DOI: 10.61954/2616-7107/2024.8.1-5 *ISSN 2616-7107*

UDC 005.33
JEL: D83, I10, P36

ASSESSING THERAPY AND REHABILITATION COMPREHENSION OF CHEMICAL LABELLING AND FORMING CHEMICAL SAFETY COMPETENCE SPECIALISTS

Alla Ishchenko*
Bogomolets National Medical University,
Kyiv, Ukraine
ORCID iD: 0000-0002-5097-4730

Nataliia Stuchynska
Bogomolets National Medical University,
Kyiv, Ukraine
ORCID iD: 0000-0002-5583-899X

Lesya Yanitska
Bogomolets National Medical University,
Kyiv, Ukraine
ORCID iD: 0000-0002-8116-2022

*Corresponding author:
E-mail: ischenko.alla.a@gmail.com

Received: 25/12/2023
Accepted: 21/03/2024

DOI: 10.61954/2616-7107/2024.8.1-5

Introduction. Considering the higher risk of man-made chemical disasters due to military operations, the demand for the training of qualified therapists and rehabilitators is increasing. Future healthcare professionals should be competent in chemical safety and fully possess information on the designation and classification of hazardous substances and the labelling of chemical substances. Therefore, the relevance of their competent risk assessment is growing regarding the use of dangerous chemical substances of an inorganic and organic nature and their anthropogenic influence.

Aim and tasks. The paper aims to determine the formation of chemical safety competence among future specialists in therapy and rehabilitation.

The results. A questionnaire established that future rehabilitators should acquire chemical safety competence to decipher hazard markings and possess information about the rules for working with chemicals based on a detailed study of the marking and labelling of chemical substances and rules for their use and disposal. Only 47.1% of the respondents (according to their assessment) knew the rules for handling chemicals, and 41.2% deciphered a potential danger to human health (carcinogenic effect). However, 88.2% of the higher education students interviewed wanted to develop chemical safety competence using unique chemical safety cards.

Conclusions. The correct interpretation of the marking constituent elements allows for avoiding accidents and injuries while handling chemicals, and in the moment of a threat to human health or damage, allows the application of the given algorithm for providing first aid. Therefore, understanding the main components of chemical safety by future rehabilitators is possible through applying relevant knowledge, skills and abilities in further professional activities. However, future therapists and rehabilitators cannot correctly decipher the designation of the carcinogenic danger and do not have complete information about the rules for working with chemical substances. Therefore, it is necessary to conduct additional activities for future therapists and rehabilitators for their better understanding of the rules for handling chemicals and deciphering the dangers indicated on the labels of chemical products.

Keywords: chemical safety, safety alert symbols, chemical labelling, therapy and rehabilitation, chemical safety competence.

1. Introduction.

In Ukraine, the issue of chemical safety is highly relevant, considering full-scale war and active military operations. Various chemical weapons are used on the battlefield, and the risk of artificial chemical disasters increases as a result of shelling. As of 2018, up to 12,000 potentially dangerous facilities were operating in Ukraine, half of which (6,000) were high-risk facilities (Rudenko et al., 2010; State Emergency Service of Ukraine, 2022).

Among these institutions, approximately 1,000 industrial enterprises used or stored hazardous chemicals, the amount of which was estimated at 308,000 tons. The most significant number of chemically hazardous facilities were located in the eastern regions of our country: the Donetsk region (149 enterprises), the Dnipropetrovsk region (108 enterprises), and the Kharkiv region (80 enterprises) (Rudenko et al., 2010).

Large-scale military operations were concentrated in the eastern part of Ukraine within the regions mentioned (Kyiv School of Economics, 2023). The consequences of damage to potentially dangerous facilities in Ukraine are characterized by approximate losses ($25.8 billion) caused by emissions of the following pollutants into the air: nitrogen oxides, carbon oxides, non-methane volatile organic compounds, sulfur oxides, lead, cadmium, mercury, arsenic, chromium, copper, nickel, selenium, zinc, polychlorinated dibenzo para dioxins, dibenzofurans, and benzopyrene (State Emergency Service of Ukraine, 2023).

Knowledge and understanding of the rules for handling chemical substances, safety measures, and first aid algorithms are the necessary components of chemical safety that every citizen of the country should possess. Health professionals are increasingly encountering cases of direct or indirect chemical exposure in the human body (Corbin, 2017).

There is a growing demand for training competitive therapy and rehabilitation specialists competent in chemical safety. The international community considers chemical safety to be a strategy for implementing sustainable development goals.

