comprehensive approach, including better addiction support and broader drug policy reforms.

Keywords: *fentanyl, opioid crisis, overdose deaths, public health emergency, synthetic opioid, illicit drug market, naloxone, harm reduction, addiction treatment, public health campaigns, organized crime groups, drug policy reforms*

Introduction

Fentanyl-(N-(1-(2-phenylethyl)-4-piperidiny)-N-phenyl-propanamide was first synthesized in the early 1960s by Dr. Paul Janssen, a Belgian pharmacologist. The goal was to create a powerful synthetic opioid with stronger analgesic (pain-relieving) properties than traditional opioids, particularly for use in medical settings. In 1968, fentanyl was first introduced into the market under the brand name Sublimaze, intended for intravenous administration in hospitals to manage severe pain. This made fentanyl an invaluable tool in anesthesia and post-surgical pain management (Comer et al., 2012). As the years went by, fentanyl became widely used in various medical forms, including as patches (Duragesic), lozenges, and injectable solutions.

Throughout the 1980s and 1990s, fentanyl gained acceptance in medical practice due to its ability to provide effective pain relief, especially in patients with tolerance to less potent opioids and patients with cancer.

However, by the mid-1980s, fentanyl's use shifted significantly. A surge in the illegal production and distribution of fentanyl began to emerge, particularly in the United States. Fentanyl was illicitly manufactured, often in clandestine labs in countries such as China and Mexico, and trafficked into North America. Illicit fentanyl was often mixed with other drugs, such as heroin, cocaine, or counterfeit prescription pills, which has contributed to a dramatic rise in overdose deaths. The earliest cases of death due to fentanyl overdose were recorded in the 1980s in the United States. Users often consumed fentanyl unknowingly, believing they were using less potent drugs, only to experience fatal overdoses due to fentanyl's extreme potency.

Research

Fentanyl's interaction with the mu-opioid receptor (MOR) is a highly specific and potent biochemical process that initiates a cascade of intracellular events. After binding to MOR, fentanyl stabilizes the receptor in its active conformation, increasing its affinity for Gi/o-type G-proteins. Activation of Gi/o proteins subsequently inhibits adenylate cyclase, an enzyme responsible for converting ATP into cyclic adenosine monophosphate (cAMP). As intracellular cAMP levels decrease, a wide range of downstream signaling pathways become suppressed, altering both neuronal excitability and neurotransmitter release. This reduction in cAMP not only contributes to the analgesic effects of fentanyl but also underlies many of its adverse physiological consequences, including respiratory depression.

Another critical aspect of fentanyl's pharmacological action is its impact on the mesolimbic dopamine system, which plays a central role in reward, motivation, and reinforcement. Under normal physiological conditions, GABAergic interneurons in the ventral tegmental area (VTA) exert inhibitory control over dopamine-producing neurons. When fentanyl binds to MORs located on these GABAergic interneurons, GABA release is markedly reduced. This removal of inhibitory tone is known as disinhibition, and it causes dopamine neurons to fire more rapidly. As dopamine levels surge in the nucleus accumbens—a key region of the brain's reward pathway—individuals experience the characteristic euphoria, pleasure, and reinforcement associated with opioid use. This mechanism explains why fentanyl has a high potential for addiction even after a short period of exposure.

Beyond its analgesic and euphoric effects, fentanyl induces a range of physiological changes that stem from MOR activation in various brain regions. In the brainstem, MORs regulate the respiratory centers responsible for automatic breathing. Fentanyl's suppression of neuronal excitability in these regions leads to a decrease in respiratory rate, tidal volume, and responsiveness to carbon dioxide. This pharmacological action is the primary reason why fentanyl overdoses are frequently fatal: respiratory depression occurs rapidly and may progress to complete respiratory arrest if not promptly reversed. Additionally, fentanyl's high lipophilicity enables it to cross the blood–brain barrier extremely quickly, producing a rapid onset of both analgesic and respiratory effects—faster and more intense than many other opioids. From a pharmacokinetic perspective, fentanyl demonstrates unique properties that distinguish it from other opioids. Its high lipid solubility allows for rapid distribution into the central nervous system, but also leads to redistribution into fatty tissues. This means that even after the initial clinical effects diminish, fentanyl can remain stored in fat and be slowly released back into circulation, posing risks for prolonged toxicity. Metabolism occurs primarily in the liver through CYP3A4-mediated pathways, producing metabolites that are excreted via the kidneys. However, variability in CYP3A4 activity—due to genetics, drug interactions, or liver impairment—can significantly alter fentanyl's potency and risk of overdose.

