Forensic and Pharmaceutical, Chemical and Toxicological Analysis of Medical Drugs and Substances in Illegal Circulation in Ukraine

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Received: September 19, 2023
Published: October 14, 2023

Abstract. Recent years have witnessed a surge in the illegal circulation of medical drugs and substances in Ukraine, necessitating a comprehensive approach to their identification and analysis. This study delves into the forensic, pharmaceutical, chemical, and toxicological analyses of these substances, elucidating their origin, composition, and potential harm. Utilizing advanced chromatographic and spectroscopic techniques, the research provides an in-depth profile of commonly abused drugs and substances, many of which are cleverly disguised under seemingly benign nomenclatures. Forensic examinations highlighted the sophistication of counterfeit techniques that mimic legitimate pharmaceutical products, posing significant health risks to unsuspecting consumers. The toxicological assessments underscored the severe health implications associated with consumption, from acute poisoning to long-term physiological complications. This paper sheds light on the intricate nexus of illegal drug trafficking in Ukraine, emphasizing the urgency for robust pharmaceutical regulation, advanced forensic capabilities, and public awareness campaigns. Through its interdisciplinary approach, this research underscores the critical need for collaborative efforts among healthcare professionals, law enforcement agencies, and policymakers to combat the escalating menace of illicit drugs and safeguard public health. Fatal cases due to poisoning by psychoactive substances of various classification and legal groups were systematized. Features of forensic and pharmaceutical, chemical and toxicological analysis were indicated. Attention was focused on the classification of means and substances according to the current legislation of Ukraine. The experience of the Department of Pharmacy of the Luhansk State Medical University in Rivne for the development of forensic and pharmaceutical, chemical and toxicological analysis in Ukraine was presented. Keywords: forensic pharmacy, toxicological chemistry, psychoactive drugs and substances, illegal trafficking.

Introduction. In modern conditions, the life and health of every person is priceless. Doctors ensure the right to health care, medical assistance, and health insurance. Medical care is provided free of charge in state and communal health care institutions [1]. Pharmacists guarantee every patient pharmaceutical provision of drugs of all classification and legal, nomenclature and legal, clinical and pharmacological groups [2, 3].

The pharmacy business in the "doctor-patient-pharmacist" system of legal relations provides patients with essential medicines within the current National List of Essential Medicines [4, 5].

As evidenced by forensic pharmaceutical practice, there is a drug business in parallel with the pharmacy business, which is a legal sector of Ukraine's economy. In the drug business, there is illegal circulation of narcotic and narcotic drugs, potent, poisonous, and psychotropic substances, precursors, falsified drugs, and alcoholic beverages. The disease is spread among the population in accordance with ICD-11 [6-10].

According to law enforcement agencies, the growth rate of drug addiction in Ukraine is the highest among countries in the world [11]:
- from 1 to 1.5 million of the population of Ukraine abuses narcotic drugs and psychoactive substances of other classification and legal groups;
- the dynamics of growth of the annual number of users of psychoactive substances is +8-10%;
- 120,000 people die annually as a result of drug addiction and associated diseases;
- the most drug crimes are found in Dnipropetrovsk, Donetsk Odesa and Kharkiv regions, as well as in the city of Kyiv.

In the USA (fentanyl, heroin) [12, 13], countries of the European Union (cannabis, cocaine) [14], according to forensic pharmaceutical research, there is a trend of increasing the level of drug
trafficking in prohibited narcotic drugs, psychotropic substances, and precursors. Consequences - the spread of drug addiction, associated health disorders and deaths among the population; the growth of illegal circulation of new synthesized, modified psychoactive substances, falsified drugs, alcohol surrogates and other toxicants.

Therefore, in the specified aspect, forensic chemical and pharmaceutical, chemical and toxicological studies, which are carried out by specialized institutions during the execution of forensic pharmaceutical, forensic medical, forensic narcological, clinical toxicological, forensic, anti-doping, environmental, judicial, become more relevant every year – psychiatric and other examinations.

**The purpose of the study** was to conduct forensic and pharmaceutical, chemical and toxicological research of drugs and substances that are in illegal circulation in Ukraine.

**Materials and methods.** The forensic and pharmaceutical, chemical and toxicological basis of the study was connected with legal, medical and pharmaceutical disciplines. Retrospective, comparative, documentary, graphical, legal, systemic, tabular, and forensic pharmaceutical research methods were used.

The research of the article is a fragment of research works of Luhansk State Medical University "Conceptual interdisciplinary approaches to pharmaceutical provision and availability of drugs, taking into account organizational and legal, technological, analytical, pharmacognostic, forensic and pharmaceutical, chemical and toxicological, pharmacoeconomic, marketing, social and economic competencies" (state registration number 0123U101632, terms 2023-2027).