In Ukraine, under the conditions of a full-scale war, the legislation in the field of chemical safety was revised. Thus, the “On Ensuring Chemical Safety and Management of Chemical Products” (Verkhovna Rada of Ukraine, 2022) law was adopted. Ukraine’s international obligations to manage and handle chemical products were formulated according to this law. Therefore, chemical safety is considered within the following principles: the main regulatory framework of chemical safety includes the international conventions initiated by the UN (Report of the United Nations Conference on Environment and Development, 1993), Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Secretariat of the Basel Convention, 2020), Rotterdam (Secretariat of the Rotterdam Convention, 2019), and Stockholm (Secretariat of the Stockholm Convention, 2020).

Chemical substances and products are dangerous to human health and the environment. Hence, it is necessary to carry out and review risk assessments regarding the production and use of chemicals and products, monitor and control their international circulation, exchange data on dangerous substances, and unify the designation and classification of hazards (United Nations, 2017; Wang et al., 2021).

At Ukraine’s legislative level, legal obligations in chemical safety have been approved to ensure the provision of emergency medical aid in cases of threats to human health and life caused by dangerous chemical substances.

It should be noted that the ways of implementing the strategy for chemical safety include education and educational work on handling household chemicals and their use, action algorithms, and rules for providing first aid in the case of poisoning injuries caused by dangerous chemicals (Verkhovna Rada of Ukraine, 2022), and protocols for providing medical and toxicological care to persons affected by chemical exposure substances (Asamani et al., 2018; Prykhodko et al., 2020; Hrynzovskyi et al., 2022).

2. Literature review.

Chemical safety includes harmonising hazard designation and chemical labelling, a universal "language" that codifies the hazards and precautions for handling chemicals. Precautionary labelling of chemical products is "a complex of data in the form of separate graphic/coloured symbols, short texts, and their combinations, which is applied to products and packaging" (Ishchenko et al., 2021a).

In Ukraine, the issue of hazard designation is harmonised with the international community's requirements (State Committee for Technical Regulation and Consumer Policy, 2010). According to the state standard, the information about composition, trade name, production information and a description of the hazard (pictogram, type of hazard, measures for working with substances) are printed on the label of chemical products.

In order to understand the handling of chemical substances, the following informative labelling elements are used: a danger sign or pictogram, a succinct explanation of the sort of threat, a "signal" word, and an explanation of the operating measures, handling and disposing of products. Next, three types of hazards are distinguished in the labelling: physical hazard, a threat to human health, and a threat to the environment.

Characterising the physical danger, the physical and chemical properties of the substances are analysed (in particular, the aggregate state of the substance or mixture). The following types of physical hazards are distinguished: explosives; flammable aerosols; gases under pressure; oxidising gases; flammable gases, liquids, solids; self-reactive substances; pyrophoric liquids, solids; substances capable of self-heating; substances that emit flammable gases when in contact with water; liquids, solid oxidising substances (United Nations, 2017).

The dangers to human health are divided according to the criteria of acute or chronic toxicity, using data on the average lethal dose LD50 (in the case of substances entering the body orally or dermally) and the average lethal concentration LD50 (in the case of substances entering the body by inhalation). Thus, the following types of threats to human health are distinguished: acute toxicity; skin corrosion/irritation; significant eye damage/irritation; skin/respiratory sensitisation; mutagenicity; carcinogenicity; toxicity for reproductive function; toxicity for target organs (for a single action); toxicity for target organs (with repeated action); toxicity in case of aspiration (United Nations, 2017). Five classes of acute toxicity are to be distinguished (Table 1.)

Table 1.Characteristics of labelling elements depending on the class of acute oral toxicity.

Acute oral toxicity, mg/kg					
	Class 1	Class 2	Class 3	Class 4	Class 5
LD_{50}	≤ 5	> 5 ≤ 50	> 50 ≤ 300	> 300 ≤ 2000	> 2000 ≤ 5000
Icon					–
Signal word	Danger	Danger	Danger	Warning	Warning
Short danger description	Fatal if swallowed	Fatal if swallowed	Toxic if swallowed	Harmful if swallowed	May be harmful if swallowed

Source: based on United Nations (2017).

Among the threats to the environment are the danger to the aquatic environment (acute and chronic toxicity to the aquatic environment, including the potential for bioconcentration and the ability to biodegrade) and the danger to the ozone layer (United Nations, 2017).