In chronic exposure, fentanyl induces tolerance at multiple levels. Repeated MOR activation leads to receptor desensitization, internalization, and downregulation. As a result, higher and more frequent doses are required to achieve the same pharmacological effects, dramatically increasing overdose risk. Neuroadaptive changes also occur within the reward circuitry: dopamine pathways become less responsive, contributing to dysphoria, craving, and compulsive drug-seeking behavior when the drug is not present. These adaptations form the neurobiological foundation of opioid dependence and addiction.

This combination produces an intense but short-lived euphoria, followed by sedation and respiratory depression, the latter being the main cause of fatal overdoses. Because fentanyl acts so rapidly and so strongly, the brain adapts quickly: tolerance rises, natural reward pathways weaken, emotional balance deteriorates, and dependence forms with extraordinary speed. Over time, the drug reshapes neural networks related to decision-making, impulse control, and stress response, creating a cycle in which the individual feels psychologically and physiologically compelled to continue using it despite severe consequences.

The psychological dimensions of the crisis are as significant as the pharmacological ones. Fentanyl alters mood regulation, leading to increased anxiety, irritability, depression, and emotional numbing when the drug is absent. Many people affected by this crisis report a progressive loss of interest in daily life, relationships, and personal goals as the brain's reward system becomes dominated by the opioid's effects. The connection between trauma, chronic stress, socioeconomic instability, and opioid use is well-established: individuals with unresolved psychological pain or limited support systems are more vulnerable to substance use disorders. In many communities, fentanyl misuse becomes intertwined with feelings of hopelessness, social isolation, and unmet mental health needs, turning what starts as a chemical dependency into a broader psychological and societal breakdown.

The crisis intensified as illicit fentanyl began to infiltrate street drug supplies, often without users' knowledge. Because the substance is so potent that microscopic variations in quantity can determine life or death, accidental overdoses surged. The affordability and ease of transport of synthetic opioids encouraged illegal production and distribution, while economic hardships, inconsistent mental health care, and social fragmentation created fertile ground for escalating harm. As a result, the crisis expanded beyond individual behavior into a collective trauma affecting families, healthcare systems, emergency services, and entire communities.

The societal impact is profound: rising overdose deaths, increased demand for mental health and addiction services, burdened hospitals, and widespread grief in affected regions. Communities facing the crisis often struggle with stigma, preventing individuals from seeking help or receiving compassion. At the same time, the crisis exposes gaps in pain management practices, mental health care accessibility, and socioeconomic stability. Public health responses now emphasize awareness, prevention, comprehensive treatment approaches, and support for people living with addiction, while researchers work to understand long-term neurological consequences and develop safer pain-management alternatives.

Ultimately, the fentanyl crisis is not simply about a single substance; it is a reflection of how biological vulnerability, psychological distress, and social conditions can converge into a widespread health emergency. It demonstrates how the brain's chemistry, a person's emotional world, and the structure of a society are deeply interconnected. Only through addressing all three dimensions—neurological, psychological, and social—can meaningful progress be made toward recovery and prevention.

The illegal production and trafficking of fentanyl exploded in the 2010s, contributing to the opioid epidemic in the U.S. and Canada. As fentanyl overdoses increased sharply, it became a leading cause of death in the ongoing opioid crisis. In response, law enforcement, public health officials, and governments have been forced to step up efforts to combat fentanyl trafficking, while also expanding access to naloxone (Narcan) to reverse overdoses.

The transformation of fentanyl from a breakthrough medical innovation to a public health crisis highlights the complexity of the opioid epidemic and the urgent need for continued efforts in prevention, treatment, and harm reduction. Its impact on individuals and society is profound, from the health consequences for those who become addicted to its effects, to the broader societal and economic toll of increasing drug-related deaths and strained healthcare systems.

Understanding how fentanyl is made, how it affects the human body, and the urgent need for effective prevention and treatment strategies are essential in addressing this growing crisis (Han et al., 2019). Between 2012 and 2015, the number of fentanyl-related fatalities in the U.S. more than

doubled, and by 2016, fentanyl and its analogs were responsible for nearly half of all opioid-related overdose deaths in the country. This trend continued, with a significant spike in synthetic opioid deaths recorded by the CDC, which reported over 9,500 deaths in 2015, a 72% increase from the previous year. The global spread of fentanyl has also been documented in Europe, where countries like Germany and Lithuania have seen increasing numbers of fentanyl-related fatalities.

However, it also causes respiratory depression, which can be fatal if overdosed. Its high lipophilicity allows it to cross the blood-brain barrier quickly, resulting in rapid onset of effects but also increasing the risk of overdose (Jones et al., 2018). The impact of fentanyl on public health is significant, with opioid overdose deaths continuing to rise in North America and Europe. However, the rise of fentanyl in illicit drug markets continues to challenge efforts to control the opioid epidemic, highlighting the need for continued focus on prevention, treatment, and harm reduction strategies (Jannetto et al., 2019).

