Application of Preventive Medicine in Traffic Medicine

Pitchayapa Jumlongkul, Ph.D.Candidate (Public Health)[1], Arnon Jumlongkul, M.D., LL.D. Candidate[2]
[1]School of Health Science, Mae Fah Luang University, Chiang Rai 57100, Thailand
[2]School of Medicine, Mae Fah Luang University, Chiang Rai 57100, Thailand
[3]Forensic Medicine Unit, Mae Fah Luang University Medical Center Hospital, Chiang Rai 57100, Thailand
Received 10 September 2024 • Revised 1 November 2024 • Accepted 5 November 2024 • Published online 1 January 2025

Abstract:

In the study of traffic medicine, readers need to have a basic understanding of the meaning, boundaries, and branch of preventive medicine as well as concepts and theories associated with preventive medicine, which forms the basis of traffic medicine in order to be able to choose the best principles for treating any health issues. The purpose of this article is to provide an overview of local and international preventive medicine works, various branches of preventive medicine, and the main theories of the nature history of disease, preventive strategies, epidemiologic triad, and spectrum of prevention as well as the applications in traffic medicine. It then provides knowledge and understanding of the fundamental principles of preventive medicine, which is the foundation for higher education in traffic medicine.

Keywords: Epidemiologic triad, Preventive medicine, Preventive strategies, Traffic medicine

Introduction

Preventive medicine, as defined by the American College of Preventive Medicine (ACPM), refers to "the practice of promoting preventive health care to improve patient well-being, with the goals of preventing disease, disability, and death." In the United States, preventive medicine physicians must have knowledge and skills in biostatistics, epidemiology, planning and evaluation of health services, management of health care organizations, research, and preventive medicine practice in clinical settings. Preventive medicine specialists are licensed physicians including, Medical Doctors (MD) and Doctors of Osteopathy (DO). Training is divided into three main specialties; 1) public health and general preventive medicine, 2) occupational medicine, and 3) aerospace medicine.[1]

In Thailand, the training program for preventive medicine residency is managed by the Preventive Medicine Association of Thailand. As of 2024, there are ten specialties for which examinations for certification and proficiency in preventive medicine are offered; 1) epidemiology, 2) travel medicine, 3) aviation medicine, 4) maritime medicine, 5) clinical preventive medicine, 6) public

Corresponding author: Arnon Jumlongkul, M.D., LL.D. Candidate
School of Medicine, Mae Fah Luang University, Chiang Rai 57100, Thailand
Chulalongkorn University, E-mail: arnon.jum@mfu.ac.th
GMSMJ 2025; 5 (1): 19-24

health, 7) community mental health, 8) occupational medicine, 9) traffic medicine, and 10) lifestyle medicine.[2] Additionally, there is a related field known as "community medicine," which focuses on the health of populations with an emphasis on preventive and health promotion in communities through primary health care. Community medicine education includes holistic care, lifelong learning, evidence-based practice, interdisciplinary teamwork, and professional ethics to foster sustainable health systems.[3] However, this specialty is not yet included in residency training in Thailand but is integrated into the medical curriculum of various medical schools.

Traffic medicine, a key branch of preventive medicine, is a multidisciplinary and comprehensive field that addresses the development, prevention, and treatment of traffic injuries. It draws on various disciplines, including psychology, sociology, statistics, engineering, biomechanics, law, and medicine. Epidemiology, relevant to both traffic and preventive medicine, plays a crucial role in identifying effective countermeasures for injury control. Big data mining has emerged as an innovative strategy for traffic safety. Recently, forensic traffic injury medicine has integrated clinical medicine, social psychology, and factors related to vehicles, roads, and road users.[4] This article provides an overview of the natural history of disease, preventive strategies, the epidemiologic triad, and the spectrum of prevention, along with their applications in traffic medicine. It also offers essential knowledge and understanding of preventive medicine principles, forming the foundation for advanced studies in traffic medicine.