Each characterised hazard type is indicated graphically by an icon or danger sign. The icon has a red frame and a black symbol (specific to a particular type of hazard). Nine pictograms are used to indicate hazards: four signs indicate a physical danger; four signs indicate a threat to human health; one sign indicates a danger to the environment (Burger et al., 2003).

The word "signal" must be indicated on the label of chemical products. For substances characterised by a high level of danger, the "Danger!" signal word is indicated. Substances with a low level of danger are marked with the "Warning!" word. The labelling combination of icons, signal words, and short hazard descriptions is shown in Table 1.

A short description of the hazard or H-phrase must be written in whole or indicated in a condensed format (with the help of three numbers) on the label of chemical products. Digital designation of physical danger is H200–299, for example, H200 is an unstable explosive substance (United Nations, 2017). Threats to human health are indicated by H300-399, for example, H300 is fatal if swallowed (United Nations, 2017). Danger to the environment is indicated with the help of H400-499, for example, H400 means extremely toxicity to aquatic organisms (United Nations, 2017).

Hazard prevention measures, namely the rules of work, handling, and disposal of chemical products, are P-phrases indicated in painted form or with the help of a digital designation (three digits). P-phrases are standard recommendations or algorithms for handling chemical products, and a combination of several phrases is used to describe specific recommendations. General recommendations for working with chemical substances are indicated by P100–199, for example, P101. In case of a doctor's consultation, please have the packaging or label of the product (United Nations, 2017). Warnings about danger are indicated with the help of P200-299 phrases, for example, P201 – please get special instructions before use (United Nations, 2017).

The response to the influence of the toxicant has the designation P300–399, for example, P301 – in the case of ingestion (United Nations, 2017). Storage conditions for chemical products are indicated by P400–499 phrases, for example, R402 – stores in a dry place (United Nations, 2017).

The methods for the disposal of chemicals are described using P500-599 phrases. For example, P502 refers to contacting a supplier or manufacturer for information on disposal or recycling (United Nations, 2017). The labelling elements, measures for handling chemical substances, and information about the type of danger are indicated in the safety passport of chemical products (Verkhovna Rada of Ukraine, 2022), a part of their technical documentation.

The safety data sheet of chemical products provides the following information: identification of the substance; data on the manufacturer/importer/supplier; product composition; physical and chemical properties (including stability and reactivity); phone numbers for emergency situations; hazard identification (marking); description of first aid measures depending on the ways of entry into the human body (inhalation, oral, dermal); data on toxicity, indicators of acute and chronic toxicity under short-term and long-term exposure; information about the most characteristic symptoms/signs of acute or chronic intoxication, further necessary medical assistance and special treatment; product storage rules; description of measures to prevent and eliminate emergency and emergency situations caused by the substance or product, and their consequences, including measures and means of ensuring fire safety; information on personal and general protective equipment, technical control measures; data on toxicity for aquatic and terrestrial organisms, bioaccumulation potential; product disposal recommendations (State Committee for Technical Regulation and Consumer Policy, 2010).

Thus, information regarding the type of hazards, work algorithms, handling of chemicals, and first aid measures is indicated on the product label or described in the safety data sheet, which simply requires correct decipherability.

3. Methodology.

Future healthcare specialists must fully master the information on the designation and classification of hazards and labelling of chemical substances, competently assess the risks of using dangerous chemicals of inorganic and organic nature, and understand the molecular mechanisms of the effect of toxicants on the human body.

Considering the military operations, the demand for training qualified therapists and rehabilitators is growing in Ukraine. Future specialists will study more practical disciplines in their future activities. In the educational process, the issues of handling chemicals are currently considered within the framework of safety regulations. One of the tasks assigned to therapy and rehabilitation specialists is the acquisition by students of subject (professional) competencies in chemical safety, which consist of understanding the rules of work and handling of chemicals, biochemical processes of metabolism, principles of its regulation, molecular mechanisms of chemical action substances, principles of neutralization of xenobiotics and endogenous toxins (Mikhno et al., 2020; Ishchenko et al., 2021).

Next, competence in chemical safety is formed throughout a person's life, particularly during studies in secondary education institutions. This is the development of an outlook on handling chemical substances and assimilating basic work rules, skills and abilities. While mastering the profession, it is necessary to continue to form chemical safety competence, particularly for future therapists and rehabilitators.