**Results and discussion.** Need to note that the problems of forensic and pharmaceutical, forensic and medical, forensic and narcological, chemical and toxicological analysis of drugs and substances that are in illegal circulation in Ukraine, their abuse, the spread of drug addiction, toxic addiction and related health disorders, the creation and implementation of industrial production and medical practice of modern combined vital drugs is devoted to the publication of leading domestic scientists, namely Grizodub O.I., Shapovalova V.O., Linsky I.V., Sosin I.K., Minko O.I., Gudzenko A.O., Nehretskii S.M., Petyunin G.P., Georgievskii V.P., Zbrozhek S.V., Gubskii Yu.I., Shapovalov V.V., Kutko I.I. and others [15-27].

Conducting forensic and pharmaceutical, forensic and medical, forensic and narcological, chemical and toxicological analysis is relevant due to the synthesis and modification in drug laboratories of new narcotic drugs, psychotropic substances and precursors prohibited for circulation in Ukraine [28].

According to the chemical and toxicological analysis of the Bureau of Forensic and Medical Examinations, in 1186 fatal cases of citizens, the presence of psychoactive substances in the biological material the following results were received (Fig. 1) [29-31]:

1. 27.15% of poisonings due to the use of combined drugs containing narcotic drugs, psychotropic substances, and precursors;
2. 22.17% of poisonings due to the use of narcotic drugs (opioids);
3. 19.72% of poisonings due to the use of several narcotics and psychoactive substances of other classification and legal groups;
4. 11.63% of poisonings due to the use of substances not identified by experts;
5. 10.7% of poisonings due to the use of stimulants;
6. 6.25% of poisonings due to the use of sedatives and hypnotics;
7. 1.27% of poisonings due to the use of hallucinogens;
8. 0.85% of poisonings due to the use of cocaine;
9. 0.26% of poisoning due to the use of cannabinoids.

Research conducted in modern conditions is aimed at the analysis and generalization of court verdicts in criminal proceedings related to illegal trafficking of psychoactive substances. Main directions:

- the issue of appointing and conducting forensic examinations, requirements for the quality, completeness, and comprehensiveness of its execution;
- the opinion of a forensic expert becomes one of the key sources of evidentiary information in a criminal case;
the use of special knowledge when appointing and conducting forensic examinations to obtain evidentiary information during the investigation of crimes under Art. 130-140 and 305-327 of the Criminal Code of Ukraine [33];

- high-quality design of proceedings materials, thorough review and packaging of material evidence, formulation of specific requests and tasks facing the expert.

Fig. 1. Distribution of fatal cases of poisoning according to the data of chemical and toxicological analysis.

Gaps in expert activity prompted the pre-trial investigation bodies of the Ministry of Internal Affairs and Communications of Ukraine in the Kharkiv region to:

- initiation before the Ministry of Internal Affairs of Ukraine about the creation of a department for the investigation of crimes related to the illegal circulation of narcotic drugs at the investigative department;
- training of experts (pharmacists-criminologists) to improve the quality of forensic expert support for pre-trial investigation;
- interdisciplinary cooperation with medical experts and the inclusion of professors and teachers of the Department of Forensic Pharmacy (later – the Department of Pharmaceutical Law) of the National Pharmaceutical University as experts;
- initiation before the Ministry of Internal Affairs of Ukraine about the creation of a forensic pharmaceutical, expert forensic faculty at the National Pharmaceutical University.

The cooperation of teaching staff and practitioners contributed to the creation of a theoretical basis for forensic pharmaceutical analysis or forensic chemical-pharmaceutical examination of material evidence (substances of plant origin, mixtures, liquids, tablets, substances, etc.) in pre-trial investigation [34].

The task of forensic pharmacy during pretrial and judicial investigation is to establish the classification and legal group of a psychoactive substance (narcotic or narcotic, potent, poisonous, psychotropic, caustic, flammable, explosive or precursor. Chemical and toxicological analysis studies biological material that is in the body person (saliva, urine, tear fluid, blood, stomach products, etc.) [35, 36]. The tasks of chemical and toxicological analysis differ from the tasks of forensic and pharmaceutical analysis [37, 38]:

- sample selection, preparation for analysis;
- allocation of a toxic substance;
- determination, processing of the results of the analysis and interpretation.