Key Theoretical Concepts in Preventive Medicine

Working in preventive medicine requires tools to help understand health issues and to find appropriate and effective solutions. Important theoretical concepts in preventive medicine that should be known are as below.

Natural History of Disease[5,6]

The nature of disease progression refers to the development of a disease in an individual over time without treatment. For example, a person infected with HIV will experience disease progression in stages, from the asymptomatic phase, through symptomatic phases, AIDS diagnosis, and ultimately to death. However, the duration of each stage can vary among individuals depending on disease prevention measures and access to treatment. This progression can sometimes be referred to as "the spectrum of disease" and can be categorized into five stages as follows:

1. Underlying stage: This is the stage where the pathogen is present but has not yet spread to others. Pathogens at this stage can cause both communicable and non-communicable diseases. For instance, HIV is a communicable pathogen transmitted through sexual contact, while smoking can lead to lung cancer, which is declared as a non-communicable disease.

2. Susceptible stage: The body has been exposed to the pathogen, but if it has good immunity, infection may not occur.

3. Subclinical stage: The body has been infected and has undergone pathological changes, but symptoms have not yet appeared. In some diseases, even if the patient is asymptomatic, they can still transmit the disease to others, such as with hepatitis B virus and COVID-19.

4. Clinical stage: At this stage, the disease can be diagnosed using standard methods, starting from the onset of symptoms to more severe manifestations.

5. Recovery/disability/death stage: This stage depends on the type of disease and the individual's resistance to it, and it encompasses recovery, disability, or death.

In traffic medicine, the use of the natural history of disease model can be compared to the different stages of an accident: pre-crash, during the crash, post-crash, and the rehabilitation phase to prevent disability. This is combined with the analysis of risk factors that may lead to injuries at each stage in order to plan preventive measures.

Preventive Strategies[5]

Preventive strategies are crucial tools in preventive medicine and consist of five steps:

1. Primordial prevention: This step aims to reduce risk factors for disease across the entire population by focusing on social and environmental conditions. Examples include government measures to increase tobacco taxes, restrict alcohol advertising, and promote healthy food sales in convenience stores.

2. Primary prevention: This involves preventing disease before it occurs in susceptible hosts who are healthy individuals at risk for disease. Methods include immunization, smoking cessation programs, and nutritional supplementation.

3. Secondary prevention: This focuses on early disease detection through screening among healthy populations who have been exposed to pathogens but are asymptomatic. Objectives are to prevent disease progression. Methods include blood pressure measurement, mammography for breast cancer, Pap smears for cervical cancer, and colonoscopy for colorectal cancer.

4. Tertiary prevention: This aims to reduce disease severity and disability, as well as the consequences after disease onset. Examples include foot care for diabetic patients and physical therapy for spinal cord injury patients.

5. Quaternary prevention: This involves ensuring that patients receive appropriate medical care and are not at risk of excessive treatment. An example is the use of antiarrhythmic drugs after myocardial infarction, which can reduce arrhythmias but may increase mortality risk. It also includes evaluating the appropriateness of existing policies.

Disease prevention strategies must be implemented alongside understanding disease progression, as illustrated in Figure 1.