The study examines the competence of medical workers in chemical safety as an integral personality quality manifested in successful treatment and preventive activities. The competency structure has three components. The encouraging value component involves establishing of enduring internal incentives for therapeutic and preventive activities within the culture of handling chemicals and the awareness that chemicals have a toxic effect at the cellular and molecular level, which is the basis for the development of pathological conditions.

The cognitive component is knowledge of the molecular mechanisms of action of dangerous chemicals, the mechanisms of their neutralization in the human body, and the designation of hazards (labelling of chemicals) (Karapantsios et al., 2008). The active component of the chemical safety competence of future therapists and rehabilitators is the ability to provide first aid and the development of algorithms for handling chemicals in order to reduce the risks of their dangerous impact on human health.

The initial data on the formation of encouragement value and comprehensible and practical aspects of proficiency in chemical safety competence among first-year university students were analysed. Therefore, a survey of 48 respondents was conducted. A questionnaire with 11 questions was developed, 8 of which were closed and 3 were open-ended. The survey was conducted anonymously using a Google form, so that will expect a high probability of accurate answers. The experimental study results were processed using the “MS Excel” and “Statistica” programs.

In order to check the level of formation of the professional competence cognitive component, an analysis of answers to questionnaire questions No. 1, No. 6-10 was carried out (Fig. 1). The formation of the motivational and value and activity components was diagnosed using the following questionnaire questions: No.2-5, No.11 (Fig. 1).

In the questionnaire (question No.11), future therapy and rehabilitation specialists were offered to familiarize themselves with the developed safety card for ethanoic or acetic acid (Fig. 2).

They were offered to evaluate its use in classes. This card contains information about the compound's name, its compositional equation, labelling, signal words, a brief description of the hazard, algorithms for handling this chemical substance, and rules for providing first aid if necessary (Ishchenko et al., 2021b).

Issues of chemical safety and training of therapy and rehabilitation specialists.

Dear students, please complete the survey. Your opinion is important to us!

Question	Answer
1. In your opinion, explain what the term "chemical safety" means.	
2. Do future therapy and rehabilitation doctors need no possess the knowledge of chemical safety?	yes ☐ no ☐ not sure ☐
3. In what situations does a therapy and rehabilitation doctor use the knowledge of chemical safety?	
4. As future therapy and rehabilitation doctors, do you need to know the rules of work and handling of chemicals?	yes ☐ no ☐ not sure ☐
5. In your opinion, do future therapy and rehabilitation doctors need to know the mechanisms of negative effects of inorganic and organic toxicants on the human body?	yes ☐ no ☐ not sure ☐
6. List the possible consequences of exposing human body to chemicals.	
7. In your opinion, do future therapy and rehabilitation doctors need to know the mechanisms of neutralization (detoxification) of inorganic and organic toxicants in the human body?	yes ☐ no ☐ not sure ☐
8. Do you know the rules for working with chemicals during their use, transportation, storage, and disposal?	yes ☐ no ☐ not sure ☐
9. Is it necessary for future therapy and rehabilitation doctors to know the designation (labeling) of chemical substances?	yes ☐ no ☐ not sure ☐
10. Do you know what danger is indicated on the label of household chemicals by the icon below? 	yes ☐ no ☐ not sure ☐

Figure 1. A developed questionnaire for checking the formation of competence in chemical safety among future therapy and rehabilitation specialists.

Using the developed safety cards in the educational process is planned to provide the knowledge, skills, and abilities of future specialists in therapy and rehabilitation regarding the rules for working with chemical substances, safety measures, and the ability to interpret the toxicity of these compounds. Mastering the biochemical dimensions of safety concerning chemicals (processes by which toxicants block enzyme reactions, action of inhibitors of the mitochondrial respiratory chain and oxidative phosphorylation uncouplers; neutralization of endogenous toxins and biotransformation of xenobiotics), students of higher education compare information about the biochemical and toxicological effects of a chemical substance (intermediate, toxicant, xenobiotics), which are listed in the safety data sheets, and the theoretical material covered in the related practical session. Thus, one of the results of studying biological chemistry for future therapists and rehabilitators will be forming an associative series "danger designation – molecular and cellular mechanisms of action of a chemical substance – safety measures when working with it – basic first-aid measures".