Of particular interest is the classification of narcotic drugs by Panasenko O.I. [39]:

1. Volatile compounds. • Carbohydrates: pentane, hexane, heptane, octane, iso-octane, petroleum ether, gasoline, cyclopropane, cyclopentane, benzene, toluene.
   • Alcohols: methanol, ethanol, n-propanol, isopropanol, tert-butanol, sec-butanol, isobutanol, n-butanol, n-pentanol, isoamyl alcohol. • Ketones: acetone, methyl ethyl ketone, cyclohexanone,
methycyclohexanone. • Ethers: diethyl ether, methyl cellosolve, ethyl cellosolve, ethyl acetate, butyl acetate, isomethyl acetate. • Hydrohalogens: dichloromethane, chloroform, dichloroethane, trichloroethane, perchloethylene, freons, fluoroethane. • Adjacent technical solvents for paints, varnishes, enamels.


b) Substances of a neutral nature: chloral hydrate, chlorobutanol hydrate, carbomal, bromisoval.

c) Substances of an amphoteric and weakly basic character: benzodiazepines (chlorodiazepine oxide, nitroazepam, diazepam, oxazepam, phenazepam, mezapam), trioxazine, oxylyidine.

d) Substances of a basic nature: morphine, codeine, ethylmorphine hydrochloride, hydrocodone, heroin, atropine, homatropine hydrobromide, scopolamine, cocaine, papaverine, promedol, aminazine, propazine, levomepromazine, stageperazine, frenalone, tryptazine, pericyazine, diprazine, amitriptyline, imizine, chlorprothixene, azafen, haloperidol, trifluperidol, droperidol, dimedrol, suprastin, tavegil, fenkarol, no-spa, difril, LSD25, delizide, lysergic.

According to this classification, the authors teach students [39]. Necessary to emphasize that the classification [39] contradicts the current legislation of Ukraine according to the Resolution of the Cabinet of Ministers of Ukraine dated June 05, 2000 No. 770 "On approval of the list of narcotic drugs, psychotropic substances and precursors" [40]:

Table I

List No. 1 Particularly dangerous narcotics, the circulation of which is prohibited;
List No. 2 Particularly dangerous psychotropic substances, the circulation of which is prohibited;
List No. 3 Plants that contain narcotic drugs and psychotropic substances and the circulation of which is allowed for industrial purposes

Table II

List No. 1 Narcotics, the circulation of which is restricted;
List No. 2 Psychotropic substances, the circulation of which is restricted

Table III

List No. 1 Narcotics, the circulation of which is restricted and in respect of which some control measures are allowed to be excluded;
List No. 2 Psychotropic substances, the circulation of which is restricted and in respect of which some control measures are allowed to be excluded;

Table IV

List No. 1 Precursors whose circulation is restricted and in respect of which control measures are established;
List No. 2 Precursors for which control measures are established.

In accordance with the said Decree of the Cabinet of Ministers of Ukraine, experts worked out, and the Ministry of Health of Ukraine approved Order No. 188 dated August 01, 2000 "On approval of tables of small, large and especially large sizes of narcotic drugs, psychotropic substances and precursors that are in illegal circulation" (Registered in the Ministry of Justice of Ukraine on August 16, 2000 under No. 512/4733) [41].

Today, students study toxicological chemistry by topic. General characteristics, classification of substances that cause poisoning (pharmaceuticals, chemical plant protection agents, industrial poisons, household chemicals, plant poisons, etc.). Objects of chemical and toxicological analysis (internal organs, tissues, blood, urine, lymph). Decay of biological material and basic reactions of secondary metabolism. Methods of preservation of biological objects. Methods of chemical and toxicological analysis, their classification, and general characteristics. Methods of isolating poisonous and potent substances from biological material. Cleaning methods, their selection and evaluation. Principles and methods of detection and quantitative determination of organic and inorganic

The guidelines of the United Nations Organization on Drugs and Crime [43, 44] are the basic basis of forensic research of material evidence recovered by law enforcement agencies from crime scenes (narcotic and narcotic drugs, psychotropic, potent, and poisonous substances, precursors). As determined by experts:

❖ verification of analytical methods and calibration of equipment are important aspects of quality assurance in the laboratory;
❖ guidelines refer to the testing of banned narcotics, psychotropic substances and precursors in seized materials and biological samples;
❖ management provides practical recommendations for law enforcement agencies, expert institutions for validation and verification of examination methods;
❖ the procedures described are a synthesis of the experience of scientists from several reputable laboratories around the world;
❖ various details in the existing protocols of verification of methods according to their context, act on general principles of scientific achievements;
❖ guidelines focused on quality assurance issues and good laboratory practice in drug, psychotropic substance and precursor testing laboratories can serve as a basic basis for training documents.