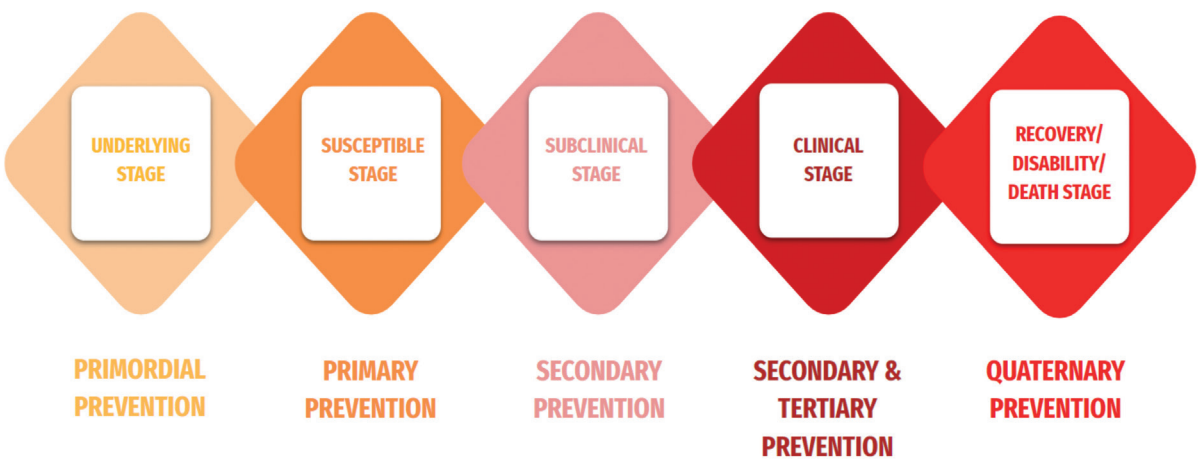

Figure 1 illustrates the implementation of disease prevention strategies alongside the nature of disease progression.

For application in traffic medicine, for example, alcohol consumption increases the risk of accidents, particularly among teenagers. Therefore, the disease prevention strategies can be analyzed as shown in Table 1.

Table 1 shows the preventive strategies of disease at each step.

Preventive Strategies	Problems	Actions
1. Primordial Prevention	Alcohol is sold in the community.	- Restrict alcohol sales advertising. - Increase alcohol taxes.
2. Primary Prevention	Teenagers in the community can easily purchase alcohol.	- Limit the hours for alcohol sales. - Restrict the age of those eligible to purchase alcohol.
3. Secondary Prevention	Some teenagers engage in drinking and driving.	- Identify individuals in the community with drinking behavior and provide training/rehabilitation.
4. Tertiary Prevention	Traffic accident victims suffer from disabilities.	- Promote physical rehabilitation and vocational training.
5. Quaternary Prevention	The rate of injuries and fatalities from traffic accidents continues to rise.	- Review the shortcomings in all the processes that have been implemented.

Epidemiologic Triad[7]

The epidemiologic triad is one of the models used to explain the components of disease occurrence in epidemiology. The triad consists of:

1. Host: This refers to the susceptible host, i.e., the person who is vulnerable to the disease. The susceptibility of each individual varies depending on several factors. The likelihood of exposure to the pathogen depends on personal behavior. For example, individuals who do not wear masks are more likely to contract respiratory infections compared to those who do. Meanwhile, the level of susceptibility and the individual's response to pathogens depend on other factors such as genetic makeup, nutritional status, immunity level, and anatomical characteristics.

2. Agent: This includes pathogens such as bacteria, viruses, parasites, and fungi. However, the presence of a pathogen alone is not enough to cause disease, as several factors contribute to the transition from exposure to disease in a host, such as the pathogen's pathogenicity and the dose of exposure. Nowadays, the definition of an agent in humans is not limited to pathogens but also includes chemicals, physical causes, and various forms of injury. For example, repeated external force applied to the palms and wrists is considered an agent that can cause carpal tunnel syndrome, or alcohol is viewed as an agent that causes liver cirrhosis. In traffic medicine, agents refer to forces that cause injury to the human body, such as high-speed driving or poorly designed vehicles that lack impact-absorbing features during a collision.

3. Environment: This refers to external factors that bring the host and the agent together, such as habitat characteristics, climate, vectors like insects that transmit diseases, socioeconomic status, hygiene,

and access to healthcare. In traffic medicine, the environment refers to driving conditions, such as lighting systems, standard road design, or the presence of obstacles on the road surface.

Disease occurrence results from the interaction between the host and the agent under environmental conditions that favor the transmission of the pathogen to the host, as illustrated in Figure 2.