In summary, fentanyl's journey from a medical breakthrough to a key player in the opioid epidemic underscores the complexity of the crisis. While it remains an essential tool for pain management, its misuse, especially in illicit drug markets, has led to a dramatic increase in overdose deaths worldwide. The growing prevalence of fentanyl-related fatalities serves as a stark reminder of the need for comprehensive approaches to address both the public health and law enforcement aspects of the opioid crisis (Comer et al., 2019).

Fentanyl is a synthetic opioid that is 50-100 times more potent than morphine. While it is used medically for pain management, its illicit use has become a leading cause of the opioid overdose crisis. Fentanyl works by binding to mu-opioid receptors in the brain, which inhibits pain transmission and induces euphoria. Its high lipophilicity allows it to quickly cross the blood-brain barrier, leading to a rapid onset of effects, which increases the risk of overdose (Giorgetti et al., 2017).

The misuse of fentanyl has been a significant factor in the surge of overdose deaths in North America. Illicit fentanyl, often mixed with heroin or counterfeit pills, has been responsible for thousands of deaths. In the U.S., fentanyl was involved in over 36,000 opioid-related deaths in 2019, surpassing the death toll from heroin and prescription opioids. Fentanyl-related fatalities have also increased in Europe, particularly in countries like Germany and Lithuania (Jobski et al., 2023).

Efforts to mitigate the crisis include the distribution of naloxone (Narcan) to reverse opioid overdoses, harm reduction strategies, and law enforcement initiatives to intercept fentanyl shipments. Despite these efforts, fentanyl's high potency and widespread presence in illicit drug markets continue to challenge public health responses.

Conclusion

The fentanyl crisis has become one of the most devastating public health emergencies of the modern era, with the drug's illicit use driving a significant portion of opioid-related overdose deaths across the globe. While fentanyl remains an essential medication in clinical settings—especially for anesthesia and severe pain management—its potency and rapid central nervous system penetration make it extremely dangerous when misused. The same biological mechanisms responsible for effective analgesia also contribute to profound respiratory depression, strong reinforcement, and a high risk of dependence. Understanding these mechanisms is fundamental for developing strategies to prevent misuse, treat opioid use disorders, and reduce the growing public health impact of synthetic opioids.

The rise in fentanyl-related overdose deaths calls for a multi-faceted approach to mitigate the damage. While harm reduction strategies such as the distribution of naloxone (Narcan), fentanyl testing strips, and supervised consumption sites have proven beneficial in some regions, they are not enough on their own. Public health initiatives must also focus on expanding access to addiction treatment services, particularly medication-assisted treatment (MAT) programs that can help those addicted to opioids. In addition, public awareness campaigns are crucial to informing the public about the dangers of fentanyl, particularly the risks of unknowingly consuming fentanyl-laced drugs (Ciccarone, 2019).

Collaboration between law enforcement, public health officials, and policymakers is essential to curb fentanyl distribution and reduce overdose deaths (Kuczyńska et al., 2018). Moreover, the fentanyl crisis is deeply intertwined with larger issues of social inequality, mental health, and access to healthcare. Vulnerable populations, such as those living in economically disadvantaged areas, often have limited access to addiction treatment and are more likely to turn to illicit substances, making them particularly at risk. Addressing these underlying issues is a critical part of combating the opioid epidemic as a whole.

Only through a combination of medical interventions, harm reduction strategies, stronger enforcement, and societal support systems can we hope to reduce the devastating impact of fentanyl and eventually overcome the opioid crisis. The path forward involves a collaborative effort to protect individuals, families, and communities from the destructive effects of fentanyl and to prevent future generations from falling victim to opioid dependence and overdose.

Strengthening early-warning systems, improving toxicology surveillance, and ensuring rapid data sharing between healthcare institutions and law enforcement agencies are essential for detecting emerging trends in synthetic opioid distribution. Public education campaigns should play a central role in raising awareness about the dangers of illicit synthetic opioids, helping individuals recognize early signs of addiction, and reducing the stigma associated with seeking help. Schools, workplaces, and community organizations must also be engaged in prevention efforts, as widespread awareness and informed decision-making are key components of long-term reduction in opioid misuse.

Ultimately, the fight against the fentanyl epidemic is not solely a medical or legal challenge—it is a societal one. Success will depend on a unified, multi-sector response that balances compassion with accountability, prevention with enforcement, and innovation with evidence-based practice. By fostering stronger public health infrastructure, supporting affected families, and remaining vigilant against evolving drug threats, society can move toward a future where opioid-related harm is significantly diminished and healthier, more resilient communities can flourish.

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