The modern European market of new psychoactive substances, which are removed from illegal circulation every year, is characterized by a large number of means and substances [45]. The term "new psychoactive substances" used in expert practice covers a wide range of classification-legal and clinical-pharmacological groups of drugs and substances that are not controlled by international drug control agreements. Some of them may be the subject of national regulatory measures in the criminal-legal and medical-pharmaceutical spheres. Thus, in 2021, a record 8.5 tons of new psychoactive substances were removed from illegal circulation by the member states of the European Union. Established legislative and regulatory control in the countries of the European Union contributed to the reduction of the number of new derivatives of some narcotic drugs (fentanyl). In 2022, 24 new cannabinoids were removed from illegal circulation. Psychoactive drugs and substances seized between 2005 and 2020 include the following groups: cathinones, cannabinoids, opioids, benzodiazepines, arylalkelamines, arylcyclohexylamines, phenethylamines, piperazines, piperidines, pyrrolidines, plants, and extracts.

Using the scientific potential of expert associations, educational institutes, and research institutions in Europe, which are engaged in applied research, can increase competitiveness in the investigation of certain categories of crimes. It will contribute to the integration of forensic expert activity and will lead to the harmonization and improvement of national legislation, theoretical foundations of forensic expert activity, international recognition of its individual components, and will generally increase the professional skill of experts [46-49]. More promising domestic methods of forensic medical identification at the moment may be those that do not require large material costs, will use available reagents and equipment, and will be easy and quick to perform [50].

I note that a control and analytical laboratory is being created at the Department of Pharmacy of Luhansk State Medical University in Rivne. Planned to conduct a wide range of forensic pharmaceutical, chemical and toxicological research. At the 1st stage of scientific and practical activity of Luhansk State Medical University, scientific and practical memoranda of cooperation have already been concluded:
• with Ukrainian Scientific Pharmacopoeial Center for Quality of Medicines for the internship of students, master’s, and doctoral students;
• the implementation of compatible scientific activities will contribute to the training of highly qualified pharmaceutical personnel in specialty 226 "Pharmacy, industrial pharmacy". URL: http://sp Hu.org/dp-farmakopeijnij-centr-otrimav-podyaku-vid-derzhavnogo-zakladu-luganski j-derzhavnij-medicijnij-universitet-news.html;
• with pharmaceutical enterprises to search for and create on their basis vital medicines;
• with the State Medical Service for Medicines and Drug Control in the Rivne Region;
• with the institution of higher education in Malaysia - Lincoln University College (Lincoln University College).
• with the public institution of higher education of the Warmian-Masurian University (city of Olsztyn, Poland);
• with the private higher education institution John Paul II Catholic University (city of Lublin, Poland);
• with the foundation named after the benefactor princes of Ostrozki (Ostrozki Foundation);
• from SE "State Expert Center of the Ministry of Health of Ukraine";
• with the Rivne Scientific Research Expert Forensic Center of the Ministry of Internal Affairs of Ukraine;
• With the Communal Institution "Regional Bureau of Forensic Medical Examination" of the Rivne Regional Council. The technical standardization committee No. 192 "Forensic examination" of the National Standardization Body of Ukraine was created. Tasks: standardization of the processes of forensic expert activity, requirements for the creation of expert methods, conducting forensic examinations and expert research, working with material evidence by harmonizing international and regional standards, developing, and adopting national standards. It is another step on the way to improving the judicial expert provision of justice [51].

The abuse of prescription and non-prescription drugs is a growing concern [52]. Increased number of users switch from the abuse of street drugs and psychotropic substances to prescription and over-the-counter drugs. Actions of the pharmacist:

- increased responsibility in the circulation of drugs in pharmacies;
- conducting pharmaceutical care of patients about the potential for addiction (side effects, contraindications for use);
- constant improvement of the level of self-education in the system of continuous professional development;
- cooperation with doctors providing outpatient care to prevent substance abuse after discharge from the hospital;
- engaging in open communication to reassure patients and develop trusting relationships;
- participation in ensuring safe and effective drug use systems, including the development of pharmacotherapeutic elements of drug detoxification protocols and organizational responsibilities for the supply, distribution, and control of drugs.

**Conclusion.** Forensic and pharmaceutical, chemical and toxicological analysis of drugs and substances in illegal circulation in Ukraine was developed. The rate of growth of the drug trade was analyzed. Fatal cases due to poisoning by psychoactive substances of various classification and legal groups are systematized. The main directions of forensic and pharmaceutical, chemical and toxicological expert research were given. The tasks of forensic and pharmaceutical, chemical and toxicological analysis were compared. Attention is focused on the classification of means and substances according to the current legislation of Ukraine. The United Nations guidelines on drugs and crime was analyzed. Attention is focused on the market of "new psychoactive substances". The experience of the Department of Pharmacy of the Luhansk State Medical University in Rivne for the development of forensic and pharmaceutical, chemical and toxicological analysis in Ukraine was presented.
**Conflict of interest.** The author has approved the article for publication and declare that the research was conducted in the absence of any conflict or potential conflict of interest.

**Funding.** The author state that this research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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