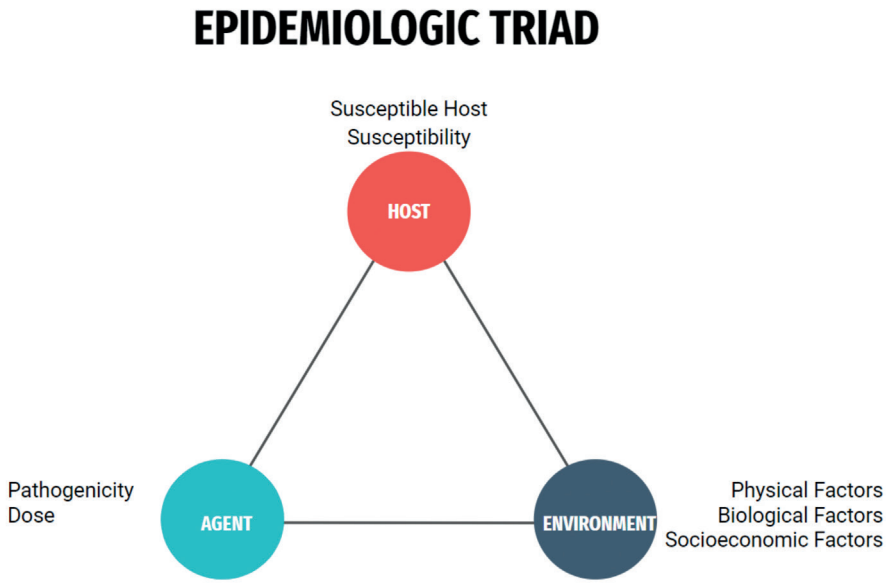

Figure 2 illustrates the relationship between the host, agent, and environment in the epidemiologic triad.

Spectrum of Prevention[8]

The conceptual framework for disease prevention, widely accepted in preventive medicine, was developed by Larry Cohen and Susan Swift. Originally designed for injury prevention, it can also be adapted for the prevention of other diseases. The spectrum of disease prevention consists of six steps:

1. Strengthening individual knowledge and skills: This step involves transferring information and methods for disease or injury prevention to the public to enhance individual capabilities. This is done by professionals or those in authority, such as doctors asking patients during consultations whether they wear helmets while riding motorcycles, along with providing information on injury and mortality rates from traffic accidents. Such recommendations can help reduce injuries or fatalities from traffic accidents.

2. Promoting community education: The purpose of supporting community education is to reach groups of people by providing information and promoting health. This often involves mass communication campaigns aimed at raising awareness and changing attitudes among large populations, such as organizing "exercise days" and "safe driving days."

3. Educating providers: Educating service providers, such as educators, childcare workers, and nursing home staff, is one way to disseminate disease prevention knowledge to the community. These individuals are experts in their fields and have channels to pass on information, skills, and inspiration to those they supervise or serve, thereby spreading knowledge widely.

4. Fostering coalitions and networks: Promoting collaboration and building networks encourages participants to feel confident that projects or ongoing efforts

are likely to succeed, while also reducing competition between groups.

5. Changing organizational practices: Changing organizational practices, such as enforcing laws, health organization policies, and school practices, is a key factor in strengthening community health and safety systems.

6. Influencing policy and legislation: Advocating for changes at the policy or legislative level is the method that can have the most widespread health impact.

Conclusion

Traffic medicine is one of the branches of preventive medicine in Thailand. It is operated by the Preventive Medicine Association of Thailand, with a parallel field working to promote health and well-being. The foundational theories of preventive medicine support the effective implementation of traffic medicine, helping to achieve its goals and contributing to the resolution of public health issues in society.