Ethanoic acid CH_3COOH	  Danger! *Short hazard description* *H-phrases*: 226-314; flammable liquids and their vapors; cause severe skin burns and eye damage. *Measures to prevent danger* R-phrases: 280-301+330+331-307+310-305+ 351+338 use protective gloves/protective clothing, eye/face protection; in case of ingestion: rinse the mouth, do not induce vomiting; in case of negative impact: immediately contact the information center or call a doctor; in case of contact with the eyes: rinse carefully with water for several minutes; if possible, remove contact lenses; continue to wash the eyes.	 Caution! Caustic  Caution! Flammable substanses  In case of getting the reagent on skin or clothing – wash with water and neutralize  Use protective gloves  Use eye protection

Figure 2. Safety data sheet for acetic or ethanoic acid.

4. Results.

The formation of competence cognitive components was verified according to content components. The first of them is the understanding by future therapy and rehabilitation specialists the essence of the "chemical safety" concept, which was determined by analysing the answers to open question No. 1.

Higher education students should understand chemical safety as a set of measures aimed at preventing the negative impact of chemicals on human health and the environment, rules for working with chemicals, , and regulation and control of production, storage, transportation, and use of chemical substances in order to minimize risks to health and the environment.

In answer to question 6 of the questionnaire ("List the possible consequences of exposure to chemicals on the human body"), future rehabilitators indicate the following answers: chemical burns, poisoning, irritation of the respiratory tract, allergic reactions, effects on the reproductive sphere and teratogenic effects, acute intoxication, chronic diseases, the appearance of malignant neoplasms (carcinogenic effect), lethal effect.

Future therapists and rehabilitators know the main components of chemical safety and explain its interpretation by international standards. First-year students of higher education understand that violations of work rules and handling of dangerous chemical substances increase the risks of a threat to human life and justify the short-term and long-term effects of chemicals on the human body.

The second substantive component of the competence cognitive component in chemical safety is the understanding of the molecular mechanisms of action of toxicants and the ways of their neutralization in the human body, which was checked by analysing the answers to closed question 7 of the questionnaire. Future rehabilitators understand that they must know the mechanisms of neutralization (detoxification) of inorganic and organic toxicants in the human body. 97.1% of the respondents gave the "yes" answer.

The third component is knowledge of the rules of handling hazardous chemicals and labelling them (Winder et al., 2005). The analysis of answers to closed questions 8-10 confirms its formation. The infographic of the answers is presented in Fig. 3.

According to their assessment, only 47.1% of the respondents know the rules for working with chemical substances during their use, transportation, storage and disposal, 23.5% of them do not know, and 29.4% of the respondents are challenging to answer. Future therapy and rehabilitation specialists realize that they should know the designation (labelling) of chemical substances (88.2% of respondents chose the "yes" answer). However, according to their assessment, only 41.2% of the respondents can decipher the "danger to human health" (carcinogen) designation, 41.2% of them do not understand the type of danger, and 17.6% of the surveyed future rehabilitators find it challenging to answer.

Analysing the answers, it can be noted that first-year students of higher education do not know the elements of labelling chemicals and cannot correctly characterize the danger to human health indicated on the label of chemical products. The results can be explained by the decrease in the quality of chemistry training in general secondary education in connection with the COVID-19 pandemic (Wu & Teets, 2021) and the full-scale war in Ukraine. Consequently, it is required to carry out extra activities (lectures, webinars, and seminars) for future therapists and rehabilitators to understand better the rules for handling chemicals and decipher the dangers listed on the labels of chemical products.

The initial data on the formation of the motivational value and activity components of competence in chemical safety were checked by analysing the answers to questions No.2-5 and No.11 of the questionnaire. The infographics of the responses are presented in Fig. 3.

Future therapy and rehabilitation experts realized that in order to carry out successful professional activities, they need to possess the material and be competent in the field of chemical safety (question #2): 79.4% of respondents chose the "yes" answer. In addition, 79.4% of future rehabilitators expressed willingness to study and understand the chemical handling rules (question #4).

Of the surveyed respondents, 94.1% knew the need for knowledge about the mechanisms of the adverse effects of inorganic and organic toxicants on the human body during their professional activities (question #5). Moreover, 88.2% of the higher education students interviewed desired to work with chemical safety data sheets in the "General Biological Chemistry and Biological Chemistry of Motor Activity" course (question #11).

In addition to an upbeat assessment of the use of the developed safety cards, future therapists and rehabilitators noted that choosing such a format for summarizing and visualizing information about danger signs, rules of conduct, and first-aid measures is optimal for mastering the given material.