References

1. American College of Preventive Medicine. About Preventive Medicine [Internet]. 2024 [cited 2024 Sep 9]. Available from: https://www.acpm.org/about-acpm/what-is-preventive-medicine/
2. Medical Council of Thailand. Declaration of the Secretariat Office of the Medical Council No. 2/2024 on the Application for Examination for Certification and Proficiency in Various Medical Specialties, B.E. 2024 [Internet]. 2024 [cited 2024 Sep 9]. Available from: https://tmc.or.th/Media/media-2024-01-18-12-31-14.pdf
3. Gopalakrishnan S. Community Medicine Teaching and Evaluation: Scope of Betterment. J Clin Diagn Res [Internet]. 2015 [cited 2022 Aug 19]; Available from: http://jcdr.net/article_fulltext.asp?issn=0973-709x&year=2015&volume=9&issue=1&page=JE01&issn=0973-709x&id=5362
4. Zhou J, Qiu J. Current Developments on Traffic Medicine. In: Fu X, Liu L, editors. Advanced Trauma and Surgery [Internet]. Singapore: Springer Singapore; 2017 [cited 2024 Oct 4]. p. 59–77. Available from: http://link.springer.com/10.1007/978-981-10-2425-2_5
5. Kisling LA, M Das J. Prevention Strategies. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 [cited 2022 Aug 17]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK537222/
6. Centers for Disease Control and Prevention. Lesson 1: Introduction to Epidemiology Section 9: Natural History and Spectrum of Disease [Internet]. 2012 [cited 2022 Aug 17]. Available from: https://www.cdc.gov/csels/dsepd/ss1978/Lesson1/Section9.html#ALT118
7. Centers for Disease Control and Prevention. Lesson 1: Introduction to Epidemiology Section 8: Concepts of Disease Occurrence [Internet]. 2012 [cited 2022 Aug 19]. Available from: https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section8.html#:~:text=The%20triad%20consists%20of%20an,a%20source%20to%20that%20host.
8. Cohen L, Swift S. The spectrum of prevention: developing a comprehensive approach to injury prevention. Inj Prev J Int Soc Child Adolesc Inj Prev. 1999 Sep; 5 (3):203–7.

Pravalence of Mitragynine in Forensic Autopsy Cases at the Forensic Investigation Center Chulalongkorn University from 2022 to 2023

Nat Tansrisawad, M.D.[1], Apinya Tubtimrattana, M.Sc.[2]

[1]Department of Forensic Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok 10300, Thailand

[2]Department of Forensic Medicine, King Chulalongkorn Memorial Hospital, Bangkok10300, Thailand

Received 9 May 2024 • Revised 1 November 2024 • Accepted 5 November 2024 • Published online 1 January 2025

Abstract:

Background: Mitragynine is an active compound found in Kratom, a substance experiencing growing usage both in Thailand and globally. While Kratom is commonly perceived as safe with minimal adverse effects, instances of fatalities associated with its use and misuse have been documented.

Objective: Investigating the prevalence of mitragynine in forensic autopsy cases from 2022 to 2023. Analyzing demographic data, causes of death, and proposed lethal level.

Materials and Method: A retrospective study was conducted on the forensic toxicological analysis of 213 forensic autopsy cases from 2022 to 2023 at the Forensic Investigation Center of Chulalongkorn University.

Results: The prevalence of positive mitragynine findings rose significantly from 3.14% in 2021 to 13.39% in the years 2022-2023. The male-to-female ratio was approximately 9:1. The common causes of death were attributed to traffic accidents, undetermined and cardiovascular diseases. Mitragynine concentrations varied widely, ranging from 0.10 to 1,423.23 ng/mL, with a mean concentration of 109.85 ng/mL. However, a definitive proposed lethal level could not be determined based on the data analyzed.

Conclusion: The increasing use of kratom, coupled with the rising number of deaths associated with its consumption, necessitate a comprehensive reassessment of its safety profile. A thorough study on its safe usage, including potential positive effects and adverse reactions, is imperative. Additionally, regulatory measures governing kratom distribution and consumption require re-evaluation to ensure public safety and mitigate the risks associated with its use and misuse.

Keywords: Mitragynine, Kratom, Prevalence, Forensic autopsy

Corresponding author: Nat Tansrisawad, M.D.
Department of Forensic Medicine, Faculty of Medicine,
Chulalongkorn University, Bangkok 10330, Thailand
E-mail: tssnat@hotmail.com

GMSMJ 2025; 5 (1): 25-30

Introduction

Kratom *(Mitragyna speciosa)* is a tropical plant indigenous to Southeast Asia. In Thailand, tradition use of kratom is prevalence in the southern region, as an herb for increasing energy, reducing fatigue, relieving pain, antidiarrhea and recreational purposes to enhance euphoric, sociability and sexual desire.[1] Kratom was classified and controlled as a schedule 5 substance under Thailand's Narcotic Act of 1979. However, kratom was removed from the list of prohibited narcotic substance in 2021.[2] This alteration in classification has contributed to the increasing popularity of kratom. Since kratom is perceived to be safe and illegal in many countries, it has been popular in recent years globally and classified as a new psychoactive substance (NPS).[3]

Mitragynine is an active component of kratom leaves. It acts as opioid receptors agonist, alpha2-adrenoreceptor agonist and 5-HT_{2A} receptor antagonist. The use of kratom has been linked to various adverse reactions, including agitation, tachycardia, nausea, drowsiness, lethargy, hypertension, confusion, seizures, and in rare instances, renal failure and cardiac arrest.[1,4]

Several case reports linking mitragynine-related death have indicated polysubstance uses. Cotinine, diphenhydramine, ethanol, mirtazapine, naloxone, o-desmethyltramadol, propylhexedrine, quetiapine, temazepam were among the substances identified in polydrug cases, with mitragynine concentrations ranging from 10 to 4,800 ng/mL.[5,6] Our investigation into the presence of mitragynine in forensic autopsy cases aims to elucidate related demographics, causes of death, and potentially establish a lethal level of mitragynine. The study site is situated in Bangkok, the capital city of Thailand.

Materials and method

This retrospective study was conducted using forensic toxicological analysis of 213 forensic autopsy cases obtained from the Forensic Investigation Center at Chulalongkorn University during the years 2022 and 2023. The study focused on examining demographic information, causes of death, and the presence of co-exposure substances in the analyzed cases.

The forensic toxicological analysis of drugs and narcotics in blood was conducted using a validated LC/MS-MS method by the Forensic Toxicology Laboratory within the Department of Forensic Medicine at Chulalongkorn university.

Statistical analysis

Mean, median and range were analyzed by Microsoft Excel 2021.

Results

Among the 1,591 forensic autopsy cases examined, mitragynine was detected in 213 cases, comprising 13.39% of the total sample. The majority of these cases were Thai nationality, accounting for 193 cases (90.61%), followed by individuals from other Asian countries, totaling 15 cases (7.04%), with the remaining 5 cases (2.35%) attributed to individuals of other nationalities. Of the cases with positive mitragynine findings, 197 were male and 16 were female, resulting in an estimated male-to-female ratio of 9:1. The demographic data are summarized in Table 1.

The predominant co-exposure substances detected alongside mitragynine included caffeine, antihistamines, ethanol, methamphetamines, and benzodiazepines. Notably, instances of sole mitragynine use were not observed within the examined cases. Additionally, other substances identified in this study encompassed

sildenafil, metformin, amlodipine, quetiapine, gabapentin, zolpidem, LSD, and cocaine, as detailed in Table 2. During the study period, new psychoactive substances (NPS) such as estazolam, fentanyl, JWH-073, and methcathinone were also identified.

The related causes of death observed in the analyzed cases predominantly included traffic accidents, undetermined circumstances, and cardiovascular diseases, as depicted in Table 3.

The concentrations of mitragynine detected in the bodies of the individuals examined ranged from 0.10 to 1,423.23 ng/mL (mean 109.85 ng/mL), as shown in Table 4.

Table 1 Demographic data of forensic autopsy cases with the presence of mitragynine

Year	Demographic data					
	Gender		Age (years)		Nationality	
	Male	Female	range	mean	Thai	Others
2022	88 (91.7 %)	8 (8.3 %)	3 mo. -66 y	32.83	87 (90.6 %)	9 (9.4 %)
2023	109 (93.2 %)	8 (6.8 %)	15 – 74	33.76	106 (90.6 %)	11 (9.4 %)

Table 2 Substances found in the forensic toxicological analysis along with mitragynine

Drugs and narcotics	2022	2023
Caffeine	49	86
Antihistamine	40	50
Ethanol	36	26
Methamphetamine	21	16
Benzodiazepine	12	13
Morphine	7	8
Tramadol	7	14
Ketamine	10	6
THC	0	3
Others	26	37

Table 3 Causes of deaths attributed to mitragynine

Cause of death	2022	2023
Traffic accident	27 (28.1 %)	35 (29.9 %)
Cardiovascular disease	16 (16.7 %)	23 (19.7 %)
Undetermined	19 (19.8 %)	32 (27.4 %)
Asphyxia	9 (9.4%)	10 (8.5 %)
Fall	5 (5.2 %)	5 (4.2 %)
Gun shot	3 (3.1 %)	3 (2.6 %)
Drowning	4 (4.2 %)	0
Others	13 (13.5 %)	9 (7.7 %)
Total	96	117

Table 4 Mitragynine concentration in forensic autopsy cases

Year	Gender	Mitragynine level (ng/mL)	
		range	mean
2022	male	0.19 – 1,198.73	134.49
	female	0.35 - 675	111.26
2023	male	0.10 – 1,423.23	118.58
	female	0.29 – 487.56	75.07

Discussion

The true prevalence of kratom use and misuse remains uncertain. However, based on the findings of this study between 2022 and 2023, kratom was detected in up to 13.39% of the forensic autopsy cases, compared to 16 cases out of 510 (3.14%) in the year 2021.[2] Traffic accidents, cardiovascular diseases, and undetermined causes were identified as the major causes of death, with mitragynine potentially exerting direct or indirect effects contributing to these outcomes. In some cases of asphyxia and gunshot fatalities, mitragynine was identified as a coincidental finding.

A study conducted at Ramathibodi Hospital, another forensic center in Bangkok, spanning from 2015 to 2019, revealed the presence of mitragynine in approximately 1% (24 from 2,160) of the autopsy cases, predominantly affecting 96% of males.[7] The most common cause of death identified in the study was traffic accidents, with concurrent poly-drug usage being notably prevalent.

A case report detailing a single mitragynine-associated death revealed a blood mitragynine level of 950 ng/mL.[8]

It is critical to state the lethal concentration of mitragynine because of the potential effects of co-intoxicants, variation in individual metabolism, and methamphetamine and opioid tolerance. Postmortem change of mitragynine has not been clearly studied. Data on redistribution, stability, and other factors essential for

interpreting cases are currently unavailable. The synergistic toxicity of mitragynine in conjunction with other drugs targeting opioid and adrenergic receptors in the central nervous and cardiovascular systems may contribute to severe adverse effects and potential lethality.

Notably, our study revealed instances where individuals with mitragynine levels exceeding 1,000 ng/mL were still alive, while a death case report documented a single use with a level of 950 ng/mL. Conversely, some cases in our study exhibited mitragynine levels below 100 ng/mL but were complicated by co-intoxication and underlying diseases. Due to the diverse factors influencing the effects of mitragynine, a definitive proposed lethal concentration of mitragynine could not be established based on the available data. However, based on case reports highlighting the adverse effects of kratom ingestion on traffic safety and its association with fatalities, we propose that a blood concentration of mitragynine exceeding 25 ng/mL should be established as the cutoff point for driving impairment. Furthermore, levels surpassing 1,000 ng/mL may be indicative of sole mitragynine intoxication leading to death.[9]

Given these complexities and the absence of established toxic and lethal levels, it is the responsibility of forensic pathologists and toxicologists to meticulously gather and analyze all pertinent data to accurately interpret the effects of mitragynine found in each case.

In other Southeast Asian countries, kratom remains illegal and is regulated in Laos, Malaysia, Myanmar, Singapore, and Vietnam. In contrast, it is legal in Cambodia, the Philippines, and Indonesia.[10]

Analyzing the benefits and adverse effects of kratom reveals that some of its medicinal uses do not offer advantages over standard and traditional treatments. Most users consume kratom for recreational purposes or in conjunction with other narcotics. Although this study was conducted in the capital city, it may reflect trends in other major cities, suggesting an increasing use of kratom. Therefore, we recommend that kratom be regulated under narcotics legislation, as it has been in the past.

Conclusion

The number of deaths were attributed or possibly associated with kratom use or misuse. Traffic accident, undetermined and cardiovascular diseases were noted with mitragynine findings. Polysubstance use could be traced back to the original kratom product. The growing use and misuse of kratom, particularly following its removal from the Narcotic Act in Thailand, pose significant concerns. Therefore, there is a pressing need to reassess both the safety protocols surrounding its use and the regulatory framework governing its distribution and consumption.

Conflict of interest

The authors declare they have no conflicts of interest with the content of this article.

References

1. Warner ML, Kaufman NC, Grundmann O. The pharmacology and toxicology of kratom: from traditional herb to drug of abuse. Int J Legal Med. 2016;130 (1):127-38.
2. Towithelertkul C, Tansrisawad N. Epidemiology of blood kratom and cannabis detection from postmortem autopsy at the Forensic Medicine Department of Chulalongkorn University before and after the change of narcotic laws in Thailand. J Crim and Forensic Sci. 2023; 9 (1): 37-52.
3. Davidson C, Cao D, King T, et al. A comparative analysis of kratom exposure cases in Thailand and the

United States from 2010-2017. Am J Drug Alcohol Abuse. 2021; 47 (1): 74-83.
4. Coonan E, Tatum W. Kratom: The safe legal high?. Epilepsy Behav. 2021; 117: 107882. doi:10.1016/j.yebeh.2021.107882
5. Striley CW, Hoeflich CC, Viegas AT, et al. Health effects associated with Kratom (Mitragyna speciosa) and polysubstance use : a narrative review. Subst Abuse. 2022;16:1178221822 1095873. doi:10.1177/1178221822 1095873
6. Behonick GS, Vu C, Czarnecki L, El-Ters M, Shanks KG. Two single-drug fatal intoxications by mitragynine. J Anal Toxicol. 2022; 46 (5): e110-e114. doi:10.1093/jat/bkac016
7. Jittasopa W, Srisont S. The causes of death and pathological findings of Kratom users: a 5-year retrospective analysis. Am J Forensic Med Pathol. 2021; 42 (4): 335-40.
8. Schmitt J, Bingham K, Knight LD. Kratom-associated fatalities in Northern Nevada-What mitragynine level is fatal?. Am J Forensic Med Pathol. 2021; 42 (4): 341-9.
9. Papsun D, Schroeder II W, Brower J, Logan B. Forensic implications of Kratom: Kratom toxicity, correlation with mitragynine concentrations, and polypharmacy. Curr Addict Rep. 2023; 10 : 272–81.
10. The Transnational Institute. Kratom in Myanmar and Southeast Asia: time for legal regulation? [Internet]. 2021 [cited October 11,2024].Available from: https://www.tni.org/en/article/kratom-in-myanmar-and-southeast-asia-time-for-legal-regulation.