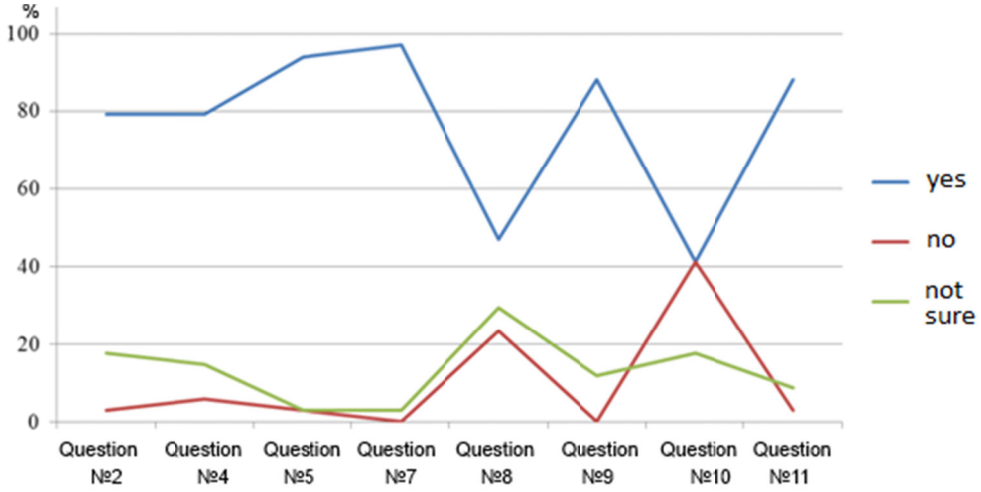

Figure 3. Graphical representation of the results of questionnaires on closed questions.

The answers of the respondents to open question No. 3 of the questionnaire ("In what situations does a therapy and rehabilitation doctor use knowledge of chemical safety?") are meaningful and diverse.

The students of higher education indicate the following answers: during military operations, it is essential to know how to act in case of use of chemical weapons and substances; handle and treat patients affected by chemical poisoning or contact with hazardous substances; provide medical assistance at the sites of accidents involving chemical substances; planning and carrying out rehabilitation of patients with chemical injuries in order to improve their condition and quality of life; ensuring safety for medical personnel and patients in the process of using chemical agents, for example, during physical therapy or other procedures; selection and prescription of drugs, analysis of their chemical structure and interactions may require understanding of possible side effects; understanding the chemical sensitivity and individual reactions of the patient to medicines for the most effective and safe treatment.

Having analysed the answers received regarding the formation of the encouraging value and competence in chemical safety, it can be stated that future therapists and rehabilitators have stable internal motives, readiness, and desire to apply the culture of handling chemicals in further treatment and prevention activities.

5. Conclusions.

Chemical safety is a complex of various measures to reduce the negative impacts of chemical substances on living organisms. The international community considers its main principles a strategy for implementing sustainable development goals.

It has been established that one of the components of chemical safety is the marking of hazards on the labels of chemical products. The correct interpretation of the constituent elements of labelling (danger signs or icons, a brief description of the type of danger, a "signal" word, and a description of measures for work, handling, and disposal of products) will avoid accidents and injuries during the handling of chemical substances, and in the event of a threat to a healthy person or injury, apply the given first aid algorithm.

A survey on the foundational stages of prospective specialists' chemical safety competency creation was carried out. The encouraging value, and internal incentives are formed at the appropriate level because 79.4% of respondents realize that in order to carry out successful professional activities, they need to possess the material and be competent in the field of chemical safety. However, 94.1% of the surveyed rehabilitators understood the need to apply knowledge about the mechanisms of the adverse effects of inorganic and organic toxicants on the human body in their future professional activities. Meanwhile, 79.4% of respondents are ready to learn the rules of handling chemicals; 88.2% of the interviewed higher education students had a desire to work out chemical safety data sheets.

However, the cognitive component of competence in chemical safety is not sufficiently formed, as 47.1% of future rehabilitators do not know enough information about the rules of working with chemical substances during their use, transportation, storage and disposal; 41.2% of respondents cannot decipher the type of danger regarding the threat to human health.

After analysing the results, it can be stated that future rehabilitators are competent in chemical safety, understand its main components, and are motivated and ready to apply relevant knowledge, skills, and abilities in further professional activities. Nevertheless, first-year higher-education students cannot correctly decipher the designation of hazards to human health (carcinogenic effect); they need to fully know the rules for working with chemical substances. Therefore, it is necessary to review the content of the training of natural and professionally oriented disciplines of higher education students regarding a more detailed study of the designation and labelling of chemical substances, rules of operation, and disposal of chemicals